Knowledge Management as a Requirement for successful Sustainability Management

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LIST OF ABBREVIATIONS

BAO	Believe-Action-Outcome
B2B	Business-to-Business
B2C	Business-to-Customer
bn	Billion
C2C	Cradle-to-Cradle
CEO	Chief Executive Officer
CHF	Swiss Franc
CO2	Carbon Dioxide
CSR	Corporate Social Responsibility
e.g.	Exempli gratia
ed.	Edition
Ed.	Editor
Eds.	Editors
EKM	Environmental Knowledge Management
EMAS	Eco-Management and Audit Scheme
EOG	European Outdoor Group
et al.	Et alii
etc.	Et cetera
EUR	Euro
FSC	Forrest Stewardship Council
GOLDEN	Global Organizational Learning and Development Network
GRI	Global Reporting Initiative
Hrsg.	Herausgeber
HSE&Q	Health, Safety, Environment & Quality

i.e.	Id est
ITEM	Institute of Technology Management, University of St. Gallen
KBV	Knowledge-Based View
KPI	Key Performance Indicator
LED	Light-Emitting Diode
m	Million
MNE	Multinational Enterprise
MSC	Marine Stewardship Council
NGO	Non-Governmental Organisation
p.	Page
PhD	Philosophiae Doctor
R&D	Research & Development
RBV	Resource-Based View
SME	Small- and Medium-Sized Enterprise
UN	United Nations
UNCED	United Nations Conference on Environment and Development
VRIN	Valuable, Rare, Inimitable and Non-substitutable
WBCSD	World Business Council for Sustainable Development
WWF	World Wildlife Fund

ABSTRACT

The sustainability challenge consists of various stakeholder pressures. For instance, firms need to cope with increasing public scrutiny and higher customer expectations regarding their approaches to sustainability. This challenge does not only represent a threat but also an opportunity as competitive advantages can be gained by successfully addressing it. By understanding these stakeholder pressures, firms are better able to make decisions, find suitable solutions and benefit from this opportunity. In order to be able to find these solutions, firms need knowledge. While the actual knowledge for sustainability at the project-level is critical, the evidence in this research suggests that firms need to go beyond that. On a higher level, firms need to manage, coordinate and adjust this knowledge in order to keep up with market change. This requires knowledge-related dynamic capabilities such as the knowledge management capacity which entails the internal and external dimensions of exploration, retention and exploitation. Academic research exists on the dynamic capability construct with a focus on knowledge management as well as on sustainability management. However, there is little understanding of knowledge-related dynamic capabilities in the context of the sustainability challenge which represents the research gap of this work.

It is the objective to theoretically and practically contribute to knowledge management for sustainability. In terms of theoretical implications, this research closes the identified gap by merging the knowledge-related dynamic capability construct with the sustainability challenge. Four case studies provide a new dataset and contribute to theory at the intercept of these two research streams. Based on the empirical evidence, research propositions are derived. These suggest, for instance, that external pressures dominate internal ones, that knowledge determines the ability to address the sustainability challenge, that a dynamic market undermines firms' prior knowledge, makes path-breaking activities more likely and knowledge exploration more important than exploitation and that the willingness to challenge established thinking prevents inertia. In terms of practical implications, this research suggests, for instance, that firms need to address knowledge exploitation and exploration in balance with the longer-term horizon in mind, that partnerships are critical to compensate for knowledge gaps, that dedicated sustainability teams are needed to assess opportunities, that the sustainability theme needs to be integrated in overall strategy to signal its importance, that workgroups which implement sustainability initiatives are held liable to ensure a sense of responsibility and that strong motivation for sustainability is indispensable for successful initiatives.

ZUSAMMENFASSUNG

Anspruchsgruppen stellen unterschiedliche Erwartungen daran, wie Firmen mit Nachhaltigkeitsthemen umgehen. Beispielsweise sind öffentliche Aufmerksamkeit und Kundenerwartungen in Bezug auf Nachhaltigkeit gestiegen, was nicht nur eine Bedrohung sondern auch eine Chance darstellt. Wenn Firmen diese Erwartungen erkennen und verstehen, können sie entsprechende Entscheidungen treffen, passende Lösungen finden und Wettbewerbsvorteile generieren. Um solche Lösungen zu finden, braucht es fundiertes Wissen zu Nachhaltigkeit. Die vorliegende Arbeit zeigt, dass dieses über das konkrete Wissen auf Projektebene hinausgehen muss. Auf einer übergeordneten Ebene müssen Firmen ihr Wissen zu Nachhaltigkeit verwalten und koordinieren, um sich an dynamische Marktbedingungen anzupassen. Hierfür werden dynamische Fähigkeiten wie das Wissensmanagement benötigt, welches sich intensiv mit den internen und externen Dimensionen der Exploration, Retention und Exploitation auseinandersetzt. Zwar existieren Studien über die Forschungsströme der wissensbasierten dynamischen Fähigkeiten sowie des Nachhaltigkeitsmanagements, doch das Verständnis von wissensbasierten dynamischen Fähigkeiten im Kontext von Nachhaltigkeit ist kaum vorhanden, was die Forschungslücke dieser Arbeit darstellt.

Ziel der Arbeit ist es, einen Beitrag zur akademischen und praktischen Diskussion über Wissensmanagement für Nachhaltigkeit zu leisten. Theoretische Implikationen beinhalten das Füllen der Forschungslücke durch das Verbinden der genannten Forschungsströme. Anhand von vier Fallbeispielen werden neue Daten generiert und basierend auf den empirischen Erkenntnissen Propositionen abgeleitet. Diese zeigen, dass externer Druck stärker als interner ist, dass die Fähigkeit im Umgang mit Herausforderungen durch Wissen geprägt ist, dass ein dynamischer Markt die Bedeutung von historischem Wissen untergräbt und Exploration forciert und dass organisationale Trägheit durch die Bereitschaft bestehende Denkmuster zu hinterfragen verhindert wird. Praktische Implikationen zeigen, dass Firmen die Balance zwischen Exploration und Exploitation wahren müssen, um längerfristig gerüstet zu sein. Darüber hinaus sind Partnerschaften wichtig, um Wissenslücken zu füllen und fokussierte Nachhaltigkeitsteams nötig für das Abwägen von Chancen. Zudem müssen Projektteams für die Umsetzung von Initiativen verantwortlich sein, um die für die Zielerreichung nötige Eigenverantwortung sicherzustellen. Des Weiteren muss Nachhaltigkeit tief in der Strategie verankert sein, damit sie als integraler Bestandteil betrachtet wird und muss ein hoher Motivationsgrad für Nachhaltigkeit für die Umsetzung von Initiativen gegeben sein.

1 Introduction

The introduction is structured as follows:

- The theoretical relevance of this research is discussed indicating a growing research interest in sustainability management.
- The practical relevance is outlined which shows that practitioners can derive substantial competitive advantages by successfully addressing the sustainability challenge.
- The objectives of this research are discussed.
- Based on these objectives, the research questions are derived which provide guidance to the literature review and following chapters.
- The resource-based view (RBV) is introduced as the theoretical anchor of this research which is extended by the knowledge-based view (KPV) and the dynamic capabilities construct.
- To assist the reader, the structure of this work is outlined.

1.1 Theoretical relevance

The amount of academic work undertaken in the field of environmental sustainability has been increasing sharply, especially since the UN Conference on Environment and Development (UNCED) in Rio in 1992, also referred to as the Earth Summit. The series of UN Climate Change Conferences taking place annually - most recently in Durban at the end of 2011 - indicates that the sustainability theme is considered critical by various stakeholders and therefore relevant to academia. Linton et al. (2007) argue that sustainability is increasingly discussed by policy makers, the media as well as academics. The authors illustrate this trend with the steeply increasing number of publications on sustainability-related topics in academic journals.

Sustainability from a firm's perspective can be defined as "meeting the needs of a firm's direct and indirect stakeholders without compromising its ability to meet the needs of future stakeholders as well" (Dyllick and Hockerts, 2002: 131). Sustainability entails the three pillars of the triple bottom line, namely environmental, social and economic aspects (e.g. Dyllick and Hockerts, 2002; Elkington, 1998; Hart and Milstein, 2003). The importance of all three aspects of the triple bottom line for manufacturing firms is recognised. The focus of this research, however, lies on the ecological aspect while the economic aspect is assumed to be accounted for in any given activity that firms undertake. In line with the notion that all three aspects are integrated in the triple bottom line (e.g. Dyllick and Hockerts, 2002; Elkington, 1998; Hart and Milstein, 2003), the ecological aspect has an impact on the social aspect as well. For instance, successful measures to reduce emissions at a manufacturing site have a positive impact on the quality of life of the wider community in the neighbourhood. Vice versa, the social aspect (while it is regarded important in its own right) does only have a limited impact on the ecological aspect. Therefore, this research does not focus on the social aspect

explicitly but solely on the ecological aspect. The interrelations between the three pillars of the triple bottom line are not emphasised in this research. Therefore, whenever "sustainability" is mentioned here, it refers to the ecological aspect of sustainability. The World Business Council for Sustainable Development (WBCSD) defines ecological sustainability as "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity" (WBCSD, 2008: 15).

As mentioned above, the environmental aspect of sustainability has increasingly gained attention in the academic community (Linton et al., 2007). For instance, these research activities focus on concepts such as eco-efficiency (e.g. Rashid and Evans, 2009; Rashid et al., 2008) and eco-effectiveness (e.g. McDonough and Braungart, 1998; Young and Tilley, 2006), management tools such as the balanced scorecard (e.g. Figge et al., 2002) and lean management (e.g. Johannson and Winroth, 2009) as well as factors that pressurise firms to engage in ecological sustainability (e.g. Bansal and Roth, 2000; Delmas and Toffel, 2004; Etzion, 2007).

Manufacturing firms increasingly encounter a number of pressures which force them to address environmental issues through various initiatives and the required building of knowledge. These pressures originate from different stakeholder groups. For instance, customers are widely regarded as demanding stakeholders because they can respond negatively if their expectations are not met (e.g. Delmas and Toffel, 2004; Elkington, 1998; Khanna and Anton, 2002; Rivera-Camino, 2007). Further, values and norms held in society often expressed through powerful interest groups are regarded critical (e.g. Eesley and Lennox, 2006; Etzion, 2007; Wade-Benzoni et al., 2002; Wheeler et al., 2003). Due to their often substantial public support and aggressive communication methods, non-governmental organisations (NGO) can cause significant pressure on firms to engage in sustainability (e.g. Eesley and Lennox, 2006; Etzion, 2007). Environmental regulation can impose pressures as it prescribes the legal framework which firms have to comply with unless they are prepared to risk repercussions (e.g. Banerjee, 2001; Carroll, 1999; Delmas and Toffel, 2004, 2008). Shareholders as the owners of listed firms can demand sustainability initiatives as a risk-management measure to avoid reputational damage (e.g. Rivera-Camino, 2007). Competitors can force firms to engage in sustainability indirectly in that their approaches to sustainability may be perceived superior by customers (e.g. Etzion, 2007; Rivera-Camino, 2007). Working with suppliers which focus on sustainability can also push firms' own sustainability initiatives because a more sustainable supply chain motivates others to engage in sustainability (e.g. Linton et al., 2007; Rivera-Camino, 2007). The entirety of these pressures is referred to as the "sustainability challenge" throughout this research.

While the mentioned pressures of the sustainability challenge can be a potential threat, they mainly represent an opportunity as addressing sustainability successfully can be a source of competitive advantage (López-Gamero et al., 2009; Russo and Fouts, 1997). In order for firms to be able to capture this opportunity, the different pressures of the sustainability challenge need to be understood well (Berry and Rondinelli, 1998; Hoffman and Ventresca, 2002). These pressures have been widely discussed (e.g. Bansal and Roth, 2000, Etzion, 2007, Rivera-Camino, 2006). Especially exogenous pressures have received attention, in particular, environmental regulation and customer expectations (e.g. Delmas and Toffel, 2004; Etzion, 2007).

With heightened awareness and a deeper understanding of these exogenous stakeholder pressures and their underlying dynamics, firms are better equipped to make strategic decisions and to benefit from this opportunity. However, it is not enough to examine these external stakeholder pressures because firms also need to identify and examine capabilities that are required in order to address these stakeholder pressures (Kusyk and Lozano, 2007). Given the highly dynamic market context caused by the sustainability challenge, it is useful to examine the construct of dynamic capabilities (e.g. Eisenhardt and Martin, 2000; Teece et al., 1997). For instance, Eisenhardt and Martin (2000) define dynamic capabilities as "the firm's processes that use resources - specifically the processes to integrate, reconfigure, gain and release resources - to match and even create market change" (p. 1107). This suggests that dynamic capabilities support managers to adjust their resources according to arising challenges which allows them to maintain and build competitive advantage (Eisenhardt and Martin, 2000; Grant, 1996; Henderson and Cockburn, 1994; Pisano, 1994; Teece, 2007). However, even though manufacturing firms have increasingly been exposed to the sustainability challenge which makes the use of suitable dynamic capabilities even more relevant, the discussion of dynamic capabilities in the sustainability context is missing in the literature. Plenty of research has independently been done on the stakeholder pressures in the context of the sustainability challenge (e.g. Bansal and Roth, 2000; Delmas and Toffel, 2004, 2008; Etzion, 2007, Rivera-Camino, 2007; Wade-Benzoni, 2002; Wheeler et al., 2003) and on dynamic capabilities (e.g. Eisenhardt and Martin, 2000; Fredrickson, 1984; Helfat, 1997; Henderson and Cockburn, 1994; Teece et al., 1997; Winter, 2003), but there is little understanding on the links between these two research streams.

Knowledge management is considered an indispensable dynamic capability (e.g. Eisenhardt and Martin, 2000; Lichtenthaler and Lichtenthaler, 2009). This is particularly relevant in the context of the sustainability challenge because market dynamics caused by stakeholder pressures require managers to be responsive and to come up with new ideas in order to solve an arising problem (Reinhardt, 1998; Sharma and Vredenburg, 1998). Management needs to accumulate relevant knowledge in order to be able to create

competitive advantage (Barney et al., 1984; Nickerson and Zenger, 2004; Rumelt, 1984; Teece et al., 1997) because this defines a firm's ability to turn inputs into outputs (Nelson and Winter, 1982; Nickerson and Zenger, 2004). Teece (1998) notes that a firm's ability to create, transfer, assemble, integrate and exploit knowledge assets is critical in order to maintain and build competitive advantage which puts dynamic capabilities into the context of knowledge management. Along this line of thinking, Lichtenthaler and Lichtenthaler (2009) suggest that knowledge management includes various aspects because knowledge not only has to be created but also stored and transferred to where it is needed as well as applied intelligently.

Depending on the context a firm finds itself in, prior knowledge as discussed in the literature on dynamic capabilities and knowledge management can help the firm in mastering the challenge it faces at present (e.g. Lichtenthaler and Lichtenthaler, 2009; Teece et al., 1997). However, there are instances in which firms cannot rely on prior knowledge but need to build knowledge which they have not owned in the past and which might not be related to prior knowledge. In a market context characterised by rapid change (e.g. Argote, 1999; King and Tucci, 2002; Rindova and Kotha, 2001; Santos and Eisenhardt, 2005; Teece, 2007; Zott, 2003) as it is the case with the sustainability challenge, it is necessary to catch up and acquire or access the required knowledge with the help of rapid learning (Eisenhardt and Martin, 2000) and partnerships (Grant and Baden-Fuller, 2004; Henderson and Cockburn, 1994).

1.2 Practical relevance

Sustainability is not an academic issue exclusively. For instance, Linton et al. (2007) argue that sustainability is also increasingly discussed by practitioners. Next to typical challenges that manufacturing firms face - such as competition and cost pressures - the sustainability challenge has emerged as a key item on the management agenda. Today, firms are frequently exposed to stakeholder expectations and somehow need to generate knowledge and find solutions to address this challenge in order to ensure future competitive advantage.

It is widely believed that sustainability will continue to create significant opportunities. With the wider public becoming increasingly aware of sustainability and various related issues (such as climate change or the finiteness of non-renewable resources) and more willing to act, manufacturing firms are confronted with drastic changes. A global survey conducted by the WBCSD in 2008 shows that consumers' awareness of sustainability and their willingness to act have been rising significantly over the last few years. For instance, the share of consumers expecting firms to commit to recycling, green products and climate change has been increasing from already high numbers by a further 7%, 13% and 21%, respectively, between 2007 and 2008 alone (WBCSD, 2008). This trend is

expected to continue as the results of the survey conducted among manufacturing firms in the course of this research show.[1] Figure 1, for instance, illustrates that surveyed firms expect customers' willingness to pay a premium for sustainable products to increase over the next few years.

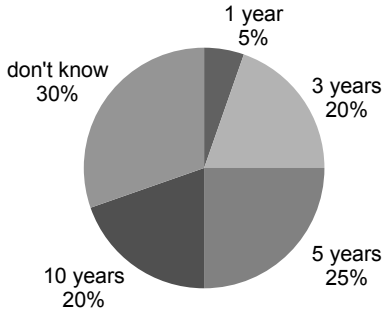

Figure 1: Expected customers' willingness to pay a premium for sustainable products

Along these lines, Figure 2 shows that surveyed firms clearly expect their spending on sustainability initiatives to grow over the next few years.

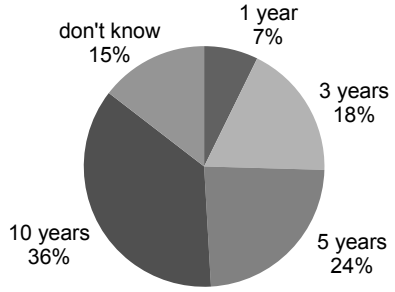

Figure 2: Expected spending on sustainability initiatives

Overall, the aspects discussed below are particularly relevant to practitioners.

1.2.1 Gaining awareness and understanding of the sustainability challenge

Some firms have begun to integrate sustainability issues into overall strategy (e.g. Etzion, 2007; Schaltegger and Burritt, 2000). Others still appear to be ignorant as regards sustainability considerations, be it knowingly or unintentionally (e.g. Schaltegger and Burritt, 2000). Crucial pre-conditions in order for firms to become more sustainable appear to be a general awareness of the importance of the sustainability theme, a thorough understanding of the sustainability challenge as well as related pressures and potential opportunities to create competitive advantage. If awareness and understating are in place, firms are better able to detect opportunities in the context of the

[1] N = 56; This is discussed in more detail in the chapter on research design.

sustainability challenge. Firms need this information before they can define their sustainability strategy including the overall goals, which challenges to address and how to address them.

1.2.2 Managing the body of knowledge

The sustainability challenge makes disciplined knowledge management necessary (e.g. Huang and Shih, 2009; Melville, 2010). If the awareness of sustainability and understanding of arising challenges are in place as discussed above, firms are better positioned to manage their body of knowledge in order to be able to find solutions to these challenges. To ensure a suitable body of knowledge for a given context, the balance between creating new knowledge and using existing knowledge is critical (e.g. March, 1991). Otherwise the firm cannot reap the full potential of knowledge and wastes resources, for instance, by creating knowledge that gets lost or is never used. If a firm is primarily concerned with knowledge creation or application and neglects the other, it will be difficult to find solutions to challenges in the long-term and create sustained competitive advantage (March, 1991). Since firms do not always possess the required knowledge internally, the acquisition of knowledge from and knowledge sharing with external parties is essential (e.g. Grant and Baden-Fuller, 2004; Henderson and Cockburn, 1994).

1.2.3 Keeping track with competition

Firms are exposed to various stakeholders who are becoming more environmentally conscious and hence more demanding as regards firms' sustainability practices (e.g. Etzion, 2007; Rivera-Camino, 2007; Wade-Benzoni et al., 2002; Wheeler et al., 2003). Firms need to address these demands which represent not only risks but also opportunities. By being able to take sustainability more seriously and to respond to demands from customers, for instance, firms can differentiate themselves (e.g. Rivera-Camino, 2007). Conversely, by ignoring these demands, firms can create considerable downside risks. In some instances, it might prove beneficial for firms to engage in self-regulation (also known as self-policing) which means that they attempt to go beyond regulatory requirements and act proactively rather than reactively (e.g. Delmas and Toffel, 2004, 2008; Ramanathan et al., 2009). Overall, firms can differentiate themselves by addressing sustainability in more credible and convincing ways compared to their competitors.

1.2.4 Saving costs

Addressing sustainability issues can have a cost-reducing effect (e.g. Kemp and Andersen, 2004; Rashid and Evans, 2009; Rashid et al., 2008). In most cases,

sustainability is practiced with a "win-win" result in mind in the form of cost savings coupled with positive environmental impact. Along this line of thinking, the concept of eco-efficiency is often mentioned which not only helps firms to lift resource productivity and thereby save costs but also reduce the environmental impact per unit produced (DeSimone and Popoff, 2000; Kemp and Andersen, 2004). For instance, more efficient manufacturing processes can help firms to reduce energy and material input as well as waste and emissions. The evidence in the case studies discussed later suggests that the ecological aspect (with economic considerations included by definition) has priority in terms of undertaken efforts and committed resources. While sample firms thoroughly address social aspects as well, the potential of ecological sustainability to help them reduce environmental impact on the one hand and costs on the other hand is unparalleled. This means that from the sample firms' perspective the economic aspect of the triple bottom line is anchored more deeply in the ecological than the social aspect. This makes it considerably more practicable for firms to engage in sustainability initiatives and justify these in the context of significant cost pressures.

1.3 Objectives of this research

Following the topics discussed above, this research has a number of specific objectives. First, this research seeks to shed more light into the pressures which exist in the context of the sustainability challenge. Stakeholders have various expectations and firms need to decide how they intend to address these. Certain knowledge-related abilities are examined which help firms to identify and understand these pressures in order to get a clearer picture of what the sustainability challenge means to them specifically. Thorough understanding of the sustainability challenge is necessary before firms can address its threats and benefit from its opportunities by creating the required knowledge.

Second, this research seeks to examine the meaning of knowledge in the context of the sustainability challenge. In order to gain understanding of the role knowledge plays in sustainability management, various aspects need to be analysed. This includes the need for specific knowledge types caused by various pressures, the decision which knowledge to build, where to find it, how to acquire or access it and how to coordinate and manage the body of knowledge. Knowledge is particularly important since firms require it in order to find solutions to specific problems.

Third, this research aims to identify critical abilities that firms need in order to be able to manage knowledge successfully. This includes not only the generation of knowledge but also its transfer (to where it is needed), its storage (to avoid loss of knowledge) as well as its application. Knowledge is critical at any point in time but the importance and usefulness of specific types and pieces of knowledge change over time. This is because circumstances in firms' market contexts change and with it the pressures which make it

indispensable that their body of knowledge is constantly updated. This requires specific abilities.

Overall, this research not only aims to contribute to the academic debate but also to assist practitioners in dealing with the sustainability challenge. First, practical implications will be based on the identification of success factors in knowledge management for sustainability. More specifically, it will be about how firms detect the pressures of the sustainability challenge, how they address them and how they manage knowledge. This is meant to build understanding among practitioners about how to build and manage the knowledge that is required to address the sustainability challenge. Second, theoretical implications will be based on several propositions that will be derived. These propositions will be based upon the findings in this research related to the issues that have been discussed above and are meant to contribute to the academic debate and highlight possible directions for further research.

Therefore, this research relates to manufacturing firms which understand the potential of the sustainability theme to build competitive advantage and which address sustainability successfully. It is the overriding objective of this research to analyse these firms in order to derive successful approaches to knowledge-related sustainability management.

1.4 Research questions

Based on the objectives discussed above, the main research question can be derived:

Which knowledge management aspects do firms need in order to address the sustainability challenge?

In order to answer the main research question, the following sub-questions need to be addressed:

Sub-question 1: Which knowledge-related abilities are perceived to be important in order to detect opportunities to build knowledge?
Sub-question 2: Which types of knowledge are perceived to be important in order to address the sustainability challenge?
Sub-question 3: Which knowledge-related abilities are perceived to be important in order to build, retain and apply knowledge continuously?

To ensure consistency across this work, the literature review and following chapters are guided by these research questions.

1.5 Theoretical anchor

The resource-based view (RBV) (e.g. Barney, 1991; Conner, 1991; Wernerfelt, 1984) represents the theoretical anchor of this research. This is because resources of different types are always needed in order for firms to generate competitive advantage and ultimately performance. However, two extensions to the RBV are needed for the purpose of this research. First, the extension from the generic RBV to the specific knowledge-based view (KBV) is necessary because this research focuses on knowledge management for sustainability. While the RBV generically recognises knowledge as one of a number of resources, the KBV puts explicit emphasis on knowledge as the most important resource. Second, the extension from the relatively static RBV to the dynamic capabilities construct is required in this research. The dynamic capabilities construct takes into account pressures that can arise in a highly dynamic market context as it is the case with the sustainability challenge.

Early works by Penrose (1959) and Demsetz (1973), for instance, laid the cornerstones of a resource-based perspective in strategic management. These authors argue that a firm consists of bundles of resources and that firm performance is a function of the quality of these resources and how well they are used relative to competitors. This research field has eventually been referred to as the RBV by Wernerfelt (1984) and developed further by Barney (1991) and Conner (1991), for instance. Barney (1991) built on these previous contributions to widely establish the RBV as a prominent research field within the academic community. Since these early works, the RBV has significantly influenced the research on strategic management (Coates and Mcdermott, 2002) and provided the groundwork for other constructs. In a nutshell, the RBV argues that firm-specific capabilities and assets as well as the existence of isolating mechanisms determine a firm's performance (Teece et al., 1997). On the basis of resources, the RBV contributes to the understanding of why some strategies help firms to build competitive advantage while others do not (Coates and Mcdermott, 2002). In other words, the RBV supports understanding of how a firm can generate sustained above-average performance by putting resources at the core of strategic development (Barney et al., 2001). Wernerfelt (1984) notes that firms in the same industry facing similar market conditions can display different resource constellations. This means that their competitive advantage is not primarily determined by the conditions in their industry or their market positioning but rather by their specific resource constellations (Wernerfelt, 1984). Helfat and Peteraf (2003: 999), for instance, define resources as "an asset or input to production that an organisation owns, controls or has access to on a semi-permanent basis". For example,

resources include machinery equipment, brand names, technological knowledge, qualified employees, financial capital and others. These resources need to meet the VRIN-criteria - i.e. they need to be valuable, rare, inimitable and non-substitutable (Barney, 1991) - in order for firms to be able to build competitive advantage (e.g. Conner and Prahalad, 1996; Peteraf, 1993; Wernerfelt, 1984). Müller-Stewens and Lechner (2001) distinguish between tangible and intangible resources. Examples for the former include a firm's machinery equipment and manufacturing sites. Examples for the latter include specific knowledge and patents. Barney (2001) argues that firms which build their strategies on complex and intangible resources usually outperform firms which emphasise less complex and tangible resources. Similarly, Ray et al. (2003) argue that intangible resources are more relevant for competitive advantage since these are harder to imitate.

Along this line of thinking, an insightful extension to the RBV exists, which builds upon the works of Barney (1991), Conner (1991), Wernerfelt (1984) and others. The knowledge-based view (KBV) of the firm is specifically concerned with these intangible knowledge-related resources (e.g. Grant, 1996; Nickerson and Zenger, 2004; Santos and Eisenhardt, 2005). While the RBV considers resources in general to be strategically relevant for the generation of competitive advantage (Barney, 1991; Wernerfelt, 1984), the KBV focuses on knowledge as the most relevant resource (Barney, 2001; Ray et al., 2003). Although the RBV recognises knowledge as an essential resource that helps firms to generate competitive advantage (e.g. Barney, 1991; Wernerfelt, 1984), it captures the importance of knowledge insufficiently (e.g. Spender, 1996). More specifically, knowledge is assumed to be a generic resource without any special characteristics such as whether it is explicit or tacit, for instance (e.g. Foss et al., 2010; Kale and Singh, 2007; Smith et al., 2005). However, the difference between explicit and tacit knowledge has important implications on how knowledge-related resources can be managed. On the one hand, explicit knowledge is highly codified, can be translated and therefore be easily shared among individuals (Cowan et al., 2000; Hansen, 1999; Kogut and Zander, 1992; Nonaka, 1994). On the other hand, tacit knowledge is highly personal and therefore properly understood only by the individual or teams owning that information which makes it hard to convey and share (Cowan et al., 2000; Hansen, 1999; Kale and Singh, 2007; Kogut and Zander, 1992; Nonaka, 1994; Smith et al., 2005). Similar to the assumption in the RBV that resources need to meet the VRIN-criteria in order to contribute to sustained competitive advantage (Barney, 1991; Dierickx and Cool, 1989; Lippman and Rumelt, 1982), knowledge-related resources in the KBV are assumed to be heterogeneous among firms, difficult to imitate and socially complex (e.g. Spender, 1996). Knowledge-related resources are highly relevant to the solution of a given task and therefore help firms to perform better in managing that task (Kale and Singh, 2007).

However, neither the RBV focusing on resources generically, nor the KBV focusing on knowledge-related resources specifically take into account how competitive advantage can be generated in a highly dynamic market context (e.g. Eisenhardt and Martin, 2000; Katkalo et al., 2010; Priem and Butler; 2001; Teece et al., 1997). Under these circumstances, the possession of resources meeting the VRIN-criteria is insufficient to generate sustained competitive advantage (e.g. Eisenhardt and Martin, 2000). To overcome this shortcoming, various authors have proposed dynamic capabilities as an extension to the RBV (e.g. Eisenhardt and Martin, 2000; King and Tucci, 2002; Rindova and Kotha, 2001; Teece and Pisano, 1994; Teece et al., 1997; Teece, 2007; Winter, 2003; Zollo and Winter, 2002; Zott, 2003). For instance, Teece et al. (1997) argue that in order for firms to be successful in a market context characterised by fast-paced change, they should not only rely on their static stock of resources that has been accumulated over time but also think about how they can adjust these resources to address arising challenges. Since the dynamic capabilities construct is a critical research stream in this work, it will be thoroughly discussed in the literature review.

The rationale for using the RBV as the theoretical anchor of this research and extending it is twofold. First, the extension from the generic RBV to the specific KBV is necessary because this research focuses on knowledge management for sustainability. While the RBV generically recognises knowledge as one of a number of resources, the KBV puts explicit emphasis on knowledge as the most important resource. Second, the extension from the relatively static RBV to the dynamic capabilities construct is required in this research. The dynamic capabilities construct takes into account pressures that can arise in a highly dynamic market context as it is the case with the sustainability challenge.

1.6 Structure of this work

This work is structured as follows:

Chapter 1: Introduction	Chapter 1 provides an introductory overview of the theoretical and practical relevance and discusses the objectives of this research. Based on this, research questions are derived. Further, the chapter introduces the theoretical anchor.
Chapter 2: State of the art in the literature	Chapter 2 reviews the relevant literature for this research. Starting from the RBV and the KBV, dynamic capabilities are addressed with a special emphasis on knowledge management. A conceptual model is discussed in detail which provides insights into knowledge management including the dimensions of knowledge exploration, retention and exploitation.
Chapter 3: Research design	Chapter 3 deals with the derivation of the research gap upon which the research model is introduced. Further, the methodological approach is discussed including data source, data generation and data analysis.

Chapter 4: Case studies	Chapter 4 features four case studies: CHEMICAL LTD, RETAIL LTD, OUTDOOR LTD and CAR LTD. These case studies focus on firms' market contexts and approaches to knowledge management including the detection of opportunities, decision-making, knowledge acquisition and sharing, partnerships and other relevant aspects.
Chapter 5: Cross-case analysis and discussion	Chapter 5 synthesises the relevant literature and the findings in the case studies. This is structured along the three sub-questions with a special focus on the detection of opportunities to build sustainability knowledge, knowledge types and continuous knowledge management. Important aspects which are related to these focus areas are addressed as well. Based on these findings, the sub-questions and the main research question are answered. Finally, success factors are identified and research propositions derived.
Chapter 6: Conclusion	Chapter 6 is dedicated to the theoretical and practical implications as well as limitations and concludes with suggestions for further research.

Table 1: Chapter overview

2 State of the art in the literature

It is the goal of this chapter to review the relevant literature in line with the discussed research questions in order to build the theoretical foundation for this research. The chapter is structured as follows:

- Building upon the RBV and the KBV, dynamic capabilities are introduced as an extension.
- Various related constructs such as resources, routines and capabilities are discussed.
- Most frequently cited articles on dynamic capabilities are examined.
- These articles' definitions and views on path-dependencies and communalities are compared.
- Based upon this comparison, the understanding of dynamic capabilities in this research is discussed.
- Limitations of the dynamic capability construct are examined to improve understanding and to obtain a realistic view on the construct's applicability.
- Concrete examples of dynamic capabilities are discussed with a special emphasis on knowledge management.
- Knowledge management in high-velocity markets is discussed in detail with a focus on the knowledge management capacity and related six knowledge capacities along the internal and external dimensions of exploration, retention and exploitation.
- The findings of the literature review on dynamic capabilities are put into the context of the sustainability challenge.

2.1 Dynamic capabilities as an extension to the RBV

As discussed in the introduction, the RBV constitutes the theoretical anchor of this research. Following this view, firms require resources which are valuable, rare, inimitable and non-substitutable (VRIN) (Barney, 1991). The possession of resources which meet these criteria helps firms to maintain their competitive advantage (e.g. Conner and Prahalad, 1996; Peteraf, 1993; Wernerfelt, 1984). As an extension to the RBV, the KBV is primarily concerned with knowledge-related resources which help firms to generate competitive advantage (e.g. Barney, 1991; Grant, 1996; Nickerson and Zenger, 2004; Santos and Eisenhardt, 2005). While the RBV (and the KBV) represent an influential and widely used framework for understanding how firms generate competitive advantage with the help of resources (Peng et al., 2008), some drawbacks have become apparent (e.g. Eisenhardt and Martin, 2000; Teece et al., 1997). One of the main shortcomings is the rather static understanding of a firm's market context which is why an extension is needed that takes into account potential dynamics arising in markets today (e.g. Eisenhardt and Martin, 2000; King and Tucci, 2002; Rindova and Kotha, 2001; Teece and Pisano, 1994; Teece et al., 1997; Teece, 2007; Winter, 2003, Zollo and Winter, 2002; Zott, 2003). This extension is meant to build upon and enhance the RBV. For instance, such dynamics can be caused by the sustainability challenge (i.e. stakeholder pressure such as environmental regulation or customer expectations) and the

pressure it exerts on firms. These dynamics can be a threat but also a significant opportunity if the firm is well-prepared to deal with such challenges. Teece et al. (1997) argue that changing environments require firms to exploit their internal and external competences and resources. They argue further, that successful firms tend to be able to respond to environmental changes in a timely manner. Rather than focusing primarily on the often static stock of resources that has been accumulated over time - as in the case of the RBV - firms should think about how they can adjust these resources to address changing business contexts. Along these lines, Teece (2007) proposes that firms operating in highly dynamic and competitive environments which are characterised by geographically and organisationally dispersed sources of innovation and manufacturing need to think beyond the mere ownership of assets (as suggested by the RBV), especially knowledge assets. In order to generate sustained advantage, firms need to continuously generate, extend, protect their assets and capabilities and ensure their relevance to the problem at hand (Teece, 2007). Similarly, Eisenhardt and Martin (2000) argue that the RBV breaks down in highly dynamic environments, which they refer to as "high-velocity markets". Such markets are characterised by an unpredictable duration of a firm's current competitive advantage and therefore by the challenge to maintain that advantage as well as by rapid strategic evolution. They note further "that the RBV has not adequately explained how and why certain firms have competitive advantage in situations of rapid and unpredictable change" (p. 1106).

In order to obtain a useful extension to the RBV that compensates for these shortcomings, Teece et al. (1997) emphasise two key aspects that have not been fully taken into account. On the one hand, the term "dynamic" highlights a firm's capacity to align its activities with a rapidly changing market context. On the other hand, the term "capability" refers to the role of strategic management in "appropriately adapting, integrating and reconfiguring internal and external organisational skills, resources and functional competences to match the requirements of a changing environment" (Teece et al., 1997: 514). Zollo and Winter (2002) argue that in such a dynamic context which is characterised by rapidly changing technological, regulatory and competitive conditions, persistence in the same operating routines may become a threat. For that reason, they argue, systematic change efforts are necessary to keep up with changes in the firm's environment. Along these lines, King and Tucci (2002) highlight the role experience plays in helping firms to adapt to changes in the business context. To gain clarity, they differentiate between static and transformational experience. The former is generated by continuously and incrementally developing existing structures, positions and strategies. This can lead to habitual routines and inertia which impede adaption to change (Gersick, 1989; King and Tucci, 2002). The latter helps to prevent inertia by developing more dynamic routines that help firms deal with shifts in their market context. Katkalo et al.

(2010) and Romme et al. (2010) highlight the importance to distinguish between the static view of resource stocks upon which the RBV focuses and the more dynamic view of the resource flow. This view of the resource flow takes into account the actual implementation of such resources (Kraaijenbrink et al., 2010) which can also be referred to as the processes in the usage of these resources (Dosi et al., 2008). In other words, firms may well be able to accumulate large resource stocks (possibly much larger than the ones of their competitors) but, nevertheless, are unable to deploy these valuable assets (Teece et al., 1997).

With regard to the notion of path-dependency promoted by the RBV, Teece (2007) argues that when putting capabilities into a more dynamic context, firms are not necessarily trapped by their past (technological) development trajectory. Even though firms might be shaped by the past to a certain degree, management can make decisions on investments and other themes in order to alter that path in a desired way. This flexibility enables firms to respond to arising dynamics in their market context.

2.2 Structuring dynamic capabilities and their components

It is worth noting that the understanding of what dynamic capabilities, their antecedents, components and related concepts exactly are (such as routines (assets), resources and capacities), diverges considerably among relevant publications (e.g. Kay, 2010; Peng et al., 2008; Thomas and Pollock, 1999; Wang and Ahmed, 2007). Therefore, in order to advance the understanding of dynamic capabilities, it is worthwhile to examine the underlying and related concepts and assess how they fit in and how components are causally linked. In addition, it is useful to put these concepts and the notion of dynamic capabilities into a structure that helps to sharpen the accuracy and rigor of this analysis. Two recent publications in particular have improved understanding and structure of these concepts, namely Peng et al. (2008) as well as Wang and Ahmed (2007).

Peng et al. (2008), for instance, provide a comprehensive framework that assesses the underlying components of capabilities (also referred to as competences) and dynamic capabilities and links them together. These components include resources (assets) as well as operating and search routines. The framework including derived definitions is illustrated in Figure 3 below:

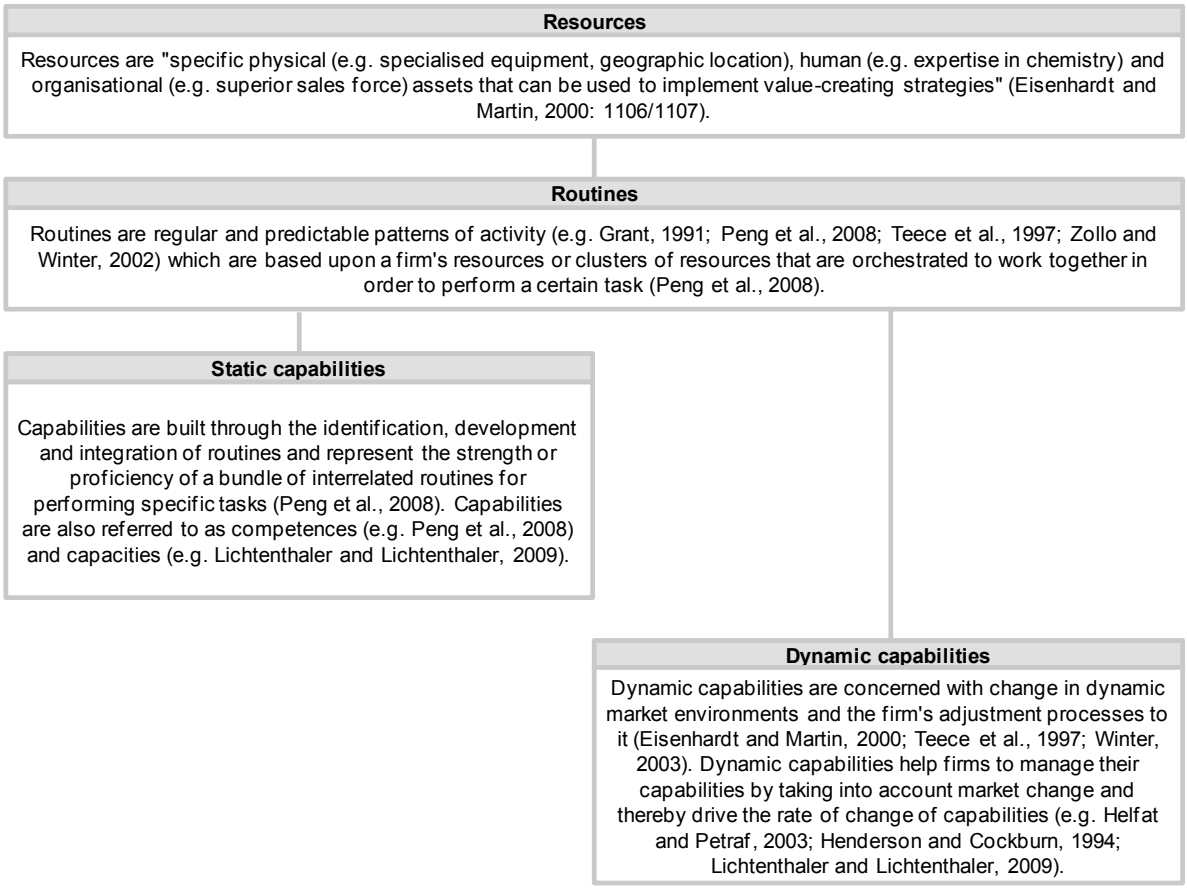

Figure 3: Framework of resources, routines, static capabilities and dynamic capabilities

First, the framework shows resources as the lowest order construct. Amit and Schoemaker (1993) define resources as "stocks of available factors that are owned by the firm" (p. 35). This is in line with a more detailed definition of a resource as "an asset or input to production (tangible and intangible) that an organisation owns, controls or has access to on a semi-permanent basis" (Helfat and Peteraf, 2003: 999). With a focus on which form resources can take, Capron and Hulland (1999) define resources as "stocks of knowledge, physical assets, human capital and other tangible and intangible factors" (p. 42). Even more specifically, Eisenhardt and Martin (2000) note that resources are "specific physical (e.g. specialised equipment, geographic location), human (e.g. expertise in chemistry) and organisational (e.g. superior sales force) assets that can be used to implement value-creating strategies" (p. 1106/1107). With a focus on the VRIN-criteria of the RBV (e.g. Barney, 1991; Eisenhardt and Martin, 2000; Wernerfelt, 1984), Teece et al. (1997) define resources as "firm-specific assets that are difficult if not impossible to imitate" (p. 516) such as trade secrets or specialised production facilities and experiences, for instance. Overall, these definitions suggest that resources represent tangible and intangible assets or stocks of assets that firms possess which are required and used to perform certain tasks.

Second, the framework illustrates routines as a component of the next order construct.

By referring to Grant (1991), Peng et al. (2008) define routines as "regular and predictable patterns of activity which are made up of a sequence of coordinated actions by individuals" (p. 731). Such regularly applied routines are based upon a firm's resources or clusters of resources that are orchestrated to work together in order to perform a certain task (Peng et al., 2008). More specifically, Teece et al. (1997) refer to organisational routines when firm-specific assets are integrated in clusters spanning individuals and groups in such a way that allows the firm to perform distinctive activities. Therefore, routines can be regarded as the way tasks are performed or as patterns of activities (Peng et al., 2008; Teece et al., 1997). Teece et al. (1997) suggest further that routines reflect how a firm performs certain tasks (i.e. the practices it uses). However, it is not only about the completion of a given task but also about the lessons learned from working on the task (Peng et al., 2008; Teece et al., 1997). This is in line with Winter (2003) who notes that routines are learned behaviours which are repetitive or "quasi repetitive" and are applied to meet a specifically defined objective. Compared to resources, Peng et al. (2008) regard routines embedded in the regular interaction of various knowledge sources, more firm-specific and less transferable which makes them more relevant for building competitive advantage.

Peng et al. (2008) propose to split routines into operating routines (e.g. Nelson and Winter, 1982; Zollo and Winter, 2002; Zott, 2003) and search routines (e.g. Collis, 1994; Nelson and Winter, 1982; Teece et al., 1997; Zollo and Winter, 2002). Operating routines represent the execution of certain procedures in order to generate revenue (Peng et al., 2008, Zollo and Winter, 2002). These are geared towards the operational functioning of the firm (Zollo and Winter, 2002). Search routines represent the execution of certain procedures that develop new routines or cause desired changes in the existing set of operating routines (Peng et al., 2008; Teece et al., 1997; Zollo and Winter, 2002).

Third, Peng et al. (2008) propose static capabilities as the next order construct in this framework. They refer to capabilities as "the strength or proficiency of a bundle of interrelated routines for performing specific tasks" (p. 734). Further, capabilities do not reside in routines but rather emerge from the interplay of various related routines (Peng et al., 2008). This suggests that capabilities are built though the identification, development and integration of routines (Peng et al., 2008). Capabilities are also referred to as competences (e.g. Peng et al., 2008) and capacities (e.g. Lichtenthaler and Lichtenthaler, 2009) and are created by operating routines (e.g. Collis, 1994; Eisenhardt and Martin, 2000; Lichtenthaler and Lichtenthaler, 2009; Nelson and Winter, 1982; Peng et al., 2008). Peng et al. (2008) refer to capabilities as a firm's competences. More specifically, Henderson and Cockburn (1994) note, for instance, that (component) competencies are capabilities in the form of required abilities and knowledge in order to solve day-to-day problems. Lichtenthaler and Lichtenthaler (2009) use the terms

capabilities and capacities interchangeably. With a focus on knowledge management, they refer to critical capabilities of managing internal and external knowledge as capacities. Winter (2003) regards a capability as a single high-level routine or collection of routines that provide firms with decision options to enhance overall success of an activity. Helfat and Peteraf (2003) add that capabilities which they refer to as operational capabilities represent the performance of an activity by applying a collection of routines in order to fulfil and coordinate all relevant tasks required to perform the activity. With a focus on the combination of a firm's resources and routines, capabilities also refer to a firm's ability to coordinate its routines and integrate its various sources of skills and resources (Peng et al., 2008; Prahalad and Hamel, 1990). In other words, a capability is the ability to perform a coordinated task by using the resources available to the firm (e.g. Helfat and Peteraf, 2003; Peng et al., 2008) in an integrated manner (Hoskisson et al., 2004; Peng et al., 2008).

Fourth, the framework appears to propose dynamic capabilities as a construct of the same or similar order as static capabilities in that the former are created through search routines while the latter are created through operating routines (Peng et al., 2008). This research, however, regards dynamic capabilities as the highest order construct in this framework. This is because dynamic capabilities - compared to their static counterpart - are concerned with change in dynamic market contexts and the firm's adjustment processes to it (Eisenhardt and Martin, 2000; Teece et al., 1997; Winter, 2003). Along this line of thinking, dynamic capabilities help firms to manage (i.e. to develop, adjust, integrate and use) their capabilities by taking into account market change (e.g. Helfat and Petraf, 2003; Henderson and Cockburn, 1994; Lichtenthaler and Lichtenthaler, 2009). In other words, dynamic capabilities are believed to drive the rate of change of ordinary (static) capabilities (Collis, 1994; Winter, 2003). Similarly, Helfat and Peteraf (2003) argue that operational capabilities change through the action of dynamic capabilities. This also corresponds to what Lichtenthaler and Lichtenthaler (2009) propose. With a focus on knowledge management, they argue that capabilities (which they refer to as capacities) are managed, coordinated and deployed by dynamic capabilities. Along this line of thinking, Henderson and Cockburn (1994) propose that component competence, which is a capability in the form of abilities and knowledge that firms require for daily problem-solving, is integrated and used with the help of architectural competence which they refer to as a dynamic capability.

2.3 Definitions of dynamic capabilities

As discussed above, various authors have contributed to the discussion and promotion of dynamic capabilities. Di Stefano et al. (2010) examine the number of citations that articles on dynamic capabilities have received in business and management journals

prior to 2008. They refer to these articles as the "intellectual core of dynamic capabilities research" (p. 1190). They find that the five most frequently cited articles are the ones by Teece et al. (1997) in the Strategic Management Journal with 1'193 citations, by Eisenhardt and Martin (2000) in the Strategic Management Journal with 470 citations, by Zahra and George (2002) in the Academy of Management Review with 218 citations, by Zollo and Winter (2002) in Organization Science with 206 citations and by Amit and Zott (2001) in the Strategic Management Journal with 119 citations. The fact that these articles have all appeared in A-rated journals likely has contributed significantly to the citation frequency. Further, it is likely that older publications are cited more frequently as time progresses compared to later ones.

Source	Definition of dynamic capability	Citation count	Path dependencies	Communalities
Teece et al., Strategic Management Journal, 1997, 18(7), p. 516	The firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments	1'193	Are important since current domains of competence are a function of past decisions.	Rare or absent since competences can only generate competitive advantage if VRIN-criteria are met.
Eisenhardt and Martin, Strategic Management Journal, 2000, 21(11), p. 1107	The firm's processes that use resources - specifically the processes to integrate, reconfigure, gain and release resources - to match and even create market change.	470	Are not entirely set by past decisions but can also be adjusted by rapidly creating situation-specific new knowledge through fast learning mechanisms and practice.	Can exist since successful ways of problem-solving will likely be adopted by competitors over time.
Zahra and George, Academy of Management Review, 2002, 27(2), p. 186	(Absorptive capacity:) A set of organisational routines and processes by which firms acquire, assimilate, transform and exploit knowledge to produce a dynamic organisational capability.	218	Memory affects process by which firms interpret incoming information and act upon it which suggests existence of path dependency.	Not explicitly mentioned but focus on firms' absorptive capacity for new knowledge indicates that communalities are possible.
Zollo and Winter, Organization Science, 2002, 13(3), p. 340	A learned and stable pattern of collective activity through which the organisation systematically generates and modifies its operating routines in the pursuit of improved effectiveness.	202	Not explicitly mentioned but notion of high level of prior experience in heterogeneous contexts having positive impact on performance suggests some degree of path dependency.	Not explicitly mentioned but focus on deliberate learning through experience accumulation, knowledge articulation and knowledge codification suggests that they can arise over time.
Amit and Zott, Strategic Management Journal, 2001, 22(7)	No specific definition stated; Following Teece et al. (1997).	119	Not discussed.	Not discussed.

Table 2: Overview of most frequently cited articles on dynamic capabilities[2]

Among the five most often cited articles, three focus on dynamic capabilities as such on

[2] Citation count represents number of citations that articles on dynamic capabilities have received in business and management journals prior to 2008. Path dependencies mean that a firm's history shapes its future evolution. Teece et al. (1997) propose that "a firm's previous investments and its repertoire of routines constrain its future behavior" (p. 523). Communalities are similar characteristics of (dynamic) capabilities among firms. Teece et al. (1997) argue that these usually do not exist among firms in the context of competitive advantage.

a generic level and also propose a definition, namely Teece et al. (1997), Eisenhardt and Martin (2000) and Zollo and Winter (2002). The other two articles, however, examine dynamic capabilities with a specific focus. Zahra and George (2002) discuss dynamic capabilities in the context of absorptive capacity, in fact, they view absorptive capacity as a dynamic capability itself which is embedded in a firm's routines and processes for knowledge creation. Absorptive capacity as a dynamic capability pertains to knowledge creation and utilisation which supports firms in gaining competitive advantage (Zahra and George, 2002). Amit and Zott (2001) focus on how dynamic capabilities help firms in creating value with e-business. In line with Teece et al. (1997), they argue that such dynamic capabilities support firms in capturing Schumpeterian rents (Schumpeter, 1934). These are rents that firms can generate in the period from the introduction of an innovation until the imitation by competing firms (Amit and Zott, 2001). It is argued that virtual markets created by e-business cause new sources of value creation to arise since new complementarities among a firm's resources and dynamic capabilities can be exploited (Amit and Zott, 2001). Since this section is meant to address dynamic capabilities on a generic level rather than with a specific focus, emphasis is put on the three articles dealing with dynamic capabilities generically.

First, Teece et al. (1997) define dynamic capabilities as "the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments" (p. 516). Competences or routines are seen as activities that focus on assembling firm-specific assets "in integrated clusters spanning individuals and groups so that they enable distinctive activities to be performed" (Teece et al., 1997: 516). Firm-specific assets in turn are resources that are "difficult if not impossible to imitate" (Teece et al., 1997: 516). These are referred to as a firm's positions and include technological, complementary, financial, reputational, structural, institutional and market (structure) assets (Teece et al., 1997). Overall, this definition of dynamic capabilities focuses on a firm's effort and ability to continuously adjust, align, extend and thereby renew its competences in order to meet newly arising challenges in the firm's market context.

Teece et al. (1997) argue that path dependencies play an important role in that a firm's choices about domains of competence are a function of past choices. Firms follow a certain path of competence development and this path affects their stock of competences and their ability to perform certain activities not only in the present but also in the future (Teece et al., 1997). In other words, a firm's previous efforts and investments and resulting routines constrain future behaviour and use of opportunities since opportunities for learning likely are closely related to previous activities and are therefore context-specific (Teece et al., 1997). This means that dynamic capabilities are seen as unique and idiosyncratic processes that are shaped by path-dependent histories.

Communalities among firms in terms of their set of dynamic capabilities are rare (or

absent) since competences or routines can only generate competitive advantage if they are based on difficult to imitate assets or skills (Dierickx and Cool, 1989; Teece et al., 1997). Firms may lose parts of their competitive advantage if certain competences or routines are replicated by competitors (Teece et al., 1997).

Second, Eisenhardt and Martin (2000) refer to dynamic capabilities as "the firm's processes that use resources - specifically the processes to integrate, reconfigure, gain and release resources - to match and even create market change" (p. 1107). This suggests that dynamic capabilities can be seen as organisational and strategic routines that support firms to configure resources to be prepared to deal with markets that might emerge, collide, split, evolve and die (Eisenhardt and Martin, 2000). Put differently, dynamic capabilities - as antecedent organisational and strategic routines - allow managers to adjust their resources according to arising challenges that firms are confronted with which enables them to generate new value-creating strategies and ultimately to maintain and build competitive advantage (e.g. Eisenhardt and Martin, 2000; Grant, 1996; Henderson and Cockburn, 1994; Pisano, 1994; Teece, 2007).

Regarding path dependencies, Eisenhardt and Martin (2000) argue that paths are not entirely set by a firm's decisions and resulting history but can also be adjusted through fast learning mechanisms, practice, making mistakes and learning from specific experiences. In their distinction between moderately and highly dynamic ("high velocity") markets, Eisenhardt and Martin (2000) argue that existing knowledge might suffice to deal with the former but not with the latter when change becomes nonlinear and less predictable. This is when dynamic capabilities are less concerned with existing knowledge and experience and more concerned with rapidly creating situation-specific new knowledge (Eisenhardt and Martin, 2000). In fact, holding on to existing knowledge and experience might even cause problems in highly dynamic markets if managers over-generalise from past experiences (Argote, 1999; Eisenhardt and Martin, 2000) which suggests that from their point of view, path dependency only partially holds. This is in line with what Santos and Eisenhardt (2005) note on path trajectories. They argue that, as a firm attempts to benefit from opportunities arising due to changes in its market context, it not only uses path-dependent resources but also path-breaking ones such as the ones gained through co-operations and acquisitions.

In addition, Eisenhardt and Martin (2000) observe that communalities can persist since more or less successful ways of dealing with specific challenges exist that deem to be addressed by a specific dynamic capability (Eisenhardt and Martin, 2000). Therefore, they suggest that successful approaches exist among firms which others can learn from. As it will be discussed later, the methodology of this research focuses on the identification of successful approaches to sustainability management among firms.

Third, Zollo and Winter (2002) propose that "a dynamic capability is a learned and stable

pattern of collective activity through which the organisation systematically generates and modifies its operating routines in pursuit of improved effectiveness" (p. 340). This definition suggests that dynamic capabilities can be learned by social and collective interactions. Further, the definition highlights that dynamic capabilities are structured and stable and therefore not rely on rapid creation of situation-specific (sometimes more radical) new knowledge (Eisenhardt and Martin, 2000). Rather, dynamic capabilities rely on existing and well-structured knowledge and experience that is built continuously and systematically over time in an incremental manner (Zollo and Winter, 2002). Such learning takes the form of experience accumulation as well as knowledge articulation and codification (Zollo and Winter, 2002). The authors refer to experience accumulation as the central learning process by which operating routines are built over time. Knowledge articulation relates to transformation of implicit knowledge held by an individual - through collective discussions, for instance - to explicit knowledge that can be understood by other individuals (Kale and Singh, 2007; Zollo and Winter, 2002). Knowledge codification goes beyond that since individuals formally make explicit their knowledge and understanding of routines in supporting documents such as project and decision support systems, manuals and guidelines (Zollo and Winter, 2002).

Zollo and Winter (2002) do not explicitly mention path dependencies as such. They note, however, that a high level of prior acquisition and alliance experience in heterogeneous contexts has a positive impact on performance of following projects which suggests some degree of path dependency. In general, lessons learned from past experiences can help firms to adjust their routines and processes (Zollo and Winter, 2002). They suggest, however, that a major difficulty lies in the fact that individuals have to assess the applicability and appropriateness of lessons learned from past experiences to the current challenge to be solved. This assessment of applicability can be hard to make and can lead to faulty conclusions (Holyoak and Thagard, 1995; Zollo and Winter, 2002).

Zollo and Winter (2002) do not explicitly discuss communalities. However, from their focus on deliberate learning through experience accumulation, on knowledge articulation and on knowledge codification and their belief that these learning mechanisms shape the development of dynamic capabilities, the deduction can be made that communalities can indeed arise over time.

2.4 Definitions compared

Overall it can be concluded that, while the wording of discussed definitions diverges to some degree, their meaning is rather similar. However, differences exist that deserve to be mentioned here in order to be able to decide which definition best suits this research. Kay (2010) notes that the definition by Eisenhardt and Martin (2000) is broadly consistent with the one by Teece et al. (1997) in that dynamic capabilities are seen as a

set of specific and identifiable processes or routines that alter a firm's resources or assets such that they support the firm in dealing with market dynamics. Differences become more apparent, however, when taking into account the definition by Zollo and Winter (2002). They argue that while the definition by Teece et al. (1997) focuses on what dynamic capabilities are and how they work, it does not address the question of where they come from. This also holds true for Eisenhardt and Martin's (2000) definition, however, they allow for a firm's path to be adjusted to specific challenges also in the shorter-term and not just in the (historic) longer-term as Teece et al. (1997) suggest. Therefore, Zollo and Winter's (2002) definition takes into account the source of dynamic capabilities. Further, Zollo and Winter (2002) note that the definition by Teece et al. (1997) emphasises the existence of "rapidly changing requirements" suggesting that dynamic capabilities are not required in less dynamic market contexts. Similarly, the definition by Eisenhardt and Martin (2000) refers to "market change" which also points at the dynamism created by it. However, this research builds upon the notion that especially dynamic capabilities are required in order to deal with dynamic markets which is why this criticism is not relevant here.

Differences among these three articles become more accentuated when looking at path dependencies. Here, the views of Teece et al. (1997) and Eisenhardt and Martin (2000) diverge. For instance, Eisenhardt and Martin (2000) note that path dependencies go beyond a unique path that is set by a firm's historic decisions as proposed by Teece et al. (1997) suggesting that this path can also be shaped and adjusted through fast on-demand learning mechanisms and specific experiences. More specifically, Eisenhardt and Martin (2000) argue that in "high velocity" markets the need for stable existing knowledge is replaced by a need for specific new knowledge created closer to the time which might cause departure from the more linear path trajectory put forward by Teece et al. (1997). As mentioned earlier, Zollo and Winter (2002) do not explicitly mention path dependencies. However, the text reveals an emphasis on strong learning mechanisms that can enable firms to rapidly accumulate the required knowledge which suggests proximity to Eisenhardt and Martin's (2000) more flexible take on path dependencies.

Communalities hardly exist as noted by Teece et al. (1997) since only (dynamic) capabilities, routines and resources that meet the VRIN-criteria can generate sustained competitive advantage. As soon as dynamic capabilities lose their VRIN-status, they become static capabilities and in consequence no longer are a source of competitive advantage. Along this line of thinking, successful practices can lose their appeal as creators of competitive advantage among firms if they are adopted by a rising number of competitors. However, Eisenhardt and Martin (2000) suggest that dynamic capabilities can in fact display communalities since there are successful approaches to solving a particular problem which might be seen as proof for driving competitive advantage and

thus be adopted by more than one firm. As with path dependencies, Zollo and Winter (2002) do not explicitly discuss communalities as Teece et al. (1997) and Eisenhardt and Martin (2000) do. However, Zollo and Winter's (2002) focus on deliberate learning through certain mechanisms, which cannot be exclusively kept by one firm and are thus applied by competitors, also suggests that communalities may well arise as noted by Eisenhardt and Martin (2000).

2.5 Understanding of dynamic capabilities in this research

Having looked at these three definitions of dynamic capabilities in detail, it is possible to decide which one to follow throughout this research. Adopting a particular definition to which this research adheres, ensures consistency across this work, ranging from this literature review through to the conclusion. The original definition proposed by Teece et al. (1997) is clearly the most frequently cited one to date. It should be noted that the fact that this publication is the oldest among the analysed sample contributes to this popularity. In addition, the fact that it is cited by most, if not all subsequently written articles that refer to the RBV and dynamic capabilities will have generated even more citations in more recent articles. More recent definitions have not meaningfully improved the original understanding provided by Teece et al. (1997). Indeed, numerous authors - even in the most recent publications (e.g. Katkalo et al., 2010) - do not develop a definition of dynamic capabilities themselves but rather refer to the original one coined by Teece et al. (1997). The second most frequently cited definition is the one by Eisenhardt and Martin (2000) which does not really deviate from Teece et al. (1997) significantly. However, Eisenhardt and Martin (2000) take a different stance on path dependencies and communalities. As discussed above, on the one hand they take a more flexible view on path dependencies, meaning that certain changes in the market context can trigger rapid learning approaches which can shape a firm's path trajectory. On the other hand they argue that communalities exist since successful approaches in performing certain tasks will always be adopted by competitors as well. As it will be discussed later, this research recognises the importance of more flexible adjustment of a firm's path and the existence of communalities among firms. Zollo and Winter's (2002) definition is roughly in line with the one by Eisenhardt and Martin (2000), however, they do not explicitly refer to the dynamism and market change caused by certain challenges which is essential for this research.

For a number of reasons, this research will follow the definition coined by Eisenhardt and Martin (2000) which is more suitable to the context of sustainability. First, this research focuses on the dynamics caused by increasing pressures of the sustainability challenge which firms have to deal with (e.g. Delmas and Toffel, 2008; Etzion, 2007; Rivera-Camino, 2007) which is not explicitly accounted for by Zollo and Winter (2002).

Second, this research takes a flexible view regarding path dependencies which does not correspond to the opinion held by Teece et al. (1997). It is acknowledged that the sooner the firm decides to focus on sustainability and invest in corresponding capabilities, the better it is for competitive advantage. However, in market contexts characterised by rapid change such as in the light of the sustainability challenge it is possible to compensate a delay through fast learning and adaption mechanisms. Third, this research allows for the emergence of communalities among firms which is not the opinion held by Teece et al. (1997). The notion that communalities exist fits well into the sustainability context since many firms adopt similar practices that have proven to be successful in order to deal with the sustainability challenge. Especially, this is likely to be the case among firms of the same and related industries where challenges are perceived similarly and therefore solutions likely are similar too. However, communalities likely exist between firms of different industries as well because successful approaches to deal with sustainability measures such as energy and material savings or reduction of CO2-emissions and waste-water are similar. Fourth, in terms of the popularity among academics which Di Stefano (2010) refers to as the "academic core of dynamic capabilities research", the article by Eisenhardt and Martin (2000) is by far among the most frequently cited works in the community which should also count as a valid indication for its rigor and relevance.

2.6 Limitations of dynamic capabilities

Dynamic capabilities have been introduced as an extension to the RBV in order to take into account the dynamics arising in a firm's market context and thereby to compensate for the RBV's shortcomings (e.g. Ambrosini et al., 2009; Barreto, 2010; Eisenhardt and Martin, 2000; Teece et al., 1997; Zollo and Winter, 2002). Like most constructs, dynamic capabilities also have limitations which should be discussed. This can help researchers on the topic to be aware of potential problems and thereby shape and advance further research.

First, many authors note that a common understanding of what exactly dynamic capabilities are has not been established and that the construct remains open to a variety of conceptualisations and definitions (Di Stefano et al., 2010; Kay, 2010; Zahra et al., 2006). Zahra et al. (2006) even go as far as to say that the literature on dynamic capabilities is full of inconsistencies and contradictions. The semantic variety in terms of what exactly dynamic capabilities are has caused confusion regarding their meaning and usefulness (Di Stefano et al., 2010; Kay, 2010).

Second, the validity of the tight link between dynamic capabilities and sustained competitive advantage as proposed by Teece et al. (1997) has been questioned in the literature (Eisenhardt and Martin, 2000; Katkalo et al., 2010). Teece et al. (1997) propose

that dynamic capabilities reflect a firm's ability to obtain competitive advantage. The existence of this link is maintained by Teece (2007). Helfat et al. (2007) suggest to break this link and to establish instead a link between dynamic capabilities and the creation, extension and modification of a firm's resource base. This can help the firm to build competitive advantage which suggests an indirect rather than a direct link between dynamic capabilities and sustained competitive advantage.

Third, Winter (2003) argues that it is possible for firms to adjust to change without having dynamic capabilities at their disposal. He notes that firms are often confronted with unknown situations they are not prepared for which makes a fast-paced, opportunistic and alternative behaviour necessary. In such instances dynamic capabilities can be substituted by what Winter (2003) calls "ad-hoc" problem-solving (p. 992) which does not depend on dynamic capabilities but can fulfil a similar purpose at considerably lower costs. This is because the building of a suitable set of dynamic capabilities for sustained competitive advantage is a strategic decision for a longer-term commitment. Therefore, it might not always be beneficial for firms to invest heavily in dynamic capabilities, especially if their competitors manage change with the help of ad-hoc problem solving and therefore have a cost advantage (Winter, 2003). This is especially true when the firm's cost of developing and maintaining dynamic capabilities is on average not compensated by the benefits (Winter, 2003).

Fourth, Helfat and Peteraf (2003) argue that operational capabilities which - following Lichtenthaler and Lichtenthaler (2009) - are also referred to as capacities in this research are high-level routines that help firms to work on a given task and produce output. Dynamic capabilities, however, do not directly involve the actual production of output but rather build, integrate and reconfigure operational capabilities. This is in line with Zollo and Winter (2002) who propose operating routines as organisational activities geared towards the operational functioning of the firm while they suggest dynamic capabilities are used to modify and alter these operating routines. Along this line of thinking, Henderson and Cockburn (1994) note that component competence is a capability for daily problem-solving which is integrated and used by architectural competence which they refer to as a dynamic capability. Further, this corresponds to Lichtenthaler and Lichtenthaler's (2009) differentiation between capacity and dynamic capability. In their opinion, knowledge capacities represent activities and processes that help the firm to generate performance while knowledge management capacities represent the dynamic capability that allows firms to transform their capacities in order to fit changing market contexts. This suggests that dynamic capabilities cannot be operationalised themselves but rather are used to coordinate and manage a firm's capabilities (capacities) that can actually be operationalised.

While it is important to examine potential limitations of dynamic capabilities, these do

not have a severe impact on the applicability of the construct in this research. The first limitation of a potential lack of common understanding of what dynamic capabilities are is overcome by analysing and structuring its components as well as by studying in depth the relevant definitions in the literature. The second limitation of the uncertain strength of the link between dynamic capabilities and sustained competitive advantage does not affect this research since dynamic capabilities are in focus and not competitive advantage itself. In addition, firms would not develop dynamic capabilities if they did not expect any benefits. Similarly, the third limitation of the actual necessity of dynamic capabilities (versus ad-hoc problem-solving) does not undermine this research since firms actively develop dynamic capabilities in order to be able to successfully deal with fast-paced change in their market context. The fourth limitation of the concept's ability to operationalise does not concern this research because dynamic capabilities are believed to manage and coordinate capabilities that can actually be operationalised. In this research, the knowledge management capacity is regarded as the managerial and coordinative dynamic capability while the knowledge capacities are regarded as the operationalisable capabilities.

2.7 Examples of dynamic capabilities

In line with their understanding of dynamic capabilities, Eisenhardt and Martin (2000) propose various examples and split them in different categories depending on the way firms alter their resources.

The first category consists of dynamic capabilities which help firms to integrate resources. Product development and strategic decision-making, for instance, are such integrative dynamic capabilities whereby firms combine skills from different sources to fulfil respective tasks and to build competitive advantage (Eisenhardt and Martin, 2000).

The second category includes dynamic capabilities which support firms to reconfigure their resources. Knowledge brokering, coevolving and patching, for instance, represent such reconfiguring dynamic capabilities whereby firms copy, transfer and recombine (mainly knowledge-based) resources in order to meet a certain purpose (Eisenhardt and Martin, 2000).

The third category are dynamic capabilities which help firms to gain and release resources. Knowledge creation as well as alliance- and acquisition-making are dynamic capabilities whereby firms build and maintain resources by tapping into internal as well as external territory (Eisenhardt and Martin, 2000). In terms of releasing resources, Eisenhardt and Martin (2000) suggest exit routines as a dynamic capability by which firms adapt or terminate resource combinations that are no longer believed to build competitive advantage as a result of a changing market context. Especially knowledge-

related dynamic capabilities have received increasing attention in the literature (e.g. Foss et al., 2010; Grant and Baden-Fuller, 2004; Kale and Singh, 2007; Katkalo et al., 2010; Khilji et al., 2006; Lane et al., 2006; Lichtenthaler and Lichtenthaler, 2009; Pandza and Holt, 2007; Rothaermel and Thursby, 2005; Shane, 2000; Smith et al., 2005; Teece, 2007; Teece, 1998). Among Eisenhardt and Martin's (2000) examples of dynamic capabilities, many are discussed in the literature on knowledge management, namely transfer processes such as knowledge brokering (e.g. Hargadon and Sutton, 1997), patching (e.g. Eisenhardt and Brown, 1999) and coevolving (e.g. Eisenhardt and Galunic, 2000) as well as knowledge creation processes such as alliance and acquisition routines (e.g. Zollo and Singh, 1998).

Many authors have observed the rising importance of knowledge in society which they refer to as "knowledge society" (e.g. Drucker, 1968; Nonaka, 1994; Toffler, 1990). Knowledge defines a firm's ability to turn inputs into outputs (Nelson and Winter, 1982; Nickerson and Zenger, 2004) which makes constant updating of the firm's knowledge base necessary (Nickerson and Zenger, 2004). Teece (1998) notes that a firm's ability to create, transfer, assemble, integrate and exploit knowledge assets is critical in order to maintain and build competitive advantage which puts dynamic capabilities into the context of knowledge management. Katkalo et al. (2010) highlight the importance of knowledge assets for firms since these are the most difficult to trade and critical to capture strategic value. For this reason, the internalisation of such strategic knowledge assets can prove to be highly beneficial (Katkalo et al., 2010; Nonaka, 1994). This raises questions about how firms appropriately go about using dynamic capabilities in knowledge management from creation to application (Lichtenthaler and Lichtenthaler, 2009; Nonaka, 1994). Firms' success in highly dynamic markets such as in high-technology industries is driven by innovation and knowledge-creating and learning firms are better positioned to build competitive advantage (e.g. Nonaka and Takeuchi, 1995; Rosenkopf and Nerkar, 2001; Simonin, 1997). In other words, the ability to create and manage knowledge in the form of intellectual assets is increasingly seen as a driver of competitive advantage (McGaughey, 2002). As Rosenkopf and Nerkar (2001) put it, the approaches that firms take with knowledge management and learning determine, for instance, how well a firm performs in research productivity (Henderson and Cockburn, 1994) as well as in the development, transfer and use of capabilities (Zander and Kogut, 1995). Overall, the accumulation and application of knowledge that is relevant to the solution of a given task help firms to perform better in managing that task (Collis, 1996; Grant, 1996; Kale and Singh, 2007). As discussed earlier, this is referred to as the KBV in the micro-context (e.g. Grant, 1996; Grant and Baden-Fuller, 2004; Kale and Singh, 2007) and to the emerging "knowledge economy" in the macro-context (Teece, 2010).

As it has been noted in the introduction and as it will be discussed in more detail later,

knowledge management is highly important in the context of dynamic capabilities for sustainability management. In generic terms, Lichtenthaler and Lichtenthaler (2009) note that knowledge and its management are crucial for technology development and ultimately the creation of competitive advantage in dynamic business contexts. More specifically, this also applies to the sustainability challenge and related pressures imposed on firms which have to be addressed (Huang and Shih, 2009; Melville, 2010; Sharma and Vredenburg, 1998). However, knowledge not only plays an important role in support of technological solutions but also in building heightened awareness and a sense of responsibility for sustainability issues as well as in developing sustainability strategies (Melville, 2010). The importance of knowledge management in the context of sustainability is further highlighted by Huang and Shih (2009) who propose to closely link the generic approach to knowledge management with environmental management which helps firms with the creation, accumulation, sharing and application of sustainability-related knowledge.

2.8 Knowledge management

Knowledge consists of information and know-how (Helfat et al., 2007; Kogut and Zander, 1992). Kogut and Zander (1992) refer to information as "knowledge which can be transmitted without loss of integrity once the syntactical rules required for deciphering it are known" (p. 386). Kogut and Zander (1992) note further that information is composed of facts, (axiomatic) propositions and symbols and that it is often proprietary. Von Hippel (1998) defines know-how as "the accumulated practical skill or expertise that allows one to do something smoothly and efficiently" (p. 76). Kogut and Zander (1992) highlight that the word "accumulated" implies that know-how cannot simply be transferred as is the case with information but must be learned. More specifically for the organisational context, Smith et al. (2005) define organisational knowledge as "the validated understanding and beliefs in a firm about the relationships between the firm and the environment" (p. 347). Such organisational knowledge reflects the view of how resources should be used in order for the firm to benefit (Smith et al. 2005). Garud and Nayyar (1994) argue that technology is a form of knowledge and consequently, technological change is related to knowledge development and learning.

In general, knowledge is created through learning which Teece et al. (1997) attach high importance to. "Learning is a process by which repetition and experimentation enable tasks to be performed better and quicker" (Teece et al., 1997: 520). They argue further that such learning involves organisational and individual skills which need to be deployed appropriately (which is context-dependent). The authors regard learning processes as social and collective interactions in which learning occurs through practice and imitation between individuals and through joint contributions. The resulting

organisational knowledge resides in routines in the form of "patterns of interaction that represent successful solutions to particular problems" (Teece et al., 1997: 520).

Knowledge can take different forms. First, knowledge can be explicit or tacit in nature (e.g. Foss et al., 2010; Garud and Nayyar, 1994; Hansen, 1999; Kale and Singh, 2007; Kogut and Zander, 1992; Nonaka, 1994; Smith et al., 2005). Explicit knowledge is highly codified, can be translated and therefore be easily shared among individuals (e.g. Cowan et al., 2000; Hansen, 1999; Kogut and Zander, 1992; Nonaka, 1994). Tacit knowledge, however, is highly personal and therefore properly understood only by the individuals owning that information which makes it hard to convey and share (e.g. Cowan et al., 2000; Hansen, 1999; Kale and Singh, 2007; Kogut and Zander, 1992; Nonaka, 1994; Smith et al., 2005).

Second, knowledge can be simple or complex (Garud and Nayyar, 1994). Simple knowledge can generally be described with relatively little information while complex knowledge needs larger amounts of information (Garud and Nayyar, 1994). Winter (1987) argues that the degrees of simplicity and complexity are context-dependent and have to be assessed accordingly.

Third, knowledge can be systemic or independent (Garud and Nayyar, 1994). Systemic knowledge tends to be well embedded in a given system and therefore has to be described in relation to other (knowledge) components of that system while independent knowledge can be developed separately from other components (Garud and Nayyar, 1994). Again, Winter (1987) argues that these knowledge characteristics have be seen in their context.

In addition to these three knowledge characteristics continua, knowledge can be differentiated by its sources from the firm's view, that is, whether it is individual or organisational knowledge (e.g. Foss et al., 2010, Lichtenthaler and Lichtenthaler, 2009; Nonaka, 1994). As the name suggests, individual knowledge is held individually and needs to be shared and accumulated collectively in order to become organisational knowledge. Often it is the case that new insights, resulting ideas and knowledge are gained at the individual level before exchange and further development by a group of individuals take place (e.g. Nonaka, 1994) and before this knowledge is embedded in the firm as organisational knowledge (Crossan et al., 1999; Lichtenthaler and Lichtenthaler, 2009). Once knowledge is held collectively by the firm, it needs to be distributed to relevant organisational units through integration mechanisms and processes (Lichtenthaler and Lichtenthaler, 2009; Matusik and Heely, 2005).

In terms of knowledge management, exploration and exploitation are widely discussed in the literature (e.g. Grant and Baden-Fuller, 2004; Henderson and Cockburn, 1994; March, 1991; Rosenkopf and Nerkar, 2001; Shane, 2000). March (1991) refers to the

former as "exploration of new possibilities" and the latter as "exploitation of old certainties" (p. 71). In other words, exploration relates to knowledge creation which can also be regarded as learning while exploitation relates to knowledge application (Grant and Baden-Fuller, 2004).

On the one hand, March (1991) argues that exploration includes "things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, innovation" (p. 71). Systems exclusively engaging in explorative activities might carry the costs of experimentation without reaping any benefits (March, 1991). Grant and Baden-Fuller (2004) relate to exploration as activities aimed at increasing a firm's stock of knowledge which Spender (1992) refers to as knowledge creation. Shane (2000) suggests that firms tend to explore and create new knowledge whenever they sense a need or demand for that knowledge. In the context of knowledge creation, alliances are meant to help firms to acquire knowledge and learn from each partner's knowledge base (Grant and Baden-Fuller, 2004).

On the other hand, exploitation includes things such as "refinement, choice, production, efficiency, selection, implementation and execution" (March, 1991: 71). Systems exclusively engaging in exploitative activities might lack new ideas and therefore be trapped in stable but increasingly outdated situations (March, 1991). Grant and Baden-Fuller (2004) relate to exploitation as activities that deploy existing knowledge to create value which Spender (1992) refers to as knowledge application. In the context of knowledge application, alliances can support firms to access each partner's knowledge base and thereby engage in knowledge sharing and exploit complementarities without acquiring that knowledge (Grant and Baden-Fuller, 2004).

Since exploration and exploitation have significant limitations on their own, March (1991) suggests that firms should address both simultaneously and keep an appropriate balance between the two. Both are regarded critical for firms but since resources are scarce, firms are confronted with a trade-off and have to make choices between the invention of a new technology and the refinement of an existing technology (Levinthal and March, 1981; March, 1991). The outcomes of exploitation (in the form of further development of existing solutions) are more certain, occur faster and more directly and are clearer to see compared to exploration of new solutions (March, 1991). Due to more secure and predictable outcomes and a shorter time-horizon, many firms put the emphasis on exploitation (Gupta et al., 2006; Jansen et al., 2006; March, 1991; Raisch, 2009). However, in order for knowledge creation efforts to be successful and to maintain competitive advantage, firms also need to focus on the longer-term search for new ideas and markets with an explorative approach (Henderson and Cockburn, 1994; March, 1991; Nelson, 1991). This is particularly important in the context of the sustainability theme which imposes different challenges on firms. These challenges not only force

firms to make existing solutions and technologies better incrementally through exploitation but also to invent new solutions that are path-breaking and radically different through exploration. Along this line of thinking, Eisenhardt and Martin's (2000) view of path-breaking adjustment processes and mechanisms fits well into the context of the sustainability challenge.

Extending the view held by March (1991), Lichtenthaler and Lichtenthaler (2009) suggest that it is important to not only address the dimensions of knowledge exploration and exploitation, but also the dimension of knowledge retention "in between" to obtain a holistic view. This third dimension is seen as a "connecting" element nestled in between exploration and exploitation that ensures the inter-temporal transfer of newly created knowledge (Kale and Singh, 2007; Lichtenthaler and Lichtenthaler, 2009; Pandza and Holt, 2006). Lichtenthaler and Lichtenthaler (2009) note further that it is important to examine these three dimensions of knowledge management from the internal (i.e. intra-firm) as well as the external (i.e. inter-firm) perspective. Several authors have discussed some of these aspects, however, not holistically (e.g. Khilji et al., 2006; Rosenkopf and Nerkar, 2001).

Rosenkopf and Nerkar (2001), for instance, give a useful overview of exploration from the internal and external perspective of the firm and distinguish between technologies that are similar or distant to the ones that are most frequently used by the firm. However, nor does the framework take into account knowledge exploitation, neither does it address knowledge retention. Going beyond Rosenkopf and Nerkar's (2001) approach to knowledge exploration, Khilji et al. (2006) suggest that firms cannot only rely on the explorative invention but also have to apply and commercialise this new knowledge through exploitation. They address at some depth internal (e.g. cooperation of teams in technology and marketing) and external (e.g. formation of alliances) aspects, but have not formally integrated these into a framework that helps to examine different internal and external aspects in a structured manner. Overall, these exemplary works offer valuable insights into knowledge management. However, they do not address knowledge management holistically because some dimensions (i.e. exploration or exploitation) are not accounted for or the differentiation between the internal and external perspective is missing.

2.9 Knowledge management capacities

A framework developed by Lichtenthaler and Lichtenthaler (2009) overcomes these shortcomings thereby shedding more light into knowledge management in the dynamic capability context. The framework addresses the dimensions of knowledge exploration and exploitation and the third dimension of knowledge retention. In addition, it examines these dimensions from an internal (intra-firm) and external (inter-firm) perspective.

Lichtenthaler and Lichtenthaler (2009) propose a firm's knowledge management capacity as a dynamic capability which gives support to reconfigure and realign knowledge capacities. As suggested by Lichtenthaler and Lichtenthaler (2009: 1322), knowledge management capacity is defined as "a firm's ability to dynamically manage its knowledge base over time by reconfiguring and realigning processes of knowledge exploration, retention and exploitation inside and outside the organisation." Therefore, knowledge management capacities enable a firm to transform (i.e. reconfigure and realign) the knowledge capacities which themselves can be described as processes at the knowledge level (Eisenhardt and Martin, 2000; Lichtenthaler and Lichtenthaler, 2009). They argue further, that a firm needs to transform its knowledge capacities which develop an evolutionary path that helps the firm to cope with market dynamics. Certain knowledge capacities might support firms to generate performance in one period while this might not suffice to sustain that performance over time in the light of market changes (Lichtenthaler and Lichtenthaler, 2009).

By examining the comprehensive knowledge capacity framework developed by Lichtenthaler and Lichtenthaler (2009), it becomes apparent that many of the dynamic capabilities put forward by Eisenhardt and Martin (2000) are highly related to these knowledge capacities. In particular, the dynamic capabilities of transfer processes (in the form of knowledge brokering, patching and coevolving) and knowledge creation (including alliance and acquisition routines) are contained in the knowledge capacity framework.

However, from a strictly definitional point of view, Eisenhardt and Martin (2000) regard knowledge creation as a dynamic capability in itself whereas Lichtenthaler and Lichtenthaler (2009) merely regard it as a subordinate exploratory capacity in the form of inventive capacity (internal creation) and absorptive capacity (external creation). The actual dynamic capability in the Lichtenthaler and Lichtenthaler (2009) framework is represented by the knowledge management capacity, i.e. the overarching management of the knowledge capacities in the framework. These knowledge capacities relate to actual creation processes at the knowledge level whereas the dynamic capability of knowledge management capacity relates to the transformation of knowledge capacities to fit certain market dynamics and meet demand. Therefore, knowledge management capacity represents an order above the knowledge capacities. This research takes precisely this view in that knowledge capacities on the one hand can be operationalised as they actually create knowledge trough given processes at the knowledge level. Knowledge management capacity on the other hand is the higher-level concept of a coordinating and managerial nature (Teece et al., 1997) that does not create knowledge itself and therefore cannot be operationalised.

In this integrative framework, Lichtenthaler and Lichtenthaler (2009) present six

different knowledge capacities which describe capabilities that firms need in order to manage their knowledge processes successfully. As mentioned earlier, they propose that knowledge management capacity represents the actual dynamic capability which helps firms to reconfigure and realign these knowledge capacities to meet their goals depending on the requirements of the market context. Repetitively using these knowledge capacities with limited reconfiguring and realigning activities on behalf of the knowledge management capacity (i.e. the dynamic capability) makes them inflexible to change (Lichtenthaler and Lichtenthaler, 2009; Zahra et al., 2006). For this reason the knowledge management capacity is required to regularly renew knowledge capacities through reconfiguration and realignment (Helfat et al., 2007; Lichtenthaler and Lichtenthaler, 2009). As Table 3 shows, Lichtenthaler and Lichtenthaler (2009) examine the dimensions of knowledge exploration, retention and exploitation from the internal (i.e. intra-firm) and the external (i.e. inter-firm) perspective. The former is concerned with the knowledge within the boundaries of a firm while the latter deals with knowledge beyond the boundaries of a firm. These two perspectives highlight the importance of both internal and external knowledge. The importance for firms operating in dynamic market contexts to combine internal and external knowledge (management) make frameworks accounting for both perspectives in conjunction necessary (e.g. Andersen and Drejer, 2008, Hargadon and Sutton, 1997; Lichtenthaler and Lichtenthaler, 2009).

	Knowledge exploration	**Knowledge retention**	**Knowledge exploitation**
Internal (intra-firm)	Inventive capacity	Transformative capacity	Innovative capacity
External (inter-firm)	Absorptive capacity	Connective capacity	Desorptive capacity

Table 3: Knowledge management capacity framework[3]

These six knowledge capacities will now be discussed in more detail from the internal as well as the external perspective along the dimensions of knowledge exploration, retention and exploitation.

2.9.1 Dimension of knowledge exploration

Starting with knowledge exploration, it contains inventive (internal) and absorptive (external) capacities (Lichtenthaler and Lichtenthaler, 2009).

	Knowledge exploration	**Knowledge retention**	**Knowledge exploitation**
Internal (intra-firm)	Inventive capacity	Transformative capacity	Innovative capacity
External (inter-firm)	Absorptive capacity	Connective capacity	Desorptive capacity

Table 4: Knowledge exploration capacities[4]

[3] Adopted from Lichtenthaler and Lichtenthaler (2009).

Inventive capacity

"Inventive capacity is a firm's ability to internally explore new knowledge" (Lichtenthaler and Lichtenthaler, 2009: 1319).

In terms of the internal perspective of knowledge exploration, the authors propose inventive capacity as the ability to explore new knowledge within the boundaries of the firm which ultimately leads to the creation of new knowledge. As the name suggests, inventive capacity is about creating new knowledge, in this context from internal sources. Inventive capacity includes the perception of opportunities and the integration of newly created knowledge into the existing knowledge base inside the firm (e.g. Khilji et al., 2006; Kogut and Zander, 1992; Lichtenthaler and Lichtenthaler, 2009; Shane, 2000; Smith et al., 2005).

The identification of certain opportunities helps firms to sharpen the focus regarding their inventive efforts (Shane, 2000). This supports firms in aligning their knowledge creation efforts with actual opportunities that they can benefit from. The ability to recognise such opportunities depends to a large extent on the firm's employees. Along these lines, Shane (2000) argues that not all individuals are equally likely to identify the same opportunities. Venkatarman (1997) suggests that different individuals are likely to discover different opportunities in a giving setting of change because the characteristics of their prior knowledge diverge. Similarly, Kirzner (1997) argues that the success in discovering opportunities depends upon the distribution of information and therefore on the information that individuals possess. In addition to recognising opportunities, the ability to understand the value of new information and knowledge inside the firm is highly important (Cohen and Levinthal, 1990). Attaching a potential value to potentially new information and knowledge helps the firm to decide how to prioritise its knowledge creation activities and thereby increase its benefits from such activities.

The integration of newly generated knowledge with the existing knowledge base of the firm is another important aspect of inventive capacity (Lichtenthaler and Lichtenthaler, 2009; Smith et al., 2005). On the one hand, Smith et al. (2005) argue that existing or available knowledge within the firm is static in nature. This can also be referred to as a firm's knowledge stock which includes employees' current education levels, experience and functional heterogeneity (i.e. the variety in employees' types and levels of knowledge). On the other hand, Smith et al. (2005) note that the creation of knowledge is rather dynamic in nature because it responds to a trigger in the market context that the firm intends to react to. Smith et al. (2005) note that in order to be able to react, the firm needs knowledge creation capabilities. This is in line with a category of dynamic capabilities suggested by Eisenhardt and Martin (2000), namely the ones related to

[4] Adopted from Lichtenthaler and Lichtenthaler (2009).

gaining resources such as knowledge creation routines which support firms in building new thinking.

Smith et al. (2005) argue that next to the discussed stock of knowledge, these knowledge creation capabilities are driven by employees' personal ego networks and the organisational climate. The former includes the number of employees' contacts within the firm, the range of contacts (i.e. the degree of different types of contacts) as well as the strength of ties within these contacts. The latter includes the openness for risk-taking and support for teamwork. Since the existing stock of information and newly created knowledge can be quite different (static versus dynamic, for instance), it is challenging to integrate the new with the existing. Along this line of thinking, Jansen et al. (2005) note that for knowledge exploration to be successful, firms primarily need coordination capabilities such as internal and external liaisons and co-operations, cross-functionality and diversity of teams and employees, employees' participation in decision making and job rotation. Especially their notion of internal and external co-operation as well as empowerment and training of employees corroborates the view held by Smith et al. (2005) that networking and organisational climate are critical.

In terms if inventive capacity, prior knowledge can positively affect the discussed ability to identify opportunities as well as the integration of newly created knowledge which suggests the existence of path dependency as featured in the RBV literature (e.g. Barney, 1991; Wernerfelt, 1984). In terms of the identification of opportunities, it depends on the degree of relatedness of the individual's - or from a collective standpoint, the firm's - prior knowledge to the opportunities arising in the market context (Venkatarman, 1997). Nonaka (1994), for instance, argues that in the event an individual's, team's or firm's experience and knowledge are highly unrelated to the newly created knowledge, the ability to integrate that and consequently make use of it is highly limited.

In summary, inventive capacity in this research is understood as an enabler for firms to internally explore and manage relevant knowledge in order to address sustainability successfully.

Absorptive capacity

"Absorptive capacity is a firm's ability to externally explore new knowledge" (Lichtenthaler and Lichtenthaler, 2009: 1319)

In terms of the external perspective of knowledge exploration, Lichtenthaler and Lichtenthaler (2009) propose absorptive capacity as the ability to explore knowledge that can be found outside the firm and to integrate it with the firm's existing body of knowledge. In other words, absorptive capacity relates to the ability to identify, value and assimilate externally available knowledge (Cohen and Levinthal, 1990, 1994). This absorptive capacity is what Lane et al. (2006) refer to as a firm's exploratory learning.

Jansen et al. (2005) as well as Zahra and George (2002) distinguish between potential and realised absorptive capacity in that the former includes the acquisition and assimilation of knowledge while the latter includes the transformation and exploitation of knowledge. In the context of the Lichtenthaler and Lichtenthaler (2009) framework, the potential absorptive capacity corresponds to absorptive capacity on the dimension of knowledge exploration while realised absorptive capacity relates to the dimensions of knowledge retention and exploitation. In terms of the potential absorptive capacity, a firm's knowledge acquisition concerns the capability to identify and acquire knowledge that has been created externally and is critical to the firm's operations (Zahra and George, 2002). Knowledge assimilation relates to the firm's capability in using routines and processes in order to analyse, interpret and then understand the knowledge that has been generated externally (Zahra and George, 2002). Jansen et al. (2005) identify organisational antecedents (mechanisms) which support potential absorptive capacity. They argue that antecedents associated with coordination capabilities are a main driver of a firm's potential absorptive capacity on the dimension of knowledge exploration. For instance, cross-functional interfaces such as teams dedicated to knowledge exchange and liaison activities or specific taskforces support the acquisition and assimilation of external knowledge (Jansen et al., 2005). Further, the degree of participation of subordinates in decision-making is an important driver. This is believed to increase the number of "receptors" to the firm's market context which supports the filtering of new external knowledge as well as the facilitation of external knowledge acquisition (Cohen and Levinthal, 1990; Jansen et al., 2005). Moreover, job rotation is believed to positively relate to the acquisition and assimilation of external knowledge. This is based upon the assumption that job rotation increases the diversity of insights and experiences as well as builds personal contacts within and outside the firm (Cohen and Levinthal, 1990; Jansen et al., 2005).

Further, the notion of opportunity discovery (Shane, 2000) again plays an important role. Opportunities have to be discovered, in this case with a focus on the ones arising externally, in order for the firm to align its knowledge creation efforts with these opportunities. Following Cohen and Levinthal (1990), it is not only critical for firms to identify opportunities externally but also understand the value of new information and knowledge that rests outside the firm. Second, the integration of newly created knowledge - again, from the external perspective in this context - into the firm's existing body of knowledge is necessary in order for the firm to use it properly and to be able to benefit from it (Lane et al., 2006; Smith et al., 2005).

Prior knowledge can be conducive to absorptive capacity. Along these lines, Cohen and Levinthal (1990) argue that early investments and efforts into areas of expertise that shape a firm's development path can be supportive of the future development of a given

technical ability or technology. Going beyond that, however, Zahra and George (2002) argue that future evolution and development not only depend upon prior investment and knowledge but also on knowledge complementarity and the diversity of external knowledge sources.

In summary, absorptive capacity in this research is understood as an enabler for firms to externally explore and manage relevant knowledge in order to address sustainability successfully.

It is important to note that because of the explorative nature of inventive and absorptive capacities on the dimension of knowledge exploration, the internally and externally created knowledge does not guarantee success in the retention and ultimately in the commercialisation of newly created knowledge (Cohen and Levinthal, 1990; Zahra and George, 2002).

2.9.2 Dimension of knowledge retention

Knowledge retention - which can be regarded as a link between knowledge exploration and exploitation - can be broken down further into transformative (internal) and connective (external) capacities (Lichtenthaler and Lichtenthaler, 2009).

	Knowledge exploration	Knowledge retention	Knowledge exploitation
Internal (intra-firm)	Inventive capacity	Transformative capacity	Innovative capacity
External (inter-firm)	Absorptive capacity	Connective capacity	Desorptive capacity

Table 5: Knowledge retention capacities[5]

Transformative capacity

"Transformative capacity is a firm's ability to retain knowledge inside the firm" (Lichtenthaler and Lichtenthaler, 2009: 1320).

In terms of the internal perspective of knowledge retention, transformative capacity relates to the ability to internally retain knowledge over time (Garud and Nayyar, 1994; Lichtenthaler and Lichtenthaler, 2009; Pandza and Holt, 2007). More specifically, transformative capacity represents the capacity to choose relevant internal knowledge and technology, maintain that knowledge in the firm's knowledge base and retrieve certain pieces of knowledge if the need arises (Garud and Nayyar, 1994). The advantage of transferring internal knowledge is that it is not widely accessible to other firms as external knowledge which facilitates competitive advantage (Barney, 1991; Garud and Nayyar, 1994; Mansfield, 1988). Maintaining chosen pieces of internal knowledge is what Garud and Nayyar (1994) refer to as a "knowledge storehouse" for later application

[5] Adopted from Lichtenthaler and Lichtenthaler (2009).

which can be advantageous if the firm possesses the resources to do so. Inter-temporal transfer of knowledge depends on its characteristics discussed above, that is whether it is tacit or articulable, simple or complex and whether it is systemic or independent (Garud and Nayyar, 1994; Winter, 1987). The more tacit, complex and systemic the knowledge, the harder the transfer becomes. It makes necessary greater amounts of information to understand that knowledge and richer media to preserve that knowledge (Garud and Nayyar, 1994).

Pandza and Holt (2007) note that transformative capacity enables a firm to constantly redefine opportunities based on knowledge that is endogenous to the firm. Along these lines, firms discovering novel applications of knowledge (i.e. exploitation) cause the internal existing body of knowledge to progress and develop into new directions and thereby maintain its usefulness across time (Pandza and Holt, 2007). This suggests that transformative capacity represents the connection between the dimensions of exploration and exploitation from the internal perspective.

However, as Szulanski (1996) suggests, firms can encounter difficulties with knowledge transfer, most notably internal stickiness in knowledge transfer which is defined as "the difficulty of transferring knowledge within the organisation" (p. 29). Stickiness depends upon the characteristics of the actual knowledge transferred, of the source and the recipient of that knowledge as well as on the context in which knowledge is transferred (Szulanski, 1996). First, knowledge transferred is characterised by causal ambiguity (i.e. awareness of reasons for success and failure of knowledge transfer to a new setting) and unprovenness (i.e. usefulness of knowledge not certain). Second, the source of knowledge is characterised by a lack of motivation and the perception that it is not reliable. Third, the recipient of knowledge is characterised by a lack of motivation. Fourth, the context is characterised by a lack of fit of to the given piece of knowledge and difficulties in the relationships between source and recipient units. In addition, Pandza and Holt (2007) identify a high degree of knowledge dispersion where knowledge cannot be associated with a particular industrial sector or innovation system - such as in the case of nanotechnology - which can create uncertainty in knowledge coordination within a firm (Pandza and Holt, 2007). This is because it is difficult for firms to predict which future applications arise and which kind of knowledge is required to deal with a particular circumstance.

Regarding transformative capacity, path dependency can play a role in that the more prior knowledge and experience the firm possesses, the easier it is to maintain and retrieve knowledge (Garud and Nayyar, 1994; Lichtenthaler and Lichtenthaler, 2009; McGaughey, 2002).

In summary, transformative capacity in this research is understood as an enabler for firms to internally retain, store and manage relevant knowledge in order to address sustainability successfully.

Connective capacity

"Connective capacity is a firm's ability to retain knowledge outside the firm" (Lichtenthaler and Lichtenthaler, 2009: 1320).

In terms of the external perspective of knowledge retention, connective capacity relates to the ability to access and maintain a knowledge base externally (Lichtenthaler and Lichtenthaler, 2009). This means that connective capacity represents the capacity to choose useful external sources of knowledge and technology, maintain these external relationships over time to ensure the availability of certain pieces of knowledge if the need arises (i.e. in the form of external knowledge store housing) and then to retrieve this knowledge if the need arises (Garud and Nayyar, 1994; Grant and Baden-Fuller, 2004; Kale and Singh, 2007). Therefore, connective capacity includes elements of alliance and relational capability (Kale and Singh, 2007; Lichtenthaler and Lichtenthaler, 2009). In this case, however, the firm does not necessarily transfer knowledge to the internal knowledge base but rather maintains the ability to access this knowledge without acquiring it (Grant and Baden-Fuller, 2004; Lichtenthaler and Lichtenthaler, 2009). The organisational learning perspective focusing on acquiring as much knowledge as possible might cause each alliance partner trying to learn faster than the others thus creating competition and destabilising the relationship among partners (Grant and Baden-Fuller, 2004; Hamel, 1991; Inkpen and Beamish, 1997). The authors acknowledge that learning may well take place in alliances but that the focus of alliances should be on accessing knowledge rather than acquiring it. In this case, knowledge sharing takes the form of firms searching for complementary knowledge among partners but at the same time guarding their unique and distinctive base of knowledge (Grand and Baden-Fuller, 2004). In other words, they suggest to focus on a few relevant core competences and to collaborate through knowledge sharing in order to access additional (complementary) competences. Chesbrough (2006) argues that in order for firms to be able to access other firms' knowledge and technology, they might need to make available and to transfer some of their knowledge. Such sharing and transfer mechanisms lie at the heart of open business models. Chesbrough (2006) proposes the "division of innovation labour" as a system where one firm generates new knowledge but does not use and commercialise it. Instead, it partners with other firms which then make use of this knowledge. As this works both ways, more knowledge and ideas will likely become available for consideration for all partnering firms involved. Without open business models, shares of this knowledge and ideas might lie idly because their potential has

been overlooked and therefore may never be used (Chesbrough, 2006). However, alliances can go beyond inter-firm relationships. For instance, Pandza and Holt (2007) identify different types of actors which are relevant for knowledge and innovation alliances. Next to established firms (for which a new technology likely has been less relevant in the past) and new firms (which might be closely linked to that new technology), Pandza and Holt (2007) suggest that research institutions such as universities and knowledge brokers which Chesbrough (2006) refers to as intermediaries also play a crucial role in alliances.

In the light of alliances building, Kale and Singh (2007) note that connective capacity helps firms to manage external networks in the form of inter-firm relationships with the goal to retain knowledge and maintain access to external knowledge sources. Being able to establish alliances can significantly improve competitive advantage, however, firms need to undertake efforts to learn, accumulate and leverage alliance know-how in order to develop skills needed for alliance success (Kale and Singh, 2007; Nonaka 1994). The authors refer to an alliance learning process which should help firms develop partnering skills such as insightful partner selection, alliance negotiation, formulation of alliance design and alliance management. Kale and Singh (2007) regard this alliance learning process as a dynamic capability itself. However, in this research it is treated as a capacity that helps firms to create knowledge through alliances, namely connective capacity (Lichtenthaler and Lichtenthaler, 2009) with the actual dynamic capability being the knowledge management capacity that realigns and reconfigures knowledge capacities. Kale and Singh (2007) suggest that the alliance learning process includes the articulation, codification, sharing and internalisation of alliance management know-how. Articulation refers to "efforts of accessing and externalising individually held knowledge into explicit knowledge, to the extent that it is possible" (p. 984). Codification means "creating and using knowledge objects or resources such as alliance guidelines, checklists, or manuals to assist action or decision making in future alliance situations" (p. 985). Knowledge sharing involves "exchanging and disseminating individually and organisationally held alliance management knowledge, which is both tacit and/or codified, through interpersonal interaction within the organisation" (p. 385). Internalisation involves "efforts to facilitate absorption of accumulated organisational level know-how by individuals" (p. 986).

Connective capacity can benefit from prior knowledge in that the more knowledge a firm possesses in a given field, the better the firm understands potential issues at hand and the easier the firm can manage inter-firm relationships on that field (Lichtenthaler and Lichtenthaler, 2009).

In summary, connective capacity in this research is understood as an enabler for firms to externally retain, store and manage relevant knowledge in order to address sustainability successfully.

2.9.3 Dimension of knowledge exploitation

Finally, knowledge exploitation can be split into innovative and desorptive capacities (Lichtenthaler and Lichtenthaler, 2009).

	Knowledge exploration	Knowledge retention	Knowledge exploitation
Internal (intra-firm)	Inventive capacity	Transformative capacity	Innovative capacity
External (inter-firm)	Absorptive capacity	Connective capacity	Desorptive capacity

Table 6: Knowledge exploitation capacities[6]

Innovative capacity

"Innovative capacity is a firm's ability to internally exploit knowledge" (Lichtenthaler and Lichtenthaler, 2009: 1321).

In terms of the internal perspective of knowledge exploitation, innovative capacity is about the ability to exploit knowledge internally by aligning inventions with market demand (Cohen and Levinthal, 1990; Lichtenthaler and Lichtenthaler, 2009). In other words, innovative capacity represents the internal application or - following March (1991) - exploitation of knowledge that has been generated from both, internal and external sources (Lichtenthaler and Lichtenthaler, 2009). Therefore, the internal perspective of innovative capacity refers to the application of knowledge and not the sources. Innovative capacity of the exploitative dimension represents the internally applied component of inventive and absorptive capacities of the explorative dimension (Lane et al., 2006; Lichtenthaler and Lichtenthaler, 2009). Lane et al. (2006) note that absorptive capacity positively influences the speed, frequency and magnitude of results through innovative capacity (i.e. innovation). This is because incremental innovation is primarily based upon knowledge that has previously been explored and that "waits" to be exploited (Helfat, 1997; Kim and Kogut, 1996; Lane et al., 2006). Innovative capacity for incremental innovation is driven by absorptive capacity characterised by understanding of narrowly defined and closely related knowledge domains (Lane et al., 2006; Van den Bosch et al., 1999). By contrast, innovative capacity for radical innovation is believed to be driven by absorptive capacity characterised by understanding of broadly defined and loosely related knowledge domains (Lane et al., 2006; Van den Bosch et al., 1999).

[6] Adopted from Lichtenthaler and Lichtenthaler (2009).

However, it is important to note that the amount of explored knowledge is not necessarily a good indication of the number of exploited innovations. As Lichtenthaler and Lichtenthaler (2009) put it, some firms with strong exploitative capacities might exploit a large number of innovations from a small knowledge base while others (with strong explorative capacities) might struggle to do so. Along these lines, Khilji et al. (2006) argue in their study on biotech firms that it is not enough to rely on inventions and that investments and effort have to be put into the application of new knowledge in order to benefit from the innovation potential.

Shane et al. (2000) argue that prior knowledge which individuals and the organisation have about a particular market and how to serve it can help firms to discover how to use new knowledge and technology to serve the market today. Further, prior knowledge on a given field supports firms in the identification of commercialisation opportunities on that field and in the generation of innovations from internal and external knowledge (Kogut and Zander, 1992; Lichtenthaler and Lichtenthaler, 2009; Smith et al., 2005).

In summary, innovative capacity in this research is understood as an enabler for firms to internally exploit and manage relevant knowledge in order to address sustainability successfully.

Desorptive capacity

"Desorptive capacity is a firm's ability to externally exploit knowledge" (Lichtenthaler and Lichtenthaler, 2009: 1322).

External knowledge exploitation in the form of desorptive capacity is regarded as a complement to internal knowledge exploitation in the form of innovative capacity (Lichtenthaler and Lichtenthaler, 2009; Lichtenthaler, 2007). In terms of the external perspective of knowledge exploitation, desorptive capacity relates to the ability to identify external knowledge exploitation opportunities and to exploit that knowledge externally by transferring it to beyond the firm's boundaries (Fosfuri, 2006; Lichtenthaler and Lichtenthaler, 2009). In other words, desorptive capacity relates to the external deployment of knowledge that has been built from both, internal and external sources (Lichtenthaler and Lichtenthaler, 2009). Lichtenthaler (2007) suggests that technology licensing has become significantly more popular in recent years. He argues that firms seeking additional sources of revenues by transferring specific pieces of their technology to other firms such as buyers, suppliers, competitors and partner firms face a dilemma. They may well generate substantial revenues through outward licensing on the one hand but may lose part of their competitive advantage to licensees on the other (Fosfuri, 2006; Lichtenthaler, 2007). Therefore, it is critical that the negative consequences in the form of lost competitive advantage are overcompensated by additional revenues (Lichtenthaler and Lichtenthaler, 2009).

As regards the identification of external exploitation opportunities, monetary and strategic considerations play an important role (Rivette and Kline, 2000). More specifically, monetary considerations refer to generating revenues from licensing that would otherwise not have been realised by the firm's sale of goods (Lichtenthaler, 2007). Strategic considerations, for instance, can relate to the firm's entry into a foreign market whereby technology licensing may be decided to complement the supply of products (Lichtenthaler, 2007). This identification of opportunities is regarded a major challenge since licensing markets are imperfect in that demand and supply of knowledge and technology are not always known to (all) market participants (Fosfuri, 2006; Lichtenthaler, 2007; Teece, 1998). Following the same logic as with innovative capacity discussed above, desorptive capacity of the exploitative dimension represents the externally applied component of inventive and absorptive capacities of the explorative dimension (Lane et al., 2006; Lichtenthaler and Lichtenthaler, 2009).

Prior knowledge in external knowledge exploitation such as in the form of technology licensing can support the development of desorptive capacity. This includes, for instance, prior knowledge in identifying opportunities to be exploited externally, in screening potential licensing partners and in the actual outward knowledge transfer (Chesbrough, 2006; Fosfuri, 2006; Lichtenthaler and Lichtenthaler, 2009; Lichtenthaler, 2007).

In summary, desorptive capacity in this research is understood as an enabler for firms to externally exploit and manage relevant knowledge in order to address sustainability successfully.

2.10 Knowledge management in the context of sustainability

As discussed earlier, knowledge management plays a key role regarding the firm's ability to drive technology development, understand the market context as well as strategic implications and to derive competitive advantage from it (Lichtenthaler and Lichtenthaler, 2009). Especially, this holds true in the context of the sustainability challenge which represents fast-paced change and pressures that firms need to deal with (Huang and Shih, 2009; Sharma and Vredenburg, 1998). As various authors suggest, knowledge creation and its management are critical to address the dynamics of that challenge (e.g. Ahmed, 2007; Huang and Shih, 2009; Laszlo and Laszlo, 2007; Melville, 2010; Robinson et al., 2006; Stephens et al., 2008).

Lichtenthaler and Lichtenthaler's (2009) view is applicable to this challenge in that it not only forces firms to make existing solutions and technologies better incrementally through knowledge exploitation but also to invent new solutions that are path-breaking and radically different through knowledge exploration. In addition, the connection of

explorative and exploitative knowledge processes and the inter-temporal knowledge transfer through knowledge retention as suggested by Lichtenthaler and Lichtenthaler (2009) are crucial in dealing with the sustainability challenge to ensure that newly explored knowledge does not get lost or lies idle forever. In terms of path-breaking explorative solutions, Eisenhardt and Martin's (2000) view of path-breaking adjustment processes and mechanisms fits well into the context of the sustainability challenge. Sharma and Vredenburg (1998) argue that environmental strategies can lead to different paths of learning and knowledge creation which can also include experimentation with alternative approaches. This in itself can lead to the recognition of new objectives and means to satisfy these objectives with (different) capabilities (Sharma and Vredenburg, 1998). Learning processes in fast changing business contexts such as in the case of sustainability that require new resources, routines and capabilities are referred to as "higher order" learning (e.g. Fiol, 1994; Sharma and Vredenburg, 1998). Higher order learning enables firms to develop different interpretations of newly created and existing information which helps to gain new understanding of events surrounding the sustainability arena (Sharma and Vredenburg, 1998). Further, these often rapid learning processes can result in reorientations involving altered norms and values as well as the fast development of new capabilities (Sharma and Vredenburg, 1998; Shrivastava and Mitroff, 1982) which suggests that the notion of path dependency does not fully hold in the sustainability context. Along these lines of thinking, Kusyk and Lozano (2007) argue that the fast demand-dependent development of capabilities supports firms to engage in successful sustainability management. Further, Russo and Fouts (1997) suggest that well-informed managers can recognise opportunities and threats of the sustainability challenge and assemble necessary organisational resources and capabilities in order to manage the challenge successfully and derive competitive advantage.

Melville (2010) argues that knowledge can significantly contribute to the perception of individual and collective environmental responsibility within the firm and the formation of certain beliefs held about sustainability (i.e. the belief in sustainability), to the development of innovative environmental strategies (i.e. the action in sustainability) as well as to the improvement of the natural environment (i.e. the outcome of sustainability activities). These three aspects are regarded highly important for successful sustainability management and are combined in a "believe-action-outcome" (BAO) framework approach (Melville, 2010: 4). He notes further that knowledge creation and the sharing thereof, both internally and externally as suggested by Lichtenthaler and Lichtenthaler (2009), help individuals, teams and firms to assess which ideas and sustainability approaches could or could not work and why. Along this line of thinking, Sharma and Vredenburg (1998) suggest that environmental innovation that proves to be successful is adopted by a wider circle of firms as time passes. Thus, Melville's (2010) as well as

Sharma and Vredenburg's (1998) views are closely related to Eisenhardt and Martin's (2000) view that communalities exist in the sustainability context since such knowledge sharing supports the exchange of ideas and successful approaches which are then adopted by a wider group of firms. It is important to note that such knowledge sharing mechanisms can cause a trade-off situation between keeping knowledge secret and meeting the need to pool environmental information among firms (Carberry, 2001; Melville, 2010).

An integrated knowledge assessment approach that supports firms in evaluating and combining knowledge from different sources (e.g. internally and externally) and disciplines (Lichtenthaler and Lichtenthaler, 2009; Melville, 2010; Tol, 2006) can prove to be highly beneficial in building the knowledge required to deal with sustainability (Melville, 2010). In the light of the potential for significant value creation in a market context characterised by the rapidly evolving sustainability challenge such knowledge management efforts can be expected to have a significant chance of success and to have an impact on firm performance (Massey et al., 2002; Melville, 2010).

Huang and Shih (2009) propose "environmental knowledge management" (EKM) as a combination of generic knowledge management as suggested by Lichtenthaler and Lichtenthaler (2009) and environmental management. EKM is meant to advance a firm's activities in sustainability by creating, accumulating, sharing and applying environmentally relevant knowledge (Huang and Shih, 2009). More specifically, EKM is meant to integrate environmental concerns into a firm's resource management, routines and building of capabilities (Huang and Shih, 2009). Huang and Shih (2009) propose that EMK should not only focus on explicit but also tacit knowledge. While the highly codified and widely understood explicit knowledge (e.g. Cowan et al., 2000; Nonaka, 1994) is important, firms must also focus on the highly personal and hard to convey tacit knowledge (e.g. Kale and Singh, 2007; Nonaka, 1994). Tacit knowledge is obtained through informal learning mechanisms and experiences which often represent the origin of ideas for sustainable solutions (Huang and Shih, 2009). Employees with a high degree of openness for sustainability and an often related higher level of environmental knowledge, process new information by using this knowledge and are better able to develop sustainable solutions and to understand the benefits of sustainable actions (Huang and Shih, 2009; Stephens et al., 2008).

Katkalo et al. (2010) suggest that the dynamic capabilities construct needs to be developed further by researchers, for instance, through the integration into other research streams. This is what this research seeks to do at the example of the sustainability theme. Katkalo et al. (2010) argue that this integration is critical for the continued development of the dynamic capabilities construct. The authors also note that other aspects such as a firm's strategy, objectives, employee motivation and enablement need to be better

integrated in the dynamic capability view. The literature review on knowledge-related dynamic capabilities discussed so far has focused on how firm's acquire, maintain and apply knowledge in order to successfully fulfil a certain task and consequently build competitive advantage. The focus has been on the generic nature of knowledge-related dynamic capabilities since hardly any empirical work appears to have been done on dynamic capabilities in the context of sustainability management so far. Based on the cross-case analysis and the discussion further below, this research attempts to contribute to that.

3 Research design

This chapter on research design is structured as follows:

- The research gap is derived based on the research questions addressed in the introduction and on the literature review.
- By translating this research gap into a research structure, a conceptual framework is built.
- The research methodology is outlined featuring a conceptual, quantitative and a qualitative stage with a focus on case study research.

3.1 Research gap

Following the research questions as well as the literature review discussed earlier, the research gap can be derived. Eisenhardt and Martin (2000) argue that dynamic capabilities have to be regarded in the market context they are used in. The authors distinguish between capabilities required to cope with what they call "moderately dynamic markets" and "high-velocity markets". The literature on sustainability management as well as the conducted case studies clearly suggest that the sustainability challenge generates highly dynamic market conditions in the form of different stakeholder pressures (e.g. Delmas and Toffel, 2004, 2008; Etzion, 2007; Rivera-Camino, 2007; Wade-Benzoni et al., 2002). With the wider public becoming increasingly aware of the importance of sustainability and also willing to act (WBCSD, 2008), the sustainability challenge introduces drastic changes that management needs to address (e.g. Delmas and Toffel, 2008; Etzion, 2007; Linton et al., 2007). As the literature review in this research with a focus on knowledge-related capacities of the dynamic capability construct suggests, firms need to build and use relevant knowledge in order to address such challenges (e.g. Lichtenthaler and Lichtenthaler, 2009).

While abundant research exists on the dynamic capability literature stream with a focus on knowledge management (e.g. Eisenhardt and Martin, 2000; Teece, 2007) as well as on the sustainability management literature stream (e.g. Dyllick and Hockerts, 2002; Etzion, 2007; Rivera-Camino, 2007), there is little understanding on the potential of dynamic capabilities in the context of the sustainability challenge. Such a link between these aspects appears to be missing in the academic literature. Two related combinations have been addressed in the literature, which represent early attempts to partially fill this gap, namely the combination of the RBV (and static capabilities) with sustainability and the combination of knowledge (management) with sustainability.

First, some research was done on the combination of the RBV and static capabilities with environmental concerns (Hart, 1995; Russo and Fouts, 1997; Sharma and Vredenburg, 1998) just around the time when Teece et al. (1997) began to establish dynamic

capabilities as a generic construct. For instance, Hart (1995) discusses the RBV as a competitive theory in the context of corporate environmental strategies. As discussed in the section on the theoretical anchor of this research, the RBV proposes that competitive advantage and performance of firms depend on firm-specific resources and capabilities meeting the VRIN-criteria (e.g. Barney, 1991; Conner and Prahalad, 1996; Ginsberg, 1994; Peteraf, 1993; Wernerfelt, 1984). Hart (1995) analyses this view in the domain of sustainability by proposing that innovative environmental strategies - as an emerging concern - guide firms in developing firm-specific capabilities that are suited to build competitive advantage.

Extending Hart's (1995) theoretical work with qualitative and quantitative empirical analysis, Sharma and Vredenburg (1998) propose the development of static capabilities in order for firms to maintain and build their competitiveness in the context of uncertainties at the intercept of business goals and environmental concerns. Evidence from their studies with the Canadian oil and gas industry suggests that the development of such organisational capabilities is driven by firms' proactive environmental strategies reflected in firms' responsiveness to environmental issues (Sharma and Vredenburg, 1998). Evidence suggests further that such organisational capabilities include stakeholder integration, learning and continuous innovation which can all support firms in building competitiveness (Sharma and Vredenburg, 1998).

More work on the RBV in the context of sustainability has been done by Russo and Fouts (1997). Their central argument is that the RBV can help to sharpen the understanding of the impact of corporate social responsibility on business success. On the one hand, this is because the RBV focuses on competitive advantage and performance, on the other hand this is because it takes into account the importance of intangible concepts such as corporate culture and reputation (Russo and Fouts, 1997). As their statement "it pays to be green" (p. 549) suggests, Russo and Fouts (1997) find a positive link between environmental and economic performance and that growth in the industry under investigation strengthens this relationship.

While these works are related to the focus of this research and offer valuable insights, they are not suited to fill the research gap. This is because the authors have not addressed dynamic capabilities but rather focus on their static predecessor, the RBV and related static capabilities. However, as outlined earlier, it is indispensable for firms to deal with the market dynamism caused by the sustainability theme which the RBV does not accommodate to the degree the dynamic capability construct does.

Second, research exists on the combination of knowledge management with sustainability (Ahmed, 2007; Huang and Shih, 2009; Laszlo and Laszlo, 2007; Melville, 2010; Robinson et al., 2006; Stephens et al., 2008). The authors suggest that knowledge creation and management are critical for firms in order to be able to advance sustainability and respond to requirements.

However, the authors do not explicitly propose the dynamic capability construct for firms to deal with the sustainability challenge but merely refer to knowledge management. This connection between knowledge management and the sustainability theme, however, misses the importance of being able to deal with dynamic market change by applying higher-order constructs (e.g. Winter, 2003) such as dynamic capabilities. Therefore, the authors make no attempt to develop the dynamic capability construct further by applying it to new fields (such as to sustainability) as suggested by Katkalo et al. (2010).

The recent foundation of a large-scale research initiative called Global Organizational Learning and Development Network (GOLDEN) for Sustainability provides additional evidence for the existence of this research gap and highlights the importance to fill it. The initiative seeks to combine the fields of sustainability, organisation and strategic management in order to achieve the highest possible integration of sustainability into management practice. The initiative's main goal is to develop a research network among a large group of research institutions and hundreds of firms globally in order to produce high-level research with practical relevance. Members of the council and management team include well-known academics in the fields of dynamic capabilities and sustainability management. Dynamic capabilities for sustainability are a main focus area as these are believed to be instrumental in shifting to more sustainable business practices. Emphasis is laid on dynamic capabilities related to sensing capacities to understand arising challenges and opportunities such as stakeholder expectations, change capacity to adjust to new market forces and learning capacity to build the knowledge required to address sustainability issues. These capacities are all relevant to knowledge management and learning discussed in the literature section.

As noted earlier, Katkalo et al. (2010) suggest that the dynamic capabilities construct should be integrated with other research streams in order to spread its applicability and hence support its further development and maturing process. By providing empirical evidence, this is what this research seeks to do at the example of the sustainability theme. Specifically, this research combines knowledge-related capacities of the dynamic capability construct with the sustainability challenge and thereby "cross-fertilises" two entirely different but yet complementary research streams in order to fill the discussed research gap. This "cross-fertilisation" is particularly important as regards the sustainability challenge since it requires firms to have knowledge at their disposal to find

solutions. However, having that knowledge at the project-level is not enough. On a higher-level, firms need to be able to manage and coordinate this knowledge in order to keep up with changes in the market context and to be ahead of the curve. To succeed on this higher level, firms require knowledge-related dynamic capabilities such as the knowledge management capacity suggested by Lichtenthaler and Lichtenthaler (2009).

3.2 Research model

Based on the discussion of the research gap, the conceptual framework depicted in Figure 4 can be constructed. The objectives and research questions discussed in the introduction are reflected in this framework. This ensures a consistent approach throughout this work in answering the research questions.

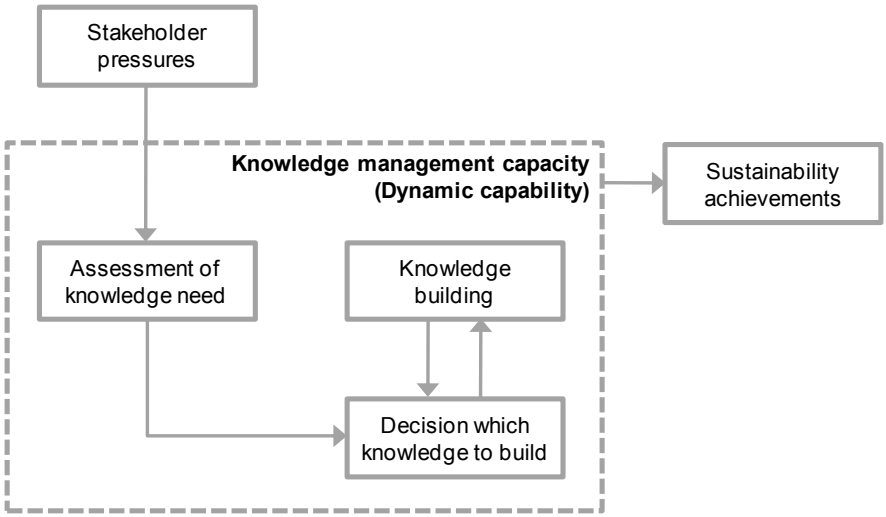

Figure 4: Conceptual research framework

This framework proposes important relationships between elements of research streams in the academic literature that have hardly been covered. Overall, the framework connects the sustainability challenge, the knowledge management capacity - which Lichtenthaler and Lichtenthaler (2009) regard as the actual dynamic capability that includes the management and coordination of knowledge capacities - as well as the resulting impact on a firm's approach to sustainability.

First, it is proposed that the sustainability challenge and the stakeholder expectations it consists of impose pressure on firms (e.g. Delmas and Toffel, 2008; Etzion, 2007; Rivera-Camino, 2007). Sharma (2000) finds that in order for firms to act more progressively with respect to sustainability, this ecological challenge needs to be regarded as an opportunity for future business success rather than as a threat. Before firms can develop knowledge-based solutions to challenges and thereby make use of such opportunities, they have to identify these pressures. As Lichtenthaler and Lichtenthaler (2009) argue, the detection of opportunities embedded in the internal and

external explorative capacities (inventive and absorptive capacities, respectively) plays a crucial role. Overall, this addresses the issue of which knowledge-related abilities firms perceive to be important in order to detect opportunities to build knowledge in the light of the sustainability challenge.

Second, it is proposed that this need for knowledge to deal with the sustainability challenge shapes firms' beliefs on what is the necessary knowledge (i.e. target knowledge). By comparing this target knowledge with the exiting knowledge of the firm (i.e. actual knowledge), this connection helps the firm to determine the knowledge gap that needs to be filled. Overall, this addresses the issue of which types of knowledge firms perceive to be important in order to address the sustainability challenge.

Third, it is proposed that once firms have decided on which knowledge they need, they have to build it (i.e. inventive and absorptive capacities), retain it (i.e. transformative and connective capacities) and apply it (i.e. innovative and desorptive capacities). Since the market context continuously generates changing requirements, firms need to keep track by readjusting and realigning their knowledge base internally and externally (Lichtenthaler and Lichtenthaler, 2009). This should not only include explorative or exploitative efforts (e.g. March, 1991) but also retentive efforts (e.g. Grant and Baden-Fuller, 2004; Kale and Singh, 2007; Pandza and Holt, 2007) as proposed by the knowledge capacities in the Lichtenthaler and Lichtenthaler (2009) framework. Disciplined and structured knowledge management efforts are particularly important for firms in order to master requirements of the sustainability challenge (e.g. Huang and Shih, 2009; Laszlo and Laszlo, 2007; Melville, 2010; Stephens et al., 2008). Overall, this addresses the issue of which knowledge-related abilities firms perceive to be important in order to build, retain and apply knowledge continuously.

3.3 Research methodology

3.3.1 Research design

As illustrated in Figure 5, the research design consists of a conceptual, a quantitative and a qualitative stage.

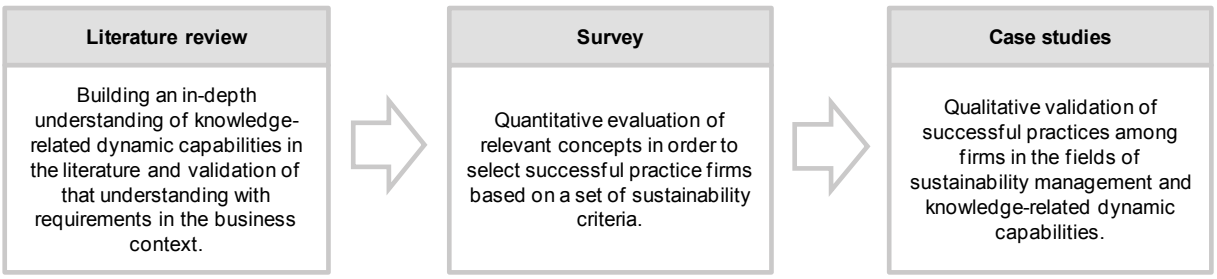

Figure 5: Methodological approach

3.3.2 Literature review

A thorough literature review was conducted to gain insights into the research streams of sustainability with a focus on the ecological aspect and of knowledge-related dynamic capabilities which this study aims to apply in the context of the sustainability challenge. This literature review helped to define the focus of this work before starting to generate empirical data. This procedure supports researchers to systematically gather the desired data set while at the same time avoiding an overflow of irrelevant information (Eisenhardt, 1989). The building of understanding of knowledge-related dynamic capabilities in the literature was complemented by regular interviews with practitioners in manufacturing firms which actively address the sustainability theme. This regular validation of the understanding derived from the literature with the requirements in the business context ensured an alignment of theoretical and managerial implications.

3.3.3 Data generation

Data generation consist of two parts, namely a survey and a series of case studies.

Survey

In order to be able to select a relevant sample of manufacturing firms for case studies in this research, an industry survey was conducted. Based on the literature review and interviews with practitioners and academics in sustainability management, a questionnaire was built. The questionnaire measured items on a five-point Likert scale, generally ranging from 1 = "totally disagree" to 5 = "totally agree" and including an option "don't know". The questionnaire was pre-tested for understanding among industry experts as well as academics (Dillmann, 1978) and their feedback was incorporated to ensure a user-friendly and well-structured questionnaire.

The questionnaire-based survey was conducted to obtain a broad quantitative data set. The sample of target firms to participate in the online survey was taken from the extensive ITEM-HSG industry data base. This was complemented by existing personal contacts and newly identified contacts through publicly available information (websites, industry association databases, etc.) to avoid potential bias from convenience sampling (Zhu et al., 2008). The focus was laid on manufacturing firms headquartered in German-speaking Europe whereby a cross-industry approach was followed to avoid sector bias (Voss et al., 2002). To ensure a relatively consistent organisational view on the matter (Voss et al., 2002), predominantly senior managers on the field of sustainability were contacted, namely the Head of Sustainability or the Head of Health, Safety, Environment & Quality (HSE&Q).

Overall, the sample size was 421 from which 56 useable questionnaires were returned with a relatively even distribution across industry sectors and other characteristics such

as firm size. The returned questionnaires proved to be highly useful in order to select the most interesting firms for case studies.

Case studies

This work follows a qualitative research approach. Qualitative social research is suited for instances when not much is known of a given issue or when known results should be looked at from a new perspective (Eisenhardt, 1989; Voss et al., 2002; Yin, 1994). It is the goal of case study analysis to examine one case or a small number of cases in detail to gain depth and comprehensive knowledge (Punch, 1998). To reach this level of depth, explorative case studies are conducted in order to be able to - as Gephart (2004) and Eisenhardt and Graebner (2007) put it - better approximate social reality. In the case of this research, the qualitative case study approach helps to analyse and interpret firms' approaches to knowledge management under the dynamic capability umbrella in order to address the sustainability challenge with appropriate solutions. This approach is chosen because not much is known about knowledge-related dynamic capabilities including knowledge exploration, retention and exploitation in the context of the sustainability challenge. Therefore, more detailed information and in-depth understanding are required. The goal of this research is to understand the phenomena under investigation and contribute to the body of literature such as how firms address knowledge management in the context of the sustainability challenge. Trying to gather this information with quantitative measures would limit research objects to respond within given categories (such as Likert scales) and would not let them provide important qualitative detail (Mayring, 2002; Tomczak, 1992). Punch (1998) states: "Quantitative research readily allows the researcher to establish relationships among variables, but is often weak when it comes to exploring the reasons for those relationships. A qualitative study can help to explain the factors underlying the broad relationships that are established" (p. 247). This lends further support to the qualitative approach since exploration is necessary to gain more insights into knowledge-related dynamic capabilities in the context of sustainability.

Case study procedure

Ten firms were selected among survey respondents by applying theoretical sampling (Eisenhardt, 1989). The defined set of criteria included a workforce larger than 250 which is conditional to be considered a large enterprise (Strahm, 2008), international operations, a team in charge of sustainability and an annual sustainability report. Semi-structured telephone interviews of one hour were then conducted with these firms by two experienced researchers to allow for "investigator triangulation" (Patton, 1987). Interviews were based upon a set of questions derived from the literature review and interviews with both, academics and practitioners. Research partners at the Norwegian

University of Science and Technology, the University of Cambridge and the Centre for Corporate Responsibility and Sustainability at the University of Zurich were actively involved in the definition and refinement of these questions. The questions were validated by three practitioners and academics each who are working on sustainability management. Ten short case study summaries were written, validated among the two involved researchers and then sent back to the interviewees to check for misunderstandings and misinterpretations. The collection of data from various sources facilitated triangulation (Lamnek, 1995; Leonard-Barton, 1990; Yin, 2009). Along these lines, primary data such as interview findings were complemented by openly available secondary data for the purpose of data triangulation (Patton, 1987; Yin, 2003) which facilitates the development of "converging lines of inquiry" (Yin, 2003). This means "any finding or conclusion in a case study is likely to be much more convincing and accurate if it is based on several different sources of information, following a corroboratory mode" (Yin, 2003, p. 98). This is particularly important in "polarising" research areas such as sustainability management, meaning that extremely positive and negative attitudes might be encountered. Among these ten cases, the four sample firms shown in Table 7 were selected to be visited on-site. These firms were selected based on the overall credibility of their sustainability management, their approaches to sustainability innovation, their business case for sustainability as well as their willingness to participate in a research study. The interviews with these firms also enabled researchers to check how proactive these firms really are in addressing sustainability. This check is particularly important since most firms claim to engage in sustainability as it is socially expected (e.g. Stier, 1999) but not all actually do which cannot reliably be detected in the survey results. This follows the notion of multiple cases for more robust results (Eisenhardt and Graebner, 2007) and is in line with a sample size of four to ten as recommended by Eisenhardt (1989).

Sample firms	Industry	Headquarter
CHEMICAL LTD	Manufacturer of pharmaceuticals and high-performance materials	Germany
RETAIL LTD	Food and non-food retailer with integrated manufacturing operations	Switzerland
OUTDOOR LTD	Manufacturer of outdoor textiles and wearing apparel	Germany
CAR LTD	Manufacturer of vehicles	Germany

Table 7: Sample firms

Overall, the unit of analysis in this research is a group of manufacturing firms which emphasise the ecological aspect of sustainability and which are headquartered in the German-speaking region of Europe to avoid cultural bias (Vereecke et al., 2006). This analysis takes a management view because this allows a holistic perspective of sustainability management which otherwise could not be obtained. Therefore, the research team interacted directly with the global head of sustainability of each sample

firm and their sustainability team which provided all-encompassing insights of sustainability practices among sample firms. Focusing on sustainability management concerning processes or products in isolation would be insufficient to provide such a holistic view.

The selected four firms were visited whereby several blocks of semi-structured interviews of 60 to 90 minutes were conducted with different employees of the sustainability teams. This was complemented by open discussion sessions which provided additional insights. In line with the emphasis of this research, interviews and discussions focused primarily on sustainability management and strategy as well as the specific business case for sustainability. Along these topics, special emphasis was laid on knowledge-related dynamic capabilities. The main goal was the identification of successful and less successful approaches to facilitate learning of all involved parties. The procedure regarding the construction of the set of questions as well as the writing of case study summaries was the same as with the ten short case study summaries described above. These sessions were recorded with the purpose to double-check statements while writing the case study summaries. In addition, two research partners took notes during interviews and discussions to allow triangulation from multiple sources of evidence (Yin, 2003), in this case investigator triangulation (Patton, 1987). Such triangulation among different evaluators (i.e. two researchers) included the comparison of notes to ensure accurate findings through a corroboratory mode (Patton, 1987; Yin, 2003). In case of disagreement between researchers, the topic was discussed and if no consensus was found, the topic was brought back to the firm for clarification. This procedure allowed the research team to check for inter-rater reliability (Voss et al., 2002).

Data analysis

As noted earlier, this research follows Eisenhardt's (1989) approach of building theories from case studies. Generated data was successively entered into a case database. Following each interview, a summary was written to highlight emergent issues (Miles and Huberman, 1994; Sharma and Vredenburg, 1988). The complete dataset of each firm was then aggregated into separate case histories in order to be able to assess the fit of the case study data (e.g. Eisenhardt, 1989; Leonhard-Barton, 1990). In an iterative process, various documentations such as interview transcripts and filed notes were compared with and mirrored at the relevant literature. Cross-case analysis was performed (e.g. Eisenhardt, 1989; Yin, 2003) and data was tabulated whereby techniques such as cross-case pattern sequencing and pair-wise comparisons were applied (Miles and Hubermann, 1994). As suggested by Eisenhardt (1989), the within-case study analysis supported understanding of the phenomena and facilitated the cross-case analysis.

4 Case studies

This chapter is dedicated to four cases studies (see Table 7) conducted in the course of this research. For the purpose of consistency and comparability, all case studies are structured in the same way. With a focus on knowledge management for sustainability, this structure features the following topics:

- General information on sample firms
- Market context
- Approaches to sustainability strategy
- Approaches to knowledge management
- Achievements of sustainability management

4.1 CHEMICAL LTD

4.1.1 General information

CHEMICAL LTD is a major international player in the fields of pharmaceuticals, agrochemical products and high performance polymers. The group owns a large number of fully consolidated firms. CHEMICAL LTD is headquartered in Germany. R&D and manufacturing are done in Western Europe, North and South America, China and other regions in Asia. Sustainability is managed centrally by the Corporate Centre of Sustainability and Environment to ensure a consistent global strategy which is then adjusted to local requirements. The firm issues a separate annual sustainability report.

4.1.2 Market context

CHEMICAL LTD's answer to market pressures

CHEMICAL LTD argues that sustainability is an essential requirement for internal and external stakeholders and is therefore indispensable in order to keep the "license to operate". The firm notes that expectations of external stakeholders regarding the firm's commitment to sustainability have become more explicit. These expectations include a high level of sustainability efforts (such as keeping the impact of a new plant on the ecosystem as low as possible and preventing waste of hazardous substances) and high transparency in its activities. Stakeholder groups such as NGO and politics are becoming more confident and demanding. The generally held belief is that the public is entitled to know what the firm does in terms of sustainability. CHEMICAL LTD's Corporate Centre of Sustainability and Environment is aware that more resources need to be in place to better account for stakeholder expectations. However, resources tend to be tightened in an attempt to cut cost further in response to the financial crisis.

Sustainability is relevant for all three subgroups. First, health care is exposed to demands from scientists, environmental associations and NGO regarding the effects of pharmaceuticals following their use. Specifically, there is concern about the remaining doses of pharmaceutical substances that go into the sewage system and therefore into the water, the soil and consequently agricultural produce. In most countries, water purification plants cannot extract remaining substances. Second, crop science is already highly sustainable since it hardly uses any water and energy in production and since the products themselves contribute positively to sustainability (such as crops that need considerably less water to grow). This is particularly important since agriculture consumes about 70% of fresh water globally. Third, material science products contribute to sustainability in the form of high-tech polymers which are used as building insulations.

Overall, sustainability for CHEMICAL LTD means that the business needs to generate economic benefits and simultaneously reduce the ecological and social impact of its operations. Therefore, CHEMICAL LTD's sustainability initiatives focus on all three aspects of the triple bottom line. In terms of initiatives in social sustainability, the firm seeks to build access to health care such as family planning and the provision of drugs against certain diseases in developing countries. In terms of initiatives in ecological sustainability, the firm promotes sustainable agriculture in order to satisfy the rising global demand for high-quality food supplies while simultaneously contributing to the conservation of nature. This is achieved through innovative crop protection products that safeguard harvest yields, limit the application of pesticides and help to maintain biodiversity of crop landscapes. The economic aspect of the triple bottom line is incorporated in all of the firm's sustainability initiatives. Such initiatives that tackle sustainability challenges are called "Lighthouse Projects".

The overall goal of the firm's sustainability initiatives can be summarised as an attempt to meet stakeholders' expectations in sustainability, to build trust internally as well as externally by credibly engaging in sustainability and consequently to strengthen reputation and image (through "Lighthouse Projects") while at the same time reducing risks that might at some point in time materialise and affect reputation and image negatively (through stakeholder involvement, most notably with NGO).

In terms of the history of adoption of sustainability, CHEMICAL LTD's first official initiative was the foundation of the "Waste-Water Commission" in 1901. The initiative focused on adjusting the processes in the firm's dye production in order to improve the quality of waste-water and reduce the overall environmental impact. With the rapid expansion of its headquarter, an increasing number of employees moved into the neighbourhood. The initiative was launched in order to ensure a high quality of life for this growing community. Since then, sustainability has played an integral part in its

operations. In terms of reporting, the first report on the environment and society was issued in 1976 with the goal of being as transparent as possible in the disclosure of information.

Among the vast number of sustainability initiatives, the most important efforts at the moment focus on an even tighter integration of sustainability aspects into overall business strategy in all three subgroups. To ensure that, the participation of the Corporate Centre of Sustainability and Environment in decision-making processes of the three subgroups has been established.

This should ensure that sustainability considerations - across all business units and functions - are aligned with business objectives right from the start of a project through to the end. Other current sustainability initiatives focus on climate and environmental protection (e.g. energy saving technologies applied in the energy-intense chlorine production), provision of nutrition to a growing population with decreasing agricultural space available (e.g. more resistant crops) and global access to health care (e.g. vaccination against tropical diseases).

Prioritisation mechanisms are in place, which help the firm to identify the initiatives to focus on. Prioritisation is based upon disciplined and well-structured "stakeholders checks" in the form of interviews with various stakeholders which identify trends in terms of tomorrow's needs. These uncover the most important topics and challenges on the market and give an indication as to which stakeholders are most powerful and dangerous. In addition, each of the three subgroups' competitive intelligence units collect market intelligence from sales forces and run regular interview sessions with their specific stakeholders since their requirements in terms of sustainability diverge between subgroups. For example, customers of health care expect the firm to deal with residual substances in the waste water while customers of material science expect lightweight high-performance materials. These complementary interviews are highly valuable to the subgroups' closeness to their specific markets. In response, publically demanding stakeholders such as NGO are then involved in discussions before an initiative is implemented such as the construction or extension of a manufacturing site. Such stakeholder involvement allows involved parties to openly discuss and reach an agreement on the impact of that construction (such as building new access road or cutting trees) as well as on measures to keep the impact as small as possible (such as constructing a CO2-neutral building or planting more trees along the road).

Stakeholder pressures

The described stakeholder checks help the firm to detect opportunities on the field of sustainability and to build understanding of sustainability drivers. CHEMICAL LTD believes that necessary abilities include detailed market knowledge (by the three

subgroups) which includes gathering knowledge about potential demand for a given product line and challenges such as regulatory risks or NGO pressures. Further, a thorough understanding of the subgroups business case is essential which includes the ability to see possibilities of implementation of sustainability initiatives which does not only include products but also efficient production. In addition, the willingness and ability to pursue a long-term horizon is essential which allows employees to see sustainability as a proper opportunity rather than a short-term hassle.

Three stakeholder pressures are particularly important for CHEMICAL LTD, with NGO being the most important one, followed by customers and shareholders. First, NGO are extremely powerful in that they have strong support in the public as they neither represent political nor business interests. If they turn against a firm it can cause severe reputational damage which the firm tries to prevent. Specific expectations of NGO include their early involvement in important projects such as the construction or extension of a manufacturing site. This allows both parties to openly discuss the issue and find an agreement on the impact of the project such as the need to build a new access road or cutting trees. It also supports an agreement on measures to keep the impact as small as possible such as constructing a CO2-neutral building or planting more trees along the road. Second, customers are important by definition since they purchase the firm's products. For instance, customers expect that no child labour is involved in production processes, that emissions from production are reduced and that products represent no hazard after use such as in the form of toxic residual substances in sewage water and patients' bodies. The last concern mainly comes from medical doctors not wanting to prescribe pharmaceuticals that might cause these effects. Third, shareholders are important since they are the owners of the firm and provide the working capital the firm needs. Specific expectations, for instance, include that sustainability initiatives cause extra return and cost savings through efficiency and ensure risk-reduction.

4.1.3 Sustainability strategy

Sustainability strategy highlights

CHEMICAL LTD understands sustainability as realising economic benefits while at the same time reducing negative social and environmental impact in order to keep its license to operate. Also, the firm regards sustainability as a measure for risk mitigation, especially in the context of NGO which can put any firm's reputation at risk. In addition, sustainability is seen as a large source of future business opportunities such as with drought-resistant crops or CO2-absorbing technologies in the context of global warming. Due to the vast number of powerful external stakeholder groups, sustainability efforts are more externally than internally driven.

CHEMICAL LTD has a formally written sustainability strategy which is featured on the website and in the sustainability report. The sustainability strategy is reviewed at quarterly sustainability committee meetings. However, strategy changes do not happen regularly since the sustainability strategy is primarily based on long-term planning. This is because it is in the nature of sustainability to have a long-term horizon. Regular ad-hoc changes to the sustainability strategy would have a negative impact on credibility among stakeholders. In theory, the sustainability strategy is on a higher level than manufacturing, marketing or product strategies of the three subgroups since it is embedded into the sustainability committee at the corporate centre reporting directly to the group board of directors. By contrast, manufacturing, marketing and product strategies are owned by management of the three subgroups. However, in practice the perception prevails that these "classic" strategies are on a higher level than the sustainability strategy.

CHEMICAL LTD's sustainability strategy is formulated in order to be able to respond to the sustainability challenge arising from the discussed drivers, most importantly NGO, customers and shareholders. CHEMICAL LTD defines sustainability as achieving commercial success in a way that it is compatible with meeting the needs of employees and society as well as protecting the environment and natural resources. Sustainability is integrated into corporate strategies and not separate from them. Further, sustainability drives growth by creating business opportunities and helps to mitigate risks and reduce costs. In order to achieve that, the firm constantly seeks to provide innovative solutions to global challenges in terms of sustainability, most importantly

- climate and environmental protection,
- nutrition for a growing population (ensuring sufficient quality of food supplies while acreage per capita is decreasing) and
- global access to health care (ensuring health education and supply of medicine and therapies).

As mentioned earlier, concrete initiatives to tackle these challenges are called "Lighthouse Projects" and focus on improving resource efficiency in its operations, supplying alternative crops (such as insect- and drought-resistant crop) and promoting partnership networks for sustainable buildings through the use of alternative materials. To meet the challenge of rising demand for nutrition caused by a growing world population, the firm's crop science subgroup engages in promoting partnerships along the entire food value chain with a focus on farmers in order to increase harvest yields and consequently farmers' income. For instance, this is achieved by applying new rice growing methods such as "direct-seeded rice" which is at an advanced stage to harvest before it is planted on rice paddies and therefore needs significant less water to mature.

As regards the challenge of global access to health care, the firm's health care subgroup

runs family planning initiatives (promoting sex education and provision of the pill) and provides medicine to rare and neglected diseases (such as Chagas) in developing countries. In addition, the firm has set up a donations fund department at the corporate level which is directly linked to the board of directors. Associated with this fund, all three of CHEMICAL LTD's subgroups have their specific sub-fund for which they are responsible. This includes the screening of potential sustainability projects, the selection and the allocation of funds. The allocation of funds is mainly based on criteria such as the urgency of the potential project and the potential volume of commitment, for instance. The firm occasionally selects projects on the basis of online votes. Fund allocation policies differ between regions and subgroups in order to account for specific circumstances.

CHEMICAL LTD's sustainability strategy is regarded as important because it helps to identify and develop business opportunities, enables to engage in risk identification and mitigation and strengthens its reputation and brand. All these benefits are relevant in the local and global context.

Sustainability considerations and criteria are taken into account when investment decisions are made suggesting that investments are not exclusively made upon payback and break-even considerations. Investments over EUR 10m go through the "Ecological Assessment" which is an assessment of the ecological impact along a set of criteria such as the potential of CO2-reductions and of energy-, material- and water-savings. This is monitored by the investing subgroup, approved by the investment committee on the board level and governed by group directive regarding informed decision-making.

Overall, CHEMICAL LTD understands its sustainability strategy as a systematic approach to identifying business opportunities with the help of a thorough understanding of the sustainability challenge. For instance, such opportunities exist with direct-seeded rice requiring less water to grow or sustainable high-performance materials used for better insulation in buildings. It also includes the credible execution of sustainability initiatives such as in energy-efficiency, CO2-reduction and water management in order to keep the license to operate among stakeholders. The resulting sustainability orientation is also seen as a measure for risk mitigation since environmental or social issues, such as a spill of hazardous substances or the detection of child labour can cause severe reputational damage. To sum up, the reasons why CHEMICAL LTD has decided to emphasise sustainability are the following:

- Tightening global resource markets
- Increasing capital market attention
- Increasing competitive behaviour
- Changing customer and consumer behaviour
- Higher regulatory pressure
- Employees' expectations

Need for knowledge and derivation of the knowledge gap

In order to be able to find solutions to the sustainability challenge, knowledge is needed. By understanding and taking into account these pressures, CHEMICAL LTD derives opportunities from the sustainability challenge that are met by the creation and application of the required knowledge. This helps the firm to meet expectations of stakeholders and thereby to keep its license to operate. CHEMICAL LTD derives the need for knowledge from the results of the "stakeholder check". The identification of priority topics indicates a related need for knowledge which the Corporate Centre for Sustainability and Environment assesses. For example, the fact that various stakeholders expect the firm to reduce emissions in its processes (e.g. through energy savings) creates a need for knowledge in order to find appropriate solutions. Another need for knowledge is related to what is happening on the subgroups' respective sales markets in terms of new products and pricing. The internal knowledge and skill set is regularly assessed to identify gaps and highlight a need for action. For instance, this is done by Human Resources and line managers in the process of employee and team evaluations or by leaders of sustainability projects who assess the required knowledge to complete projects. In these cases, CHEMICAL LTD assesses which knowledge is already available internally in terms of emission reduction and the market context and which knowledge is needed still. For instance, the firm identified knowledge gaps in more stringent energy-efficiency measures in the highly energy-intensive chlorine production and in the often weak market knowledge of some employees in subgroups. This assessment allows a fast reaction in terms of an appropriate adjustment of the knowledge base. Missing sustainability knowledge is aggregated from internal and external sources. CHEMICAL LTD regards the accumulation of knowledge and skills that meet the specific requirements of each subgroup as critical. In terms of hierarchy, there are differences between capabilities needed on lower and higher levels. Generally, lower-rank employees tend to need specialist knowledge focusing on a given area at the project level while higher-rank employees need more generalist knowledge, see "the bigger picture" and have a coordinating role.

Decision-making which knowledge to invest in

In terms of the organisational structure of sustainability management, the Sustainability Committee attached to the corporate centre is the highest body and reports to the board of directors. The committee is chaired by the head of the Corporate Centre of Sustainability and Environment and also consists of the heads of sustainability in the three subgroups and the two large joint-ventures. It is responsible for final decision-making about sustainability initiatives (e.g. which "Lighthouse Projects" to pursue) across the three subgroups and for the promotion of sustainability through awareness

raising events, newsletters and presentations. Previously, the three subgroups could decide independently on sustainability initiatives. This procedure was changed to ensure that sustainability has highest priority not only at the corporate level but also in the subgroups. The Corporate Centre of Sustainability and Environment assists the committee by doing the necessary groundwork for the committee to be able to make informed decisions. For example, this includes the screening of the market context (e.g. "stakeholder check") and the collection of best practices in sustainability management. Based on this information, the team also decides about the acquisition of relevant knowledge in order to address concrete aspects of the sustainability challenge (e.g. energy-saving production technologies), who acquires it (e.g. which production site in which subgroup), where it is sourced from (e.g. internally or externally) and how it is acquired (e.g. knowledge sharing in partnerships or acquisition of technology). The team also chooses the most critical sustainability initiatives and proposes them to the Sustainability Committee for final decision-making. At the moment, the focus of such initiatives lies on energy-efficiency and CO2-reduction (through energy savings in processes and the production of insulation materials) as well as on crops resistant to challenging environmental conditions.

The implementation of the sustainability strategy and related "Lighthouse Projects" takes place at the three subgroups. Since the three subgroups are different in terms of the challenges they face regarding their products (e.g. ingredients, components, size and weight), processes (e.g. energy-, material and water-requirements, use of hazardous substances and emissions) and culture (e.g. employees and customers in health care versus material sciences), a certain degree of mutual understanding is required. Employees of the Corporate Centre of Sustainability and Environment therefore need to be able to "speak the same language" with colleagues of all subgroups in order to be able to support them during the implementation. The Corporate Centre of Sustainability and Environment not only gives guidance but also coordinates the implementation of activities. Further, it is responsible for strengthening the collaboration on sustainability issues between the subgroups and the corporate centre during implementation and beyond. For example, this builds understanding of what the other subgroups are doing in terms of sustainability and to exchange lessons learned and successful approaches that might be useful to another subgroup.

The sustainability strategy is centrally managed because it is part of the firm's global strategy which aims to account for local requirements and specifications generically. Further, sustainability strategy is customised for subsidiaries across all regions to facilitate implementation and to allow for a better fit of initiatives (such as the "Lighthouse Projects") to local needs. Due to significant differences in challenges among subgroups and regions (e.g. regarding production processes and resource requirements,

regional environmental regulation), comparability is not given which is why the firm does not engage in benchmarking to measure performance internally. Neither does the firm use financial compensation based on sustainability performance. Moreover, managers in the Corporate Centre of Sustainability & Environment hold key accounting roles in the firm's three subgroups to ensure compatibility of central management and customised implementation. Local subsidiaries can focus on initiatives that are most relevant to them. For instance, the mentioned direct-seeded rice initiatives make more sense for dry regions because the seeds need considerably less water to mature. The underlying guidelines and principles of initiatives, however, are the same and in line with global strategy.

Required knowledge for sustainability management

CHEMICAL LTD believes that knowledge management is particularly important in order to address the sustainability challenge. In terms of knowledge types, market, strategic and technical knowledge is regarded critical. First, market knowledge is about the current and potential (groups of) customers of the three subgroups, the regions with the largest growth potential, where the largest risks lie (e.g. child labour, etc.) and which product portfolio needs to be developed in order to satisfy customer requirements (e.g. price, product characteristics). Second, since business and sustainability goals can diverge, strategic knowledge is critical in order to know how to find the largest common denominator (in terms of product portfolio) between the two. In addition, it includes knowledge about how to find the largest common denominator when moving from a single-stakeholder to a multi-stakeholder perspective. For example, opinions of NGO and shareholders can diverge substantially regarding a costly sustainability initiative. Third, innovation is seen as essential technical knowledge since it not only driven by sustainability but also drives it. An example is CHEMICAL LTD's innovative "dream production" which uses CO2 as an ingredient for the production of polymers. Another example is the development of the oxygen depolarised cathode to reduce energy consumption by 25% in the highly energy-intense chlorine production. In general, technical knowledge is required to address the challenges of CO2-emissions as well as water-, energy- and material-efficiency. Strong R&D efforts are believed to be critical in order to build technical knowledge.

4.1.4 Approaches to knowledge management

Knowledge management

All of the discussed knowledge types (i.e. market, strategic and technical) exist internally. However, in order to stay competitive in sustainability management, they need to be updated continuously to ensure that the firm is able to keep track with

changing pressures. This is why CHEMICAL LTD engages in active knowledge management which includes the creation of new knowledge, the storage of that knowledge and the transfer to where it is needed and finally the application of that knowledge. The main challenge with internal and external sourcing of knowledge is to pool, connect and transfer it in such a way that it can be efficiently deployed when needed. All discussed stakeholder pressures influence the firm to engage in such an all-encompassing approach to knowledge management. Again, the "stakeholder check" helps the firm to decide which knowledge to focus on and therefore to invest in.

Knowledge building

New knowledge from internal sources is built though intense knowledge exchange and feedback on solutions between central, subgroup and regional R&D. The generation of knowledge for the internal development of the oxygen depolarised cathode discussed above that contributes to significant energy-savings in the chlorine production is an example. To benefit from widely scattered pieces of knowledge on energy-saving measures across the firm, this knowledge was aggregated and constantly updated with new findings by the project team in charge of the initiative. Further, all employees are encouraged to contribute to improvement initiatives such as on energy-efficiency which are open to all functions and hierarchical levels to ensure contributions from a wide angle. Prizes are awarded to best contributions.

Knowledge building from external sources includes a business-research cooperation of CHEMICAL LTD's R&D with a local energy producer and a local research institution. This cooperation resulted in the new knowledge required to realise the "dream production project" discussed above which uses CO2 as a component for the production of polymers. As in the case of internal knowledge building, the project team in charge of this initiative aggregated the knowledge among involved partners to build the body of knowledge.

Knowledge storage and transfer

Internal knowledge storage and transfer with the help of intranet or databases is not currently practiced but the Corporate Centre of Sustainability and Environment notes that this needs to be done in the future to ensure flow of knowledge relevant to sustainability. However, the team issues a quarterly newsletter which includes contributions on sustainability topics of different regions and units which to some degree enables internal knowledge sharing. Authors share their knowledge with the employees who read their contributions.

Access to external knowledge is supported through CHEMICAL LTD's numerous memberships in industry associations which allow access to sustainability knowledge.

These industry associations include "Verband der Deutschen Industrie", Verband der Chemischen Industrie", Econsense, "Verband Forschender Arzneimittelhersteller" and others. At a formal level, knowledge sharing takes the form of reports, studies and minutes that are produced by these associations. At an informal level, knowledge sharing is facilitated through employees' personal networks which allow them to access other firms' or individuals' knowledge to a certain degree.

Knowledge application

The internal use of the created and transferred knowledge takes place at the product development and manufacturing technology level. Examples for the actual development of new manufacturing technologies include the oxygen depolarised cathode or the "dream production". In the case of the former, new knowledge about energy-efficiency measures in the chlorine production was used. In the case of the latter, knowledge about CO2-absorbing mechanisms to be applied in the production of polymers was used.

External use of knowledge in the form of selling licensing agreements is not currently done. However, "dream production" could be a solution to be licensed out in the future.

Supporting and hindering factors in knowledge management

CHEMICAL LTD believes that supporting factors for knowledge management in the context of sustainability exist. For instance, a critical distance from the daily business in the subgroups is regarded important. Taking such a neutral view is critical to be able to assess and absorb what is happening in the market context such as new trends in health care. Offering such a neutral view is the value proposition of the Corporate Centre of Sustainability and Environment which is independent and separate from the subgroups and their daily business.

Several factors exist at CHEMICAL LTD that hinder knowledge management for sustainability. As noted earlier, the Corporate Centre of Sustainability and Environment observes that employees in the subgroups occasionally do not have a proper understanding of their market. If this is not given, it is hard for subgroup management and the Corporate Centre of Sustainability and Environment to accumulate market knowledge and develop a suitable sustainability strategy for each subgroup. Along these lines, a thorough understanding of the subgroups' sustainability strategy is observed to be absent among some employees which is an obstacle to strategy implementation as well as the related knowledge accumulation and the running of initiatives. Overall, this lack of understanding of the subgroups' market and strategy makes it difficult among some groups of employees to fully grasp the implications of sustainability. Direct links between the Corporate Centre of Sustainability and Environment and the board are established, however, these are not always useful since there are instances when

sustainability is "not that high up on management agenda". Also, resources for sustainability initiatives are hard to obtain due to current cost-cutting efforts by management. Therefore, any sustainability initiative without a high probability of fast return can hardly be justified. In addition, sustainability is not always treated with a longer-term view which makes it even more difficult to pursue larger sustainability initiatives. Further, CHEMICAL LTD does not yet have a sustainability database in place that ensures knowledge retention and transfer among teams and employees at any time.

Ability highlights

CHEMICAL LTD believes that several abilities are needed that facilitate successful sustainability management in general and the building, storage and transfer as well as application of knowledge to deal with the sustainability challenge in particular.

First, the internal and external promotion of sustainability is seen as crucial which requires top-management commitment. Internal promotion relates to efforts which motivate employees to engage in sustainability and build the required knowledge (e.g. regular updates of results of sustainability initiatives showing commercial as well as social and ecological benefits) while external promotion relates to a product offering that helps customers to act more sustainably (e.g. building materials that improve insulation, crops requiring less irrigation). CHEMICAL LTD's material science engagement in the Solar Impulse Project is an example for internal motivation. There is no CHEMICAL LTD logo on the airplane suggesting that external advertising was not the main goal but the initiative was heavily communicated internally as an example for future sustainability innovation and technology. This proved to be an initiative that successfully raised awareness and enthusiasm of sustainability among employees. Further, it represented an example of successful knowledge accumulation for a sustainability project. The firm believes that the creation of internal "noise" in favour of sustainability through such initiatives as well as newsletters, annual and sustainability reports, brochures and articles is conducive to building employees' commitment to sustainability. New hires go through internal training of which sustainability is an integral part next to compliance, business and other subjects. In line with the firm's sustainability strategy, it has recently been decided to increase the weight of sustainability training which is to be implemented soon. An internal survey in 2009 has shown that employees expect the firm to perform well in terms of sustainability. Overall, the firm believes that its employees have understood and adopted its sustainability values well but intends to continue to build awareness so that its employees fully "live" these values. The firm argues that it is not sufficient to simply impose the sustainability theme on its staff but rather, that employees have to be motivated and convinced properly. Therefore, the integration of

sustainability aspects into various functional strategies plays an essential role. This includes R&D guidelines, procurement and supply chain management, efficient production, compliance and plant safety among others.

Second, organisational openness is believed to play an important role at the Corporate Centre of Sustainability and Environment in order to avoid seeing the organisation in isolation but rather as an element of the wider industrial context. CHEMICAL LTD encourages organisational freedom among employees to challenge established thinking which supports the firm to focus on the most relevant knowledge. This is because established knowledge and ways of thinking that are not challenged and adjusted to changes can be outdated rapidly in the context of the sustainability challenge. However, at the individual team level, the degree of operational openness is determined by the team manager's preferences which depend upon whether change is regarded as an opportunity or a threat.

Third, CHEMICAL LTD notes that highly diverse sustainability teams are crucial in order to manage sustainability knowledge and obtain a broad understanding of sustainability. For this reason, CHEMICAL LTD's Corporate Centre of Sustainability and Environment hires employees from different professional and educational backgrounds who have acquired heterogeneous knowledge bases and bundles them in one team.

Fourth, in order to make progress in sustainability innovation, the ability of making sustainability a "tangible" asset is believed to be essential. For CHEMICAL LTD, this means that the firm can attach some value to sustainability and therefore is able to measure the impact in financial terms. By this, the firm means that a clear link between sustainability initiatives and business performance should be established which underlines the importance of the economic aspect of the triple bottom line in conjunction with social and ecological aspects. Being able to show the impact of sustainability in financial terms is expected to raise the importance of the topic further yet and have a positive impact on resources deployed for sustainability management.

4.1.5 Achievements of sustainability management

CHEMICAL LTD has made contributions to sustainability. The firm has addressed energy-efficiency and CO2-emissions in its production processes through various measures. For instance, the development of the oxygen depolarised cathode has helped to significantly reduce energy-consumption in the chlorine production which uses large amounts of energy. Further, the "dream production project" has been set up which uses CO2 as an ingredient for the production of polymers, thereby absorbing CO2. This method might be used on a larger scale if the firm decides to sell licensing agreements to other polymer manufacturers. In addition, CHEMICAL LTD involves NGO in important

projects that receive wider public attention which allows both sides to negotiate proactively rather than have a dispute. This is seen as a win-win since NGO are more likely to get what is in their interest and CHEMICAL LTD can significantly reduce the risk of reputational loss. For instance, this allows both parties to discuss the impact of the construction of a new manufacturing site on the neighbourhood and assess counter-measures that suit both parties.

4.2 RETAIL LTD

4.2.1 General information

RETAIL LTD is one of the largest retailers in Switzerland. The firm offers food and non-food products. The firm owns several food manufacturing operations and runs different sales formats. The firm is headquartered in Switzerland and is one of the country's largest employers. Its own manufacturing facilities, sales and sustainability management are based in Switzerland exclusively while sourcing is done on a local and global scale. The firm produces a separate sustainability report on an annual basis.

4.2.2 Market context

RETAIL LTD's answer to market pressures

RETAIL LTD regards sustainability as a key element for its future success. The retail market is characterised by tightening requirements in terms of sustainability. Consumers have clearly become more demanding in terms of sustainability in that they increasingly search for organic products. Pressure is not only coming from customers but also from regulatory bodies and NGO in the health arena demanding healthier food options for the population. Pricing plays an important role. This is because the market context has become even more dynamic and competitive with discounters not only competing in lower-priced but also increasingly in organic products.

Sustainability is highly relevant since most products are food-products which have a direct impact on the health of the population. Customers have become more interested in where food is sourced from (i.e. the proximity of proveniences: asparagus from Greece versus Peru), how it is grown and sourced (i.e. farming and fishing: conventional methods versus organic farming and sustainable fishing) and how it is transported (i.e. transport mode: amount of CO2-emissions of road versus rail transport). In addition, ingredients and nutritional facts receive growing attention. Overall, customers demand higher transparency regarding these aspects. The responsibility of the provision of high quality and healthy food is accentuated since RETAIL LTD is one of the largest retailers in Switzerland and therefore a major provider of food. The firm is aware that its

responsibility goes beyond the simple supply of food. With close to two thousand stores across the country its chosen product portfolio on display in stores also influences to a large extent what is consumed.

Sustainability is seen as a matter of course (meaning that the firm carries responsibility as a provider of consumption goods as well as a large corporation), as a necessity and as a business opportunity. This implies that sustainability at RETAIL LTD not only includes the conventional economic aspects of the triple bottom line but also social and ecological aspects. Examples for initiatives in social sustainability include the vast apprentice scheme the firm has established to give a large number of school-leavers (also from difficult family-backgrounds) the opportunity to do an apprenticeship as well as the growing share of fair-trade products. An example for initiatives in ecological sustainability includes the attempt to become CO2-neutral by 2023 as well as the rapidly growing share of organic products.

The overall goal of the firm's sustainability initiatives are to fully establish sustainable operations in an economic, social and ecological sense as well as to offer sustainable products. The firm is convinced that its efforts positively affect the social and ecological context of its operations. This has a significant impact on sustainability in all of the firm's global sourcing markets. This is particularly important in emerging markets where - in an attempt to attract foreign capital, operations and in consequence employment - regulation is often lax which gives firms more leeway with social and economic issues. Such efforts in sustainability are believed to have both, internal and external advantages. In terms of internal benefits, it helps to obtain a high level of employee buy-in and motivation for the sustainability theme. In terms of external benefits, such sustainable behaviour builds reputation and brand loyalty among customers and the wider public.

RETAIL LTD's history of adoption of sustainability goes back to the early 1990s when the firm started its co-operation with Max Havelaar Switzerland and introduced fair-trade coffee and bananas. The main reason was the protest movement of banana pickers for better working conditions and fairer pay. Further, the firm introduced organic and fair-traded food and non-food labels in the 1990s in response to changing consumer trends and pressures.

The primary concern of sustainability initiatives is the complexity caused by sourcing from around 4'000 suppliers globally and by selling a spectrum of about 200'000 different products. In that regard, improving transparency and increasing resource efficiency to be able to offer sustainable products without causing irreversible environmental effects are key issues. Other sustainability initiatives generally focus on sustainable brands, CO2-reduction and the firm's own sustainability fund which finances innovative internal sustainability projects to encourage sustainable consumption.

In order to prioritise which sustainability initiative to address, RETAIL LTD uses various mechanisms. For instance, the "issue monitor" is conducted by the sustainability team every quarter to scan the market context and to assess the pressures perceived inside the firm by various departments. It is based on a survey and interviews with teams that are exposed to the sustainability challenge such as sales and marketing, communications, manufacturing and purchasing. This helps the firm to assess where the most important challenges lie. In addition, the sustainability team conducts the "food-screening" and "non-food-screening". These include systematic interviews with stakeholders and sustainability experts (NGO, research institutions, consultants) on the main challenges such as water and energy consumption and CO2-emissions which help the firm to identify most important fields of action. These screenings also cover a thorough assessment of social and ecological risks along the supply chain. Further, the firm organises meetings with NGO and state bodies (such as WWF, BioSuisse, Slowfood, various ministries) every four years to jointly agree on the firm's sustainability goals which also helps the firm to prioritise. If a high-priority topic is identified, the sustainability team sets up a workgroups that is headed by the person most relevant to the topic.

Stakeholder pressures

Opportunities in sustainability are detected and understanding of stakeholder pressures is obtained with the help of the discussed "issue monitor" as well as "food screening" and "non-food screening". These mechanisms support the firm to identify expectations of various stakeholders which helps the firm to detect these opportunities and sustainability pressures. The firm awards the supplier prize to honour the sustainability efforts of suppliers. This encourages better sustainability efforts and willingness to cooperate among the firm's suppliers which increases success of opportunity detection. Specific abilities help the firm to establish trustworthy and long-lasting partnerships with suppliers, openness for new ideas and the willingness to try new things.

RETAIL LTD regards suppliers as the single most important sustainability pressure, followed by customers and values and norms in society. First, suppliers are considered critical since they provide a large share of (intermediate) products sold in stores. For this reason, RETAIL LTD seeks to foster long-term relationships with suppliers that are strong innovators in the sustainability field. Due to these strong ties with suppliers, they also expect transparency of RETAIL LTD's processes and open communication in the form of constructive feedback. Due to the firm's high expectations of suppliers to comply with sustainability, large and powerful suppliers increasingly demand financial contributions to sustainability training of their staff. Suppliers also increasingly expect to get merit if their contribution to sustainability such as CO2-reductions, the replacement

of problematic ingredients or any other innovative solutions proves to be successful. Second, customers are important since they represent the sales market and the product portfolio needs to meet their requirements. Customers increasingly demand fair-trade and organic products. They also increasingly ask for transparency across supply chain. Moreover, they expect information of product source, ingredients, and nutritional facts. Third, societal values and norms are critical since they represent the framework requirement of society as a whole. Specific expectations concern the availability of ecologically and socially sustainable products, compliance with social and environmental standards such as the Global Reporting Initiative (GRI) and the efficient use of resources such as water and electricity. The particularities of these stakeholder pressures have an impact on the firm's sustainability strategy.

4.2.3 Sustainability strategy

Sustainability strategy highlights

RETAIL LTD understands sustainability as a responsibility for the wider society. As a major provider of food and non-food products, the firm carefully watches the leverage it has on consumption trends since the products on display influence consumer choice to a certain extent. This relates to the growing share of fair-trade and organic products in its product range which is the largest in the Swiss retail industry. Sustainability is especially important for the firm since the firm directly depends to a large extent on agriculture output which itself is dependent on environmental conditions. This makes climate change a major issue which is why energy-efficiency and CO2-reductions are in focus. Sustainability is clearly driven internally which is reflected in the firm's proactive behaviour.

The firm has a formally written sustainability strategy. Strategy review meetings are held every two years, however, adjustments occur rarely. The firm works with its sustainability strategy until there is need for change. The sustainability strategy is based on proactive long-term planning because this gives it the necessary stability and long-term horizon to properly deal with sustainability which in turn gives the firm credibility among stakeholders. In terms of hierarchical level, sustainability strategy is on the same level as other strategies such as manufacturing, marketing and product strategies. The sustainability strategy is embedded in the sustainability team which is managed by the head of quality and sustainability.

RETAIL LTD's sustainability strategy is formulated in order to be able to respond to the sustainability challenge arising from the discussed pressures, most importantly suppliers, customers and values and norms in society. In line with these stakeholders' expectations, sustainability is intrinsically seen as the basis for the firm's long-term success. RETAIL

LTD prefers to refer to its sustainability strategy as a sustainability concept. The firm is deeply convinced that sustainability cannot be in the hand of one owner but rather has to be included in any kind of strategy the firm has in place. This sustainability concept consists of three main pillars, namely sustainable goods and services, resource efficiency and climate protection as well as employees and community. These pillars are supported by processes and instruments as well as sustainability communications and innovation.

The pillar of sustainable goods and services is concerned with the provision of sustainable products such as under the following labels: "die Knospe" (Bio Suisse), Forrest Stewardship Council (FSC), Marine Stewardship Council (MSC) and others.

The pillar of resource efficiency and climate protection is concerned with the goal to become CO2-neutral by 2023, to increase the share of recycling, to reduce waste and to improve water management.

The pillar of employees and community is concerned with an extensive apprentice program (counting around 3'000 apprentices at any time), the responsibility as a social employer as well as the RETAIL LTD sustainability fund. This fund has a budget of CHF 15m per year for internal sustainability projects that is being spent on project proposals from teams and employees. These projects cover social as well as ecological themes of sustainability.

Supporting processes and instruments are concerned with the integration of sustainability considerations into the balanced scorecard, the sustainability issue monitor (explained above) and an active dialogue with stakeholders (such as food and non-food screenings explained above). Further, life-cycle assessment is done focusing on aspects such as water and energy consumption and CO2-emissions.

Supporting sustainability communications are concerned with the integration of marketing and corporate communications. The main aim is a more effective sustainability communication that brings across the right message to different audiences.

The RETAIL LTD Executive Committee decided in 2008 to become CO2-neutral by 2023 in the areas within its direct sphere of influence. This means that all technically feasible and financially reasonable steps are taken to reduce energy use by almost 20% and CO2-emissions by over 50% compared to 2008. The share of CO2-emissions, which can only be avoided at unreasonable cost or not at all, is compensated by appropriate projects in cooperation with the WWF.

The reason for the firm's approaches to sustainability management and the choice of its sustainability concept can be summarised with the following three considerations:

- First, sustainability is seen as a "matter of course". RETAIL LTD has a double responsibility for sustainability, that is, as a gatekeeper of consumption and as a large firm.

- Second, sustainability is seen as a necessity. This is linked to developments such as tightening regulation, customer expectations for heightened transparency as well as society as a whole expecting commitment to sustainability.
- Third, sustainability is seen as an opportunity. This is based upon opportunities arising from changing consumption patterns towards a green lifestyle and from differentiating the firm from competitors.

Investments in sustainability initiatives are evaluated by using an assessment tool which examines the impact on CO2-emissions of a given investment. Costs of CO2-reductions are compared with costs of CO2-compensation whereby the whole life-cycle of the investment is taken into account. While the primary goal is to radically cut CO2-emissions in absolute terms by reducing energy consumption and shifting into renewable energy sources, the remainder will be compensated as of 2023. In order to achieve the target of a 50% reduction of CO2-emissions in absolute terms by 2023, the firm focuses on the new building technologies, LED lightening technology and the use of alternative energy sources.

Overall, RETAIL LTD's sustainability strategy is based on the intrinsic belief that the firm is responsible for sustainable operations and products which can cause reputational gains and brand loyalty and in consequence commercial success. This is confirmed by the share of turnover with sustainable products that is growing considerably faster than the rest. These achievements are positively reinforcing motivation for sustainability among employees. To sum up, RETAIL LTD has chosen to put emphasis on sustainability because of multiple challenges that the firm has identified and tightly monitors along the triple bottom line. First, environmental challenges include climate change, water scarcity, deforestation, overfishing and the loss of biodiversity and farmland. Second, social challenges include safety and health of employees, salaries, human rights and work conditions. Third, economic challenges include changing consumption patterns, increasing competition as well as regulation.

Need for knowledge and derivation of the knowledge gap

The need for knowledge is derived from the results of the "issue monitor" as well as the "food-screening" and "non-food-screening". The firm's active stance in searching for trends helps to focus on most relevant knowledge that is required to address these trends and resulting challenges. The pressures coming from various stakeholders need to be addressed by adjusting the knowledge base accordingly. For instance, customers increasingly demand fair-trade and organic products as well as higher transparency across the supply chain. This creates a need for knowledge about how to extend sustainability criteria following the Bio and Fair-Trade certifications to other products and product lines as well as deeper knowledge of the supply chain, respectively. If a

topic arises, the sustainability team and the workgroup coordinator check whether the necessary knowledge is available within the firm. Regarding the two examples mentioned above, one knowledge gap existed in combining fair-trade and organic sustainability criteria in the same product such as rice or bananas which has not previously been done. Another knowledge gap existed in measures to extend transparency in the supply chain even further such as with even tighter involvement of the most sustainable suppliers. If it is available internally, a workgroup is set up in the relevant department headed by the most suitable employee to address the topic. If the knowledge is not available internally, external partners are consulted such as experts on LED lighting and alternative heating technologies but also other external providers. External consultants and scientists are hired if specific knowledge is needed such as for energy-efficiency measures, the assessment of alternative energy solutions, the creation of eco-balances as well as the development of new organic product lines. In these cases, the project is also headed by the most suitable employee in a given department who coordinates activities with external partners and the sustainability team. RETAIL LTD sees differences in terms of knowledge requirements on different hierarchical levels. In that regard, selecting a suitable amount and depth of information and knowledge is crucial. Knowledge needs to be more general and holistic on higher hierarchical levels and more focused and specialised on lower hierarchical levels.

Decision-making which knowledge to invest in

RETAIL LTD has set up a Sustainability Steering Committee which makes final decisions in terms of all sustainability initiatives across the firm. This includes decisions about which trends and initiatives to follow (e.g. increasing energy-efficiency in stores and manufacturing), which knowledge is required (e.g. heating or lighting technologies), where it can be sourced from (e.g. external lighting specialists) and what the overall goals of initiatives are (e.g. becoming CO2-neutral by 2023). The committee is moderated and its activities coordinated by the sustainability team. It consists of board members and sustainability representatives of relevant departments such as Marketing, Manufacturing, Logistics and Purchasing. Since the sustainability team is working most closely with the topic, it makes project proposals to the Sustainability Steering Committee. In addition, the sustainability team provides necessary input for decision-making from the generic standpoint of sustainability which the departments complement from a more specific standpoint. For example, this information includes the nature and urgency of stakeholder demands identified through the "food screening" and "non-food screening", return on investment calculations (e.g. installation of LED lighting, wood-pellet heating). The Sustainability Steering Committee meets four times a year to discuss proposals, ongoing projects, arising challenges and to make final decisions.

However, the responsibility of implementation and performance clearly rests with line managers of involved departments to ensure that sustainability is rooted in every department rather than just in the sustainability team or the committee at the top level. The sustainability team oversees the implementation of the sustainability strategy and related projects. It conducts annual objective setting meetings with all departments to discuss achievements of goals, arising problems and new objectives. This also includes objective setting for its own activities. The sustainability team's project proposals for each department are signed off by the Sustainability Steering Committee and then implemented by the respective departments themselves. The sustainability team has a coordinating and consulting role and is in regular exchange with the responsible person in charge at the department level.

Overall, the firm's sustainability strategy is centrally managed to maintain the strategic overview across all initiatives, ensure consistency in the message of initiatives and keep control of implementation and achievement of targets. Further, the sustainability strategy is customised for all regions to enable the firm to align implementation with local preferences and conditions such as regional subsidies and tax benefits. Internal benchmarking among stores is done based on data of energy usage per square metre and of the share of organic products sold of overall turnover. However, the information is not used for comparative performance measurement and financial compensation but rather for the sustainability team to identify room for improvement and make suggestions. These suggestions are taken up by regional heads to assess implementation. A standard portfolio of measures and initiatives exists, which can be chosen from to be implemented.

Required knowledge for sustainability management

RETAIL LTD argues that certain knowledge types need to be in place in order to be able to deal with the sustainability challenge successfully. This not only includes market, strategic and technical knowledge but also human resource or psychological knowledge. First, market knowledge is about which products of which categories with which specifications (e.g. price, sustainability, health, etc.) are demanded and how to package and display these to make them appealing to customers. A more recent example of market knowledge is how to respond to the rising number of single households (e.g. smaller packages of food) and the demand for healthy convenience food (e.g. ready-made meals). Second, strategic knowledge is about which new products and categories to add to the assortment in order to be able to respond to market demand. As noted earlier, it is about offering new product lines in an organic variety such as bananas and rice which have previously been offered only as a fair-trade variety. It is also about the optimisation of purchasing processes such as the reduction of goods freighted by air by

sourcing closer to Switzerland (e.g. asparagus, cotton, etc.). Third, technical knowledge is needed in order to obtain the target to become CO2-neutral by 2023. For instance, this includes energy-saving measures such as LED lighting technologies in stores and industrial heating technologies for bakeries using renewable energy sources such as wood pellets. Fourth, RETAIL LTD mentions human resource or psychological knowledge which is necessary to identify talent for sustainability jobs such as "sustainability champions" across all departments who promote the topic. In addition, this is necessary to identify a sustainability specialist in each store who gets special training and spreads this knowledge to staff at the store. This training primarily relates to reducing energy consumption in stores including advice on refilling freezers, operating ovens and air-conditioning.

4.2.4 Approaches to knowledge management

Knowledge management

The above-mentioned knowledge types (i.e. market, strategic, technical, psychological) exist already to a certain degree but need to be realigned with arising challenges. This not only makes the building of new knowledge but also the storage and transfer as well as the application necessary. All discussed stakeholder pressures influence the firm to pursue knowledge management holistically.

Knowledge building

In terms of knowledge building from internal sources, the sustainability team selects a focus topic each year to be featured on monthly posters for employees, in the employee magazine and in various events. For instance, the monthly sustainability posters which highlight different aspects of the selected focus topic are presented to staff at stores by the sustainability specialist. At these occasions, background information is given which elevates the body of sustainability knowledge among employees. RETAIL LTD also runs internal training modules that employees have to complete. These modules differ between jobs to make sure that respective needs are met (i.e. management versus retail outlet staff). These trainings also include content on sustainability. The firm operates a designated education centre where these trainings are run.

In terms of knowledge building from external sources, RETAIL LTD works with external specialists since the technical knowledge of energy-efficiency measures is not available internally. In these cases, a project coordinator is selected among the most suitable employees who is then responsible for the project workgroup and the relationship with external providers. This person is also in regular exchange with the sustainability team to discuss progress and next steps. Examples for external knowledge

building include projects on LED lighting technologies for stores, installation of solar panels and heating technologies in stores and manufacturing. Project coordinators and the sustainability team accumulate new external knowledge and integrate it with the internal body of knowledge. The main goal, however, is to learn from experiences of projects with external specialists and not to do such projects without external partners in the future. RETAIL LTD clearly states that these technologies are not its core business and will be provided by partners.

Knowledge storage and transfer

In terms of internal storage and transfer of newly created knowledge, RETAIL LTD uses the intranet. In addition, the firm operates a "sharepoint" database which employees (sustainability team and other employees involved in sustainability workgroups) use to store memos, presentations, research papers and other documents related to sustainability. In addition, memos of workgroup meetings are circulated to involved parties and management to be kept in the loop. Therefore, knowledge sharing takes place on the basis of employees reading documents based on various projects. This process also ensures that involved employees know where a given piece of knowledge can be found.

In terms of access to external knowledge, the firm is member of the European retail consortium "Coopernic" which meets regularly to discuss issues such as sourcing and sustainability. This is a forum, where large amounts of relevant industry and sustainability knowledge are available externally. It can be accessed regularly in the form of open exchange between members. Knowledge sharing takes place through the distribution of official documents to consortium members resulting from conferences and meetings as well as through conversations among members.

Knowledge application

RETAIL LTD uses sustainability knowledge to improve manufacturing technologies and the operation of its stores as well as to develop new products. An application of knowledge in new manufacturing technologies, for instance, includes heating systems using renewable energies. More specifically, internal and external knowledge is used to reduce energy-consumption and CO2-emissions by developing industrial heating systems using alternative energy sources (e.g. wood pellets) and by installing highly efficient LED lighting in stores.

RETAIL LTD does not use sustainability knowledge externally by selling licensing agreements.

Supporting and hindering factors in knowledge management

RETAIL LTD sees some critical factors that support knowledge management. For instance, a long-term focus among managers and employees, the openness for change and the ability to take criticism are highly supportive.

Hindering factors to knowledge management also exist at RETAIL LTD. For instance, key-people occasionally do not support sustainability as much as the sustainability team wants them to. This represents an obstacle to sustainability initiatives and the related knowledge management including knowledge creation, transfer and application. In instances when management support is weak, the required resources for a given sustainability initiatives are not provided which makes longer-term planning difficult for the sustainability team. In addition, there is the danger that priorities shift away from sustainability when people are absorbed by challenges in the daily business.

Ability highlights

RETAIL LTD notes that some conditions need to be in place, for knowledge management to work in the context of the sustainability challenge.

First, RETAIL LTD encourages organisational openness for employees to challenge established thinking. Specifically, the sustainability team formed various workgroups in order to address certain sustainability issues and to build the required knowledge or identify suitable external partners. This includes workgroups on energy-efficiency in stores (e.g. lighting technologies) and alternative energies in manufacturing (e.g. industrial heating technologies for bakeries), for instance. These workgroups enable all participating employees to discuss new ideas and criticism which shapes the body of knowledge the firm builds. This is also reflected in the firm's culture which is not dominated by hierarchical thinking. Managers are generally accessible for any employee if they have an issue.

Second, RETAIL LTD displays strong management commitment for sustainability. It is believed that key people within the organisation, namely the CEO, the members of the board and the department heads need to fully buy-in into sustainability and to credibly bring this message across to all employees. These individuals need to have the ability to "translate" sustainability for different audiences in the workforce which is highly heterogeneous in terms of educational levels (i.e. in-store staff versus strategic management staff). This is essential for all employees to understand the pressures and the corresponding need to build the required knowledge. For instance, in-store staff gets this message through the monthly poster campaign discussed earlier while management employees get it through sustainability conferences. Overall, the firm believes that commitment for sustainability is good among employees because strong sales growth of sustainable product lines has proven the focus on sustainability to be beneficial.

4.2.5 Achievements of sustainability management

RETAIL LTD has made achievements in terms of sustainability. For instance, the firm is actively building long-term relationships with suppliers which meet stringent criteria in terms of sustainability and are highly innovative. The firm observes that strong relationships contribute to the sharing of information and knowledge which contributes to higher transparency across the food supply chain. This allows the firm to address the expectations that various stakeholders have in terms of transparency. In addition, the firm has responded to customers increasingly demanding fair-trade and organic products by extending these product lines considerably which enjoy double-digit growth rates. As a large retailer, RETAIL LTD takes its responsibility for the provision of high-quality and healthy food seriously. The fact that its product portfolio displayed in stores shapes consumption trends in society is taken carefully into account when introducing new products. Further, RETAIL LTD has begun to install highly energy-efficient LED lighting technologies in stores and uses renewable energy sources for industrial heating in its bakeries. These measures have significantly reduced energy-consumption and CO2-emissions.

4.3 OUTDOOR LTD

4.3.1 General information

OUTDOOR LTD is a firm in the outdoor wearing apparel and textiles industry. The firm is headquartered in Germany and fully owned by the founding family. R&D is done in Germany, China and Vietnam. Its manufacturing sites are located in the same regions. Sustainability is primarily managed centrally from Germany. Sustainability issues are proactively dealt with and the brand is positioned very close to nature and transmits a sense of responsibility. Its products are sold in nearly all regions. The firm produces a separate sustainability report annually.

4.3.2 Market context

OUTDOOR LTD's answer to market pressures

OUTDOOR LTD observes that the market is moving further in the direction of sustainability with expectations becoming higher. Customers, for instance, increasingly focus on sustainability aspects of textiles. Overall, the relevance of sustainability is high in the outdoor industry. However, sustainable textiles do not suffice on their own. Sustainable apparel products such as outdoor jackets also need to fulfil strict criteria in terms of performance, functionality of apparel and design and need to be offered at the right price. Willingness to pay a premium for sustainable products exists to some extent

among customers but it needs to be combined with other characteristics valuable to customers.

OUTDOOR LTD understands sustainability as a responsibility that goes beyond the dimension of financial profits. Along these lines, the firm not only focuses on the economic aspect of the triple bottom line but also on social and ecological aspects. In terms of initiatives in social sustainability, the firm supports a healthy work-life balance among employees which takes the form of offered sports classes and child-care facilities, for instance. In terms of initiatives in ecological sustainability, the firm incentivises sustainable behaviour among employees (for instance, going to work by bike rather than by car) and motivates them to work on more sustainable solutions for operations and products (by continuously highlighting the importance of sustainability and the firm's contribution to it). Such incentives are mainly put in place through internal competitions.

The overall goal of OUTDOOR LTD's sustainability initiatives is to develop sustainable products that are produced by sustainable operations. From this, the firm derives benefits in terms of reputation and image. This also helps the firm to position its brand as a sustainable one which is crucial in order to be successful in the outdoor community where sustainability is regarded as highly important and expected from apparel manufacturers.

OUTDOOR LTD's official starting point of sustainability was marked by the foundation of a separate firm in 1994 which was engaged in the recycling of apparel made of polyester. The reason for this move was that the firm wanted to take responsibility for the products' afterlife. In order to achieve that, recycling of 100% of the material appeared to be a promising solution. The basic idea was to produce all components of goods (the textile itself, the buttons, the zips, the yarn, etc.) entirely of polyester in order to facilitate this recycling process. Out of the recycled material new thread was produced which was then used to manufacture new textiles which closed the loop along the lines of the cradle-to-cradle (C2C) approach. However, only small quantities of worn-out apparel have been returned by customers, which is why the separate firm is currently not active. A Japanese partner-firm, however, is currently using the firm's recycling principle.

The most important sustainability initiatives at the moment focus on achieving climate neutrality and using sustainable materials. The main challenge is to pursue continuous improvements in terms of manufacturing processes and material efficiency.

As regards these sustainability initiatives, there are no prioritisation mechanisms in place. OUTDOOR LTD also lacks pragmatic behaviour in decision-making and often is not focused on most important activities. The inter-disciplinary sustainability team is linked with all departments that are critical to sustainability (such as product and

material development, production, marketing and communication, quality and management). Since sustainability is integrated in the daily business of these departments, many activities are pursued at the same time which makes supervision difficult for the sustainability team. For instance, the firm pursued hemp textiles which are not relevant anymore today. Nevertheless, the project blocked resources that could have been used for something more relevant such as for developing sustainable synthetic materials.

Stakeholder pressures

Opportunities on the sustainability field are detected and understanding of the sustainability challenge is obtained by being well-positioned in the outdoor industry and having large exposure. This is achieved through first-to-market initiatives (such as the first backpack or sleeping bag on the market fulfilling the Greenshape criteria), memberships in industry consortia and workgroups as well co-operations with other firms. Further, employees attend trade fairs, trainings and material science research meetings. This ensures that the firm has a large network which helps to detect opportunities and understand arising pressures.

OUTDOOR LTD regards customers as the most important sustainability pressure, followed by NGO and values and norms in society. First, customers (end customers and retailers) are highly important since they purchase the products and often give feedback which helps guide future product development. Since end customers purchase from retailers, these demand sustainability as well. Such retailers include small local shops whose owner believes in sustainability to large internet-shops who see market potential in it. Customers expect apparel products such as outdoor jackets to meet sustainability criteria in combination with high functionality and attractive design at a reasonable price. The firm focuses its product development process to meet these criteria in conjunction. Second, NGO are perceived to be very powerful in that they have public attention and can harm a firm's reputation. Concrete expectations by the Fairware Foundation, for instance, included higher transparency across the firm's supply chain which the firm has taken very seriously. Third, the firm as a family-owned business intrinsically wants to be a "good citizen" in society and a "good neighbour" in its community. Specific expectations are that the firm stays on its path to become even more sustainable and maintain its leading role in the outdoor industry which the firm tries to achieve by making continuous efforts to sustainable textiles and dyeing processes. These stakeholder pressures have an impact on OUTDOOR LTD's sustainability strategy.

4.3.3 Sustainability strategy

Sustainability strategy highlights

The firm's understanding of sustainability is to address the triple bottom by taking into account commercial, ecological and social aspects. As a family-owned business, however, the economic rationale is not that stringent since the founding family does not need to justify any sustainability initiative among shareholders. Sustainability is an important topic since it helps to reduce the firm's impact on the environment, the community and the wider society. The emphasis on sustainability is more internally than externally driven with the owning family and management focusing on sustainability and promoting proactive behaviour. An example is the relentless effort to make dyeing processes of textiles used in apparel more sustainable by avoiding toxic substances which are used to date across the industry. As noted earlier, this is particularly challenging since sustainability considerations cannot incur any disadvantage in terms of performance, functionality and design.

OUTDOOR LTD has a formally written sustainability strategy in accordance with the Eco- Management and Audit Scheme (EMAS) environmental criteria in place. The firm's sustainability strategy is reviewed once a year at the EMAS audit. However, since the sustainability strategy is set with a longer-term horizon in mind, the management and sustainability teams rarely make adjustments to strategy. Only if an urgent need arises, such adjustments are made. The sustainability strategy is primarily based on proactive long-term planning in order to be better prepared to deal with arising pressures. The sustainability strategy is on the same level as other strategies such as manufacturing, marketing and product development. This is supported by the fact that sustainability is integrated in all departments and all processes and enjoys support of management. The sustainability strategy is embedded in the sustainability team which directly reports to management, in this case the owner family. A member of management is also part of the sustainability team.

OUTDOOR LTD's sustainability strategy is formulated in order to be able to respond to the sustainability challenge arising from the discussed pressures, most importantly customers, NGO and values and norms in society. In line with these stakeholders' expectations, the firm's sustainability strategy is focused on sustainable operations and the corresponding positioning of its brand. As customers and employees are mostly outdoor enthusiasts who value nature, the firm continuously works on living and spreading such an environmentally-minded spirit. This is actively done by setting up initiatives that incentivise sustainable action such as an award for employees accumulating the most kilometres per given time period for cycling to work. In addition, the firm looks at social aspects as the examples of on-site child care, lunch-break sport

classes and a good work-life balance through part-time positions and the option to work from home show. The sustainability strategy is not separate from overall strategy but rather very well integrated. More precisely, the firm does not distinguish between its overall strategy and sustainability strategy and treats it as the same.

The reason for choosing its sustainability strategy is the firm's sense of responsibility as a family-owned business for the wider community and all sorts of sustainability issues.

The sustainability theme has an impact on the firm's investment decisions but investments are not formally and systematically evaluated in terms of sustainability. Ecological and economic aspects are evaluated on a case-bas-case basis and final decisions are made intuitively. Such investments in sustainability initiatives might also be postponed for budgetary reasons. A recent example of a successful investment decision is the new headquarters building which will be energy- and CO2-neutral and therefore combines economic aspects (i.e. higher energy-efficiency causing cost savings in heating and lighting) with sustainability aspects (i.e. CO2-neutral building). Going forward, the firm plans to include sustainability considerations more consistently as key-criteria for all investment decision across all business units.

Overall, OUTDOOR LTD understands its sustainability strategy as the business-minded execution of sustainability practices. This means that various aspects such as energy-efficiency in production, CO2-emissions and sustainable textiles are taken into account. The firm wants to be a good example in industry and attract imitators for the benefit of overall sustainability in its industry. To sum up, OUTDOOR LTD has chosen to put emphasis on because the conservation of nature is an intrinsic value in the outdoors industry and therefore for the firm's customers. This is described as the "industry's closeness to the outdoors". Moreover, motivation for sustainability is also rooted in the values and norms and the sense of responsibility of a family-owned business. A central question is how the firm can contribute to sustainability and the conservation of nature. Also, customers have increasingly shown an interest in sustainability in recent years and are willing to pay a premium which supports this sustainability strategy.

Need for knowledge and derivation of the knowledge gap

Since OUTDOOR LTD does not have disciplined prioritisation mechanisms in place that support focused sustainability activities, the assessment of the need for knowledge to address challenges is done on an ad-hoc basis. OUTDOOR LTD attempts to assess future sustainability or fashion trends (in terms of materials and functionality, for instance) through inputs from the Bluesign certifier and various textile suppliers. The findings are then discussed by the sustainability team in order to assess which knowledge is necessary and how it can be acquired. Due to the firm's small size, specialist knowledge is often not found internally which makes cooperation with partners

necessary to address a particular issue. As noted earlier, for instance, customers demand sustainable materials that also meet highest requirements in terms of performance and design which generates the need for material science knowledge. While knowledge on high-performance textiles combined with attractive design is available, a knowledge gap exists with sustainable dyeing processes of textiles. Since this knowledge is only partially available internally and needs to be expanded for the sake of sustainability, the firm engages in partnerships with suppliers of textiles and other firms in the outdoor industry. On the one hand, it is believed that sustainability knowledge on lower hierarchical levels needs to be more focused on technical detail and know-how. On the other hand, knowledge on higher levels needs to be about having the overview of the managerial perspective and dealing with issues such as the identification of market trends as well as potential cooperations and partnerships for future growth.

Decision-making which knowledge to invest in

OUTDOOR LTD's sustainability team is in charge of the preceding steps that lead to final decisions about sustainability initiatives. The team consists of the global sustainability coordinator who has overall responsibility and one representative of relevant units such as product and material development, manufacturing, quality, marketing and communications. Further, a management representative is part of the team. The team assesses various project options based on pressures arising in the market context (e.g. extension of sustainable product line to a new product category), selects suitable employees for the project team (e.g. product development, design, manufacturing and marketing) and examines requirements in terms of knowledge (e.g. new textiles, components and dyeing processes). The team does not follow a systematic process but rather fulfils these tasks intuitively. Overall, its task is to provide management with the information that is needed to decide which sustainability activities to pursue, which knowledge to build in order to achieve the set targets and which partners are most suitable to cooperate with. Currently, the firm focuses on knowledge needed to develop textiles which not only meet requirements in terms of sustainability but also functionality and design for which partnerships are critical. Final decisions about activities and knowledge build-up are then made in conjunction with the management team.

In terms of the implementation of sustainability strategy, the representatives in the sustainability team communicate the decisions made to their respective units. A project leader is chosen among employees who has the most suitable experience in a given project area. The actual implementation is done by the units themselves with guidance and coordination given by the sustainability team. The project leader interacts with the sustainability team to discuss progress and arising issues during implementation.

The firm's sustainability strategy is managed centrally at its headquarters in Germany where most functions such as R&D and with it the main know-how are located. This is also where decision-making by the sustainability team and management is done. Further, the firm does not operate a large number of sites, with one in China and Vietnam being the only ones outside Germany. The sustainability strategy is standardised for the same reasons it is centralised. Along these lines, the sites in China and Vietnam do not engage proactively in strategic issues. The firm does not actively pursue benchmarking activities due to the lack of comparability among regions (e.g. regulation in China versus Europe) and product categories (e.g. material requirements of socks versus tents). The different product teams are only measured by financial KPI that focus on the share of sustainable products of overall turnover.

Required knowledge for sustainability management

OUTDOOR LTD notes that it requires market, strategic and technical knowledge in order to address the sustainability challenge. In line with the firm's focus on inter-disciplinarity, all teams are encouraged to acquire the knowledge aspects to a reasonable degree that are not typical to their daily business. For instance, a material scientist builds market and strategic knowledge while a sales person builds technical knowledge which helps the firm as a whole to approach sustainability more holistically. First, market knowledge is seen to be about the attractiveness of not only certain outdoor product categories such as shoes, tents and clothing but also about markets regions with emerging markets becoming more attractive. In addition, knowledge about suppliers' abilities to address sustainability is regarded critical such as their approaches to sustainable textiles. Second, strategic knowledge is about what the firm is able and wants to do in terms of sustainability. This includes considerations about which sustainable product line to introduce and which sales regions to expand to. Third, technical knowledge is primarily about sustainable materials and textiles, sustainable dyeing processes and approaches to energy-efficient manufacturing.

4.3.4 Approaches to knowledge management

Knowledge management

The knowledge types including market, strategic and technical knowledge exist to a certain degree but also need to be updated to achieve the firm's targets in terms of sustainability such as developing sustainable textiles. This requires not only the creation of new knowledge, but also the storage and transfer of existing knowledge and new ways of using that knowledge. This knowledge management is influenced by all identified stakeholder pressures but customers represent the most active pressure.

Knowledge building

An example of knowledge creation from internal sources is the intern who had the task to build knowledge about the Global Reporting Initiative (GRI) criteria for the sustainability team. This was done by interviewing sustainability team members and others with knowledge about certifications in order to aggregate the existing knowledge. This knowledge was extended by desk research about GRI criteria and the overall results were summarised in the intern's master thesis. This intern is now fully employed by the sustainability team and responsible for all of the firm's GRI issues including regular adjustments to changes in the criteria. Further, the firm runs technical and sustainability-related training (e.g. material characteristics, technical functionality) for its sales force. The main challenge lies to teach a suitable depth of technical knowledge to the sales force that is not too detailed and complex but still appropriate in order to sell successfully. This training ensures that all employees understand the sustainability theme and speak a common language so that the firm's message is consistent to external stakeholders.

Examples of knowledge creation from external sources are partnerships such as with the WWF and Bluesign. These partners provide valuable knowledge that OUTDOOR LTD does not possess internally. Specifically, they advise OUTDOOR LTD on various aspects such as on energy-efficiency and the use of alternative energy in its operations and on increasing transparency across the supply chain. In addition, they provide information in terms of which suppliers are making most innovative progress in developing sustainable textiles. The firm also acquires other specialist knowledge externally such as on quality management measures, web-marketing, the preparation for the EMAS certification and the carbon footprint. Input from external partners expands the firm's body of knowledge for which the sustainability team and relevant project leaders are responsible. Overall, alliances are regarded critical in acquiring the knowledge needed to deal with the sustainability challenge.

Knowledge storage and transfer

As regards the internal storage and transfer of knowledge, OUTDOOR LTD uses a database and the intranet which allows employees to access the existing internal body of knowledge when needed. It includes information material, presentation slides and other related content in order to support employees in working on sustainability issues. The content is provided and managed by the sustainability team and the project leader responsible for a given sustainability initiative. The firm actively tries to implement work instructions so that employees use this source of information and knowledge when dealing with sustainability issues. In addition, the sustainability coordinator and the entire sustainability team represent an informal knowledge storage which can be

accessed by employees. This group of employees ensures that knowledge is maintained centrally and that it can be deployed whenever needed.

In terms of access to external knowledge, the firm is affiliated with industry consortia and workgroups such as with the European Outdoor Group (EOG) which enables the firm to tap into external knowledge through knowledge sharing with other players in the industry. This takes place in the form of circulated reports and studies completed by the EOG and discussions among participants. Such workgroups are regarded as highly useful bundles of knowledge that can be accessed if the need arises. The firm goes a step further and notes that knowledge sharing can be extended to selected competitors. For instance, the firm found a supplier using a more sustainable dying process which initially gave it the advantage of the first mover. By sharing that knowledge with trusted competitors, the firm sacrifices some of its competitive advantage. In return, the firm benefits from knowledge from these competitors. It is believed that more transparency among competitors leads to faster and better solutions. In addition, knowledge is accessed by visiting seminars and trade fairs, by establishing and expanding the network and by doing benchmarking within the industry.

Knowledge application

Newly created knowledge is used internally in that it flows directly into product development. For instance, the acquired knowledge about sustainable materials is used to develop outdoor apparel. As noted earlier, however, it is not enough to use sustainability knowledge alone in developing new products. Apparel also needs to meet highest requirements in terms of functionality and design and needs to be offered at a reasonable price. New knowledge is also implemented in processes. More specifically, this includes knowledge about energy-efficiency measures in manufacturing (e.g. lighting and heating technologies) and the use of renewable energy (e.g. solar panels on the new headquarters building). As mentioned above, a large share of this knowledge is sourced externally.

The firm's knowledge is not used externally in the form of licensing agreements.

Supporting and hindering factors in knowledge management

A supporting factor for knowledge management is the inter-disciplinarity of employees and teams which increases chances that there is always an employee with the specifically needed knowledge. For instance, getting a sustainability certification for a new product line requires material scientists to develop sustainable textiles, production managers to produce in a sustainable way and sales and marketing specialists to determine pricing and sales strategies for new products. Another supporting factor is the open atmosphere which encourages discussions and the exchange of ideas. The firm highlights that these discussions happen informally among employees and are not prescribed by management.

OUTDOOR LTD also recognises factors which hinder knowledge management for sustainability. Most importantly, the firm often does not have the required formal organisational structures in place. Neither disciplined market scanning mechanisms to detect opportunities and threats in the market context nor prioritisation mechanisms to choose the most important focus themes are used. The main reason for these unstructured approaches is that employees are "free to do their own thing" and that the firm generally follows too many sustainability initiatives at the same time. The firm notes that more pragmatism is needed including a better focus on which sustainability and related knowledge are absolutely necessary in order to achieve the set goals. Attempts of prioritisation are done in regular discussions among the sustainability team and involved employees. Since it is hard for the sustainability team and management to keep the overview of all sustainability initiatives and their progress, the implementation teams can hardly be held liable for the results of their project which suggests that poor performance unlikely has any consequences for involved employees. In addition, the resignation of valuable employees (even though that happens rarely) means that individual experience and knowledge get lost which is a challenge for knowledge management in a smaller firm. This is especially severe with highly specified engineers and sales people with close links to their market.

Ability highlights

OUTDOOR LTD notes that some conditions need to be met for successful sustainability management and related knowledge management to work well.

First, a high level of motivation among involved employees to pursue sustainability and build the required knowledge is regarded critical. For instance, unconditional management support for sustainability initiatives as well as clear sustainability goals that are anchored in performance evaluation across all teams are expected to be an important pre-condition for the ability to manage knowledge for sustainability. Among other measures, sustainability performance should therefore be an integral part of the overall performance evaluation and the setting of incentives. Management also needs to do a good job at authentically convincing employees of the initiative to be implemented and credibly transmitting a "good spirit". Empathy is also seen as important in order to get the right spirit across. A critical pre-requisite for this is strong management buy-in. This is facilitated by the fact that OUTDOOR LTD is a family-owned business with the key-people being convinced of sustainability. This helps the firm in pursuing sustainability initiatives from the detection of opportunities and knowledge building to the implementation. Overall, OUTDOOR LTD observes that commitment among employees for sustainability in operations and products has been increasing but notes that there is still room for improvement. However, attention to sustainability depends upon the

business unit. While employees in product development attach almost the same weight to sustainability compared to other topics, employees in accounting are less enthusiastic about sustainability.

Second, and linked to motivational factors discussed above, it is critical to have enough resources available in the form of additional time, funds and room for creativity in order to address knowledge requirements for sustainability. More specifically, these extra resources enable employees to do research, visit seminars and other sustainability events and to exchange ideas with other firms more systematically.

Third, transmitting the right level of depth of information on sustainability requires good skill. This is seen as a challenge because a common denominator with just the right level of detail needs to be found for everybody without omitting important detail. This is critical to ensure that employees in different units are "on the same page" and understand what the challenges are and which knowledge is needed to address them.

Fourth, management actively encourages organisational freedom which is facilitated by flat hierarchies and the opportunity for everybody to give their opinion and talk to the sustainability team. Successful knowledge management for sustainability initiatives is believed to require a high level of mental openness for which the inter-disciplinarity among employees is critical. Different educational and professional backgrounds among employees including material science, manufacturing, engineering, product management as well as marketing and general management give the firm the mental flexibility of looking at sustainability and knowledge management from different angles.

Fifth, OUTDOOR LTD believes that the preparation for meeting the criteria of sustainability certifications as well as the actual implementation contributes significantly to knowledge creation. A recent example is the firm's efforts to obtain the Greenshape certification for its entire apparel product line which required the firm to build additional knowledge in the areas of sustainable textiles and other materials, dyeing processes and the supply chain as a whole. An increasing number of employees is involved in the preparation of certifications which has a positive effect on the firm's overall body of sustainability knowledge. Working actively on sustainability criteria of the Greenshape certification has also had a positive impact on the consciousness of the importance of sustainability which causes employees to continuously seek ways to make operations even more sustainable. Overall, OUTDOOR LTD notes that achieving sustainability certifications should not be used for "Greenwashing" (i.e. inflating the meaning of sustainable practices by exaggerated marketing) which would harm the firm's credibility among stakeholders.

4.3.5 Achievements of sustainability management

OUTDOOR LTD's commitment to sustainability causes various achievements. For example, the share of sustainable products (certified by Greenshape) of overall turnover has been growing rapidly over the last few years and is expected to continue crowing in response to customer demands. The combination of commercial and ecological success is also a major motivation for all employees. Further, significant improvements have been made to the sustainability report in order to meet expectations of higher transparency coming from NGO such as the Fairware Foundation. OUTDOOR LTD also notes that customers increasingly get in touch to give feedback on sustainable products which suggests that the firm's public perception as a sustainable firm has grown. However, as it has been noted earlier, outdoor apparel does not only need to meet criteria regarding sustainability but also regarding functionality and design which the firm has succeeded in. Sustainable dyeing processes using alternatives to toxic substances represent the main challenge. The firm focuses closely on this and has made some progress with one of its suppliers already.

4.4 CAR LTD

4.4.1 General information

CAR LTD is one of the largest multinational players in the automotive industry. The firm is systematically intensifying its engagement in emerging markets. CAR LTD is headquartered in Germany. R&D is done in Western Europe, North and South America, China and other regions. The firm's manufacturing sites are located in these regions and Eastern Europe. Sustainability management is pursued locally all over the world. Product-related sustainability initiatives around alternative propulsion solutions such as hybrid, range extenders, fuel cell and electric are pursued under the umbrella of a highly energy-efficient car range. Its products are sold in all regions. The firm's headcount has been increasing significantly and is expected to grow rapidly in the future. A considerable share of newly hired employees will be working on the development of alternative power-trains. The firm not only produces a separate sustainability report at group level but also specific ones for its regions and brands.

4.4.2 Market context

CAR LTD's answer to market pressures

The firm increasingly faces expectations of stakeholders regarding its sustainability initiatives. For instance, customers demand vehicles with higher fuel-efficiency and lower CO2-emissions but are only willing to pay marginally more for these features.

Competitors in a highly competitive market context represent a pressure in that their achievements in fuel-efficiency or CO2-emission reduction efforts might be superior in a certain market segment or product line. Shareholders expect the firm to closely monitor and avoid risks that could materialise around the sustainability theme such as reputational risks due to negative publicity (in response to highly inefficient luxury cars, for instance).

Overall, sustainability is highly relevant since expectations from various stakeholders are high. The firm believes that sustainability is not only a "hygiene factor" which everybody has to follow and therefore does not contribute to differentiation from competitors. Sustainability is also regarded as an opportunity to gain competitive advantage by developing highly fuel-efficient engines as well as alternative solutions such as electric power-trains.

CAR LTD understands its sustainability efforts as contributing to individual mobility and simultaneously minimising required energy consumption in using these vehicles. This is regarded of highest importance in the context of a growing world population and an increasing demand for mobility while resources and the world's carrying capacity to absorb environmental impact are limited. In doing so, the firm intends to be ahead of competition in the automotive industry in terms of profitability and ecological sustainability. This suggests that from the perspective of the triple bottom line, the economic and ecological aspects are particularly important. In terms of initiatives in ecological sustainability, the firms engages in CO2-reducing initiatives in both, operations as well as vehicles by increasing efficiency and developing alternative power-trains. In terms of initiatives in social sustainability, the firm runs regional growth programmes where it runs operations. This is done by focusing skills and resources for regional development in the areas of job security and the quality of life in the community it is active in.

In line with this, the overall goals of the firm's sustainability initiatives are of economic and ecological nature. Economic goals, for instance, include the creation of sustainable value and cost savings though efficiency gains. Ecological goals comprise a widely diversified offering of power-train technologies including conventional and alternative propulsion technologies as well as ongoing efficiency improvements.

In terms of process sustainability, CAR LTD's first sustainability initiative focused on saving and purifying water at production sites. This move was initiated in the early 1960s due to regulation responding to the water shortage in the region of the firm's headquarter. In terms of product sustainability, the firm launched an initiative called "Formula E" aimed at reducing fuel consumption by introducing technical changes to petrol and diesel engines and educating drivers. This initiative started in 1973 in response to the oil crisis.

The most important sustainability initiatives at the moment focus on an improvement of combustion and reduction of CO2-emissions, e-mobility and energy-efficiency. In order to improve energy-efficiency, all suitable technologies are used, such as combustion engines as well as alternative power-trains. In this context, the goals for the next ten years are ambitious.

Several mechanisms are in place to ensure prioritisation of these initiatives. The degree of urgency is determined with the help of several market research instruments such as market monitoring studies and customer surveys. These instruments closely work with stakeholders in order to find the most critical themes in the automobile industry in general and for CAR LTD in particular. Downsizing and the resulting material- and energy-efficiency in manufacturing as well as fuel-efficiency and CO2-reductions during use are clearly of highest priority among different stakeholder groups. In addition, the firm uses financial analysts' reports to assess key-issues from the perspective of capital markets and risk-management. These reports reflect major trends in society and assess the firm's degree of accomplishment which has an impact on the share price. Based on these inputs, the selection of initiatives is done by the CSR and Sustainability Coordination Team which reports findings and suggestions for high-priority initiatives to the Sustainability Steering Committee for final sign-off. Implementation of signed-off initiatives is then done by the relevant business units with guidance given by the CSR and Sustainability Coordination Team.

Stakeholder pressures

The firm detects opportunities to address the sustainability challenge and obtains understanding of the sustainability challenge with the help of market monitoring and trend scouting. This market research takes the form of stakeholder interviews, surveys and industry studies. Interviews are conducted by corporate communications as well as the CSR and Sustainability Coordination Team. In addition, the firm runs a workgroup on the future of mobility at the corporate level to which all relevant departments contribute their knowledge.

CAR LTD regards regulation, values and norms in society and competitors as the most important stakeholder pressures for its focus on sustainability. The firm does not rank these because their influence shifts over time. First, regulation is regarded critical since it may interfere with longer-term investments at any point such as by changing requirements that have not been accounted for. This is particularly important in the automobile industry where large and long-term investments are necessary. This is the reason why regulatory risks are substantial. Specific regulatory requirements that the firm is exposed to are the reduction in resource and energy use during production processes as well as fuel-efficient and alternative power trains in order to reduce CO2-

emissions of its fleet. Second, societal values and norms are considered to be important because they represent longer-term expectations of society as a whole that need to be addressed. A specific expectation is the downsizing of cars with direct impact on fuel consumption and CO2-emissions as well as reducing environmental impact of production processes. Because CAR LTD is one of the largest industrial firms globally and requires significant amounts of resource input, its activities are exposed to tight public scrutiny. The firm believes it to be critical to communicate with the right "tact" but also to clearly highlight the importance of CAR LTD to the global economy and the job market in particular. Third, competitors are considered an important pressure because of the fierce competition on energy-efficiency in the automobile industry. All firms try to gain competitive advantage through innovative solutions which drives overall competitive pressures. These pressures of the sustainability challenge influence the firm's sustainability strategy.

4.4.3 Sustainability strategy

Sustainability strategy highlights

CAR LTD understands sustainability primarily as the economic aspect of the triple bottom line. While the firm strongly believes in the ecological aspect (downsizing and fuel-efficiency, for instance) of the triple bottom line, initiatives need to contribute to commercial success. Along these lines, the firm believes in the economic potential of sustainability and regards it as "the theme of the century" which makes it an important component of overall strategy. Sustainability efforts are primarily driven by external stakeholder pressures rather than internal ones. Due to the firm's large size, internal disagreements on sustainability occur relatively often which causes slow decision-making processes. A typical scenario is that the CSR and Sustainability Coordination Team suggests a given initiative which the Finance department does not agree with.

CAR LTD has a written sustainability strategy. Since it is made for the medium- to longer-term, adjustments are very rare and occur only if an urgent need arises. The sustainability strategy is primarily based on long-term planning as this enables the firm to fully capture major trends such as downsizing. The sustainability strategy is not seen on the same level as other strategies. Specifically, the firm states that for a large manufacturer of automobiles, the manufacturing and product development are of highest priority with the sustainability strategy contributing to both. The sustainability strategy is embedded with the Sustainability Steering Committee at the corporate level which is directly linked to the board of directors.

The firm's strategy is formulated in order to be able to respond to the sustainability challenge arising from the discussed stakeholder pressures, most importantly state

regulation, values and norms in society and NGO. In a nutshell, the firm seeks to become the leader in economic and environmental sustainability by 2018 across the automotive industry. In order to achieve that, the following economic goals have been defined:

- Expansion of brand and product portfolio
- Increasing global footprint and presence in emerging markets
- Cost savings through modularisation and localisation of production
- Creation of sustainable value

Further, the following environmental goals have been defined:

- Diversified portfolio of drive-train technologies (including the conventional combustion engine, (mild) hybrid, range extender, fuel cell and electric)
- Continuous efficiency improvements of internal combustion engines
- Leadership in alternative power-train technologies (i.e. fuel cell, electric)
- High quality standards

CAR LTD clearly believes that conventional combustion engines will continue to be dominant which is why the firm focuses on these as well as alternative power-trains in parallel. To ensure a broad product offering, alternative power-trains will be used for both, existing and new product classes. Based on CAR LTD's cooperation with the "Naturschutzbund Deutschland" (NABU), the firm offers its fleet customers the opportunity to support environmental projects by paying a premium on the usual leasing contract. In addition, fleet customers can select a CO2-reducing leasing option that uses its highly energy-efficient car range. The firm's broad product spectrum and leasing options enable the firm to satisfy different customer requirements in terms of consumption, size, technical specifications and other criteria. In addition, the firm intends to benefit from the paradigm shift to alternative energy sources and to downsizing. In terms of the required innovation, the firm tries to benefit from internal competition among different units (and brands) within the firm as well as external competition among car manufacturers. The firm's innovation activities focus on increasing efficiency, de-carbonising energy sources (i.e. using alternative sources) and the optimisation of the mobility system as a whole. Key drivers for innovation are climate change, resource scarcity, urbanisation, technological progress, industry policies and customer demand. In its sustainability strategy, CAR LTD makes use of the opportunity which the popular notion of sustainability in society offers today by operationalising it across the firm. Overall, the firm's strategy affects all of CAR LTD's brands and operations in all geographic regions.

CAR LTD systematically evaluates investments according to sustainability criteria such as an investment's impact on CO2-emissions, fuel-efficiency and the use of alternative

energy sources. An environmental management system has been set up which assesses the economic benefits of an investment and the effect on sustainability. The system allows the firm to compare pre-investment environmental data such as water usage or CO2-emissions for instance, with the potential post-investment situation. The potential improvements in terms of sustainability are then assessed in the light of the cost of the investment.

This sustainability strategy has been put in place because the firm believes that economic and environmental issues cannot be separated and will therefore need to be resolved jointly. The firm argues that this is particularly important in the automobile industry which consumes significant amounts of materials and energy and produces products which continually consume energy during their use.

Overall, CAR LTD regards its sustainability strategy as orchestrated efforts that contribute to sustainability (e.g. energy- and material-efficiency in production) on the one hand as well as to cost-reductions (e.g. reduced energy- and material-use) on the other hand. More specifically, CAR LTD contributes to individual mobility while at the same time maximising efficiency and pushing technological boundaries further out. From the functional perspective, the sustainability strategy contributes to the firm's competitive advantage and profitability in the form of risk management and image. To sum up, CAR LTD has chosen to emphasise individual mobility with maximised efficiency and thereby building competitive advantage and profitability. In order to obtain that, the firm's strategy has been put in place which aims at becoming the automotive industry leader in terms of economic and environmental sustainability. This business case for sustainability has been chosen because the firm believes that economic and environmental aspects cannot be separated.

Need for knowledge and derivation of the knowledge gap

In line with prioritisation of sustainability activities, the need for knowledge is determined with the help of several market research instruments such as market monitoring, customer surveys as well as banking analysts' reports discussed earlier. The firm uses all available internal and external information on market trends in order to prioritise activities and to assess arising knowledge requirements. This is supported by an extensive network with external parties such as in academia and consulting. The prioritisation is done on a regular basis by the Sustainability Steering Committee which gets a first selection of priority items from the CSR and Sustainability Coordination Team. For instance, the dominant expectation of downsizing and alternative power trains expressed by various stakeholder groups clearly caused a need for knowledge to deal with these relatively new phenomena. In the case of downsizing, needed knowledge included smaller and more fuel-efficient diesel and petrol engines and lighter materials.

In the case of alternative power-trains, needed knowledge included radically new technologies such as electric engines that are entirely different from conventional combustion engines. Once the initiatives are selected such as downsizing or alternative power trains and the project team has been set up, the existing knowledge is compared with the needed knowledge from which the knowledge gap is derived. This process is managed by the CSR and Sustainability Coordination Team in conjunction with the involved units. Regarding downsizing, the identified knowledge gap was relatively small since fuel-efficiency and light materials have always been emphasised by the firm which provided large amounts of prior knowledge that could be used. Regarding alternative power-trains, however, the knowledge gap was rather large since previous experience was limited with battery technology, for instance. This deficit in knowledge is compensated by partnerships with specialists in this field. The firm argues that different depths of knowledge are required on different hierarchical levels. Employees of higher ranks often come across situations which require a thorough understanding of sustainability in order to bring across sustainability in a way that motivates their staff. Employees of lower ranks, are not required to have specific sustainability capabilities.

Decision-making which knowledge to invest in

In terms of the organisational structure of sustainability management, the firm has established three bodies at different hierarchical levels. First, the Sustainability Steering Committee is the most senior team. It is composed of the heads of all of the firm's departments such as R&D, manufacturing, marketing and communication, finance and purchasing. The committee meets twice to three times a year to discuss important strategic sustainability issues and to make final decisions as to which sustainability initiatives to pursue. A major decision has been to focus on downsizing which led to the development of the smallest car ever built by CAR LTD. The committee reports directly to the board of directors of CAR LTD. Second, the CSR and Sustainability Coordination Team is responsible for the content of the sustainability theme, its promotion and the support of the Sustainability Steering Committee. Information of sustainability trends and the resulting opportunities and threats is accumulated and evaluated. Further, the team decides what knowledge will be built to address a given challenge (e.g. new measures to energy-efficiency, light-weight materials and alternative power-trains) and where this knowledge will be sourced from (e.g. internally or externally from partners). In addition, it decides about a pre-selection of sustainability initiatives to be proposed to the Sustainability Coordination Team. The team also consults all departments on sustainability issues and listens to their needs and ideas. This team is headed by the Global Head of CSR and Sustainability and is part of Group Communication and External Affairs. Third, the Sustainability Project Team comprises designated employees

of all departments and reports to the CSR and Sustainability Coordination Team from which it receives different tasks. Therefore, it focuses on the actual implementation of sustainability-related projects of a given team across the firm.

The implementation of the sustainability strategy and related initiatives is preceded by several stages. First, the CSR and Sustainability Coordination Team works out a sustainability strategy proposal. Second, the proposal is discussed by the Sustainability Steering Committee and signed off. Third, the strategy is implemented by the respective departments with the help of the Sustainability Project Team. The process of implementation is supervised by the CSR and Sustainability Coordination Team. In order to facilitate the implementation of the chosen sustainability strategy, a high level of integration of sustainability in overall strategy is needed. Further, pragmatic rather than bureaucratic approaches and processes are needed that support involved teams and individuals. This in turn requires a high level of management commitment and willingness to put in place necessary resources.

Due to the global reach of the firm and the particularities of local markets, the sustainability strategy is de-centrally managed and implemented. The local approach is particularly important because individual sites highly value their independence to take approaches that best fit their purpose and convictions of local management. For instance, operations in Latin America have sustainability issues tightly integrated in their balanced score-card while other regions have it separate. In addition, sites take individual approaches to the use of alternative energy sources. Depending on climatic circumstances, wind energy is generated and used at some sites while solar energy makes more sense at other sites. Further, country-specific environmental legislation differs substantially which is taken into account by local operations (such as tax thresholds in Sweden which incentivise to buy cars emitting less than 120 grams of CO2 per kilometre driven). Also, social considerations might be more important in, say Argentina than in China, while environmental considerations are more relevant in the EU than in Russia, for instance. For these reasons, the CSR and Sustainability Coordination Team at the group level leaves the active management of sustainability to local operations and does not engage in benchmarking of practices among them. Along these lines, the firm does not compare sustainability performance of individual sites, products, departments or projects and does not have financial incentives based on sustainability KPI in place. For instance, energy- and material-intensive units produce more CO2 by definition and would therefore be disadvantaged relative to other units. Rather than imposing universal rules and regulations on local operations, the CSR and Sustainability Coordination Team has the role of an internal consultant to promote sustainability at the group level. However, all sustainability coordinators have regular coordination meetings that serve as a platform for exchange of ideas and practices. Sustainability strategy is

customised for specific regions for the same reasons it is de-centralised, most importantly because requirements and cultural readiness in terms of sustainability differ considerably across regions.

Required knowledge for sustainability management

CAR LTD believes that certain knowledge types need to be present to be able to address the pressures caused by the sustainability challenge. These types include market, strategic and technical knowledge. First, market knowledge is understood to be not only about sales potential and attractiveness of market segments but also of regions with emerging markets, Europe and the US in focus. Second, strategic knowledge is about which directions to follow and focus on. In this case, the board of directors has explicitly made downsizing a top-priority with the development of the smallest and most economical car ever made. Third, technical knowledge is about fuel-efficiency of conventional diesel and petrol engines, alternative power trains, material-efficiency and CO2-reduction. This knowledge is necessary to address downsizing properly.

4.4.4 Approaches to knowledge management

Knowledge management

CAR LTD possesses the discussed market, strategic and technical knowledge already but it also needs to be continually expanded to meet changing requirements in the face of the sustainability challenge. This does not only affect knowledge building but also its storage and transfer as well as its application to find more sustainable process and product solutions. CAR LTD is keen to be ahead of the curve which makes continuous updating and adjustment of the knowledge base necessary. Along these lines, knowledge management is not only driven by regulation and societal values and norms but also by competitors since the firm intends to outpace them in addressing the sustainability challenge.

Knowledge building

In terms of building new knowledge from internal sources, CAR LTD has expert groups in place who intensively discuss issues such as downsizing. These expert groups collect knowledge from all relevant departments (e.g. competitors' activities in downsizing, fuel-efficient engines, light-weight material technologies) and aggregate it. This represents an ongoing knowledge creation process to ensure that the internal knowledge base is always up to date. While knowledge is created at the project level, the CSR and Sustainability Coordination Team is involved in order to keep the overview. Created knowledge then flows directly into the development of the new car concept such as in the case of the smallest car ever built by the firm. In order to ensure the broadest array of different

knowledge possible, these groups consist of inter-disciplinary teams. In order to take this knowledge to wider audiences, internal conferences are organised on different sustainability topics. Further, ongoing education and training of staff are critical to ensure appropriate knowledge levels. A coaching program has been set up which is in charge of continuing education. Moreover, academic education is pursued by an in-house university which closely collaborates with various universities of the region and has an extensive global network. the firm runs an onsite-academy focusing on continuing education for employees. The firm also has a large apprenticeship scheme and a PhD program.

In terms of building new knowledge from external sources, partnerships with universities and research institutions are established with special focus on alternative power-trains for which internal knowledge needs to be complemented. As noted earlier, battery technology, for instance, is such a field where the firm seeks to partner with external players to build know-how. CAR LTD is aware that some specialists on the field of alternative propulsion possess valuable specialist knowledge that it wants to benefit from. As with knowledge creation from internal sources, expert groups collect knowledge from relevant external sources, aggregate and integrate it into the firm's knowledge base.

Knowledge storage and transfer

In terms of internal knowledge storage and transfer, CAR LTD uses databases and online project collaboration tools that involved expert groups and teams have access to which ensures exchange of knowledge anytime and anywhere. In addition, designated project teams working on a specific topic also have the responsibility for related knowledge and to make it accessible to entitled teams that need it.

In terms of access to external knowledge, the firm uses memberships in various industry associations and consortia to access the required knowledge. In addition, the head of the CSR and Sustainability Coordination Team sits on advisory boards of various sustainability campaigns and projects under the umbrella of the UN Global Compact, CSR Europe or Econsense. Knowledge is shared by the circulation of reports, studies and memos. In addition, knowledge sharing takes place informally among participants in these campaigns. Moreover, partnerships with various education and research institutions as well as consultants provide access to knowledge exchange. These activities are coordinated centrally by the CSR and Sustainability Coordination Team in conjunction with the departments themselves. The challenge here is to focus on key-capabilities and to find the right balance between external and internal sources of capabilities.

Knowledge application

Sustainability knowledge is applied internally in various group- and brand-level projects concerning product development and manufacturing. In terms of product development, for instance, the firm applies the acquired knowledge about downsizing and fuel-efficiency in various initiatives such as in the development of the smallest car ever built by CAR LTD. In terms of manufacturing, knowledge about material- and energy-efficiency as well as measures to reduce water consumption in paint-shops is used to make processes more sustainable.

Sustainability is not applied externally in the form of licensing agreements sold to other firms.

Supporting and hindering factors in knowledge management

A major supporting factor for knowledge management is CAR LTD's extensive internal and external network that enables the firm to share information and access knowledge that the firm does not have internally. For instance, this allows the firm to complement internal knowledge with externally available knowledge as it is done in case of alternative power-trains.

Hindering factors to knowledge management for sustainability also exist. For instance, management processes are not always open enough for sustainability to be established deep enough in daily business and integrated in overall strategy. Therefore, the direct links between the CSR and Sustainability Coordination Team and management are not always useful. This also makes the justification of costs of sustainability initiatives and related knowledge management efforts highly difficult, especially when the resulting advantage is hard to measure and the timing of benefits is unknown. Along these lines, a longer-term perspective for sustainability is missing in some instances. Further, some departments disagree on sustainability at a number of occasions. For instance, the Finance department and the CSR and Sustainability Coordination Team often have diverging opinions on the value of a given sustainability initiative and related knowledge creation that is required, especially when large and long-term investments are involved. Moreover, due to the firm's size and hierarchical organisation, decisions about sustainability initiatives have to go through various decision loops which increases the risk of obstacles and prolongs decision-making processes. This hierarchical approach also makes it harder for employees to challenge established thinking and engage proactively in sustainability management. Further, employee motivation for sustainability is not mentioned explicitly.

Ability highlights

CAR LTD believes that several other abilities need to be in place, which support active knowledge management to address the sustainability challenge.

First, commitment to sustainability of the board of directors and the CEO is critical to ensure employee motivation for sustainability and well-functioning knowledge management. Broad management support of sustainability is not just about motivating employees to buy into the idea but also about allocating the resources required to pursue sustainability initiatives. The ability to make employees aware of the importance of sustainability and why they are expected to engage themselves and build the required knowledge is highly important. In general, high values and norms in terms of sustainability among employees as well as management and an appropriate alignment of sustainability with overall strategy are believed to be necessary and highly supportive of sustainability. The firm believes that employees' commitment for the sustainability theme has been improving in line with rising awareness and a growing general understanding of sustainability issues.

Second, CAR LTD notes that the nature of internal communication and the resulting flow of information is critical for knowledge management. Communication needs to occur regularly without significant time lags and be consistent and transparent to ensure a common understanding of sustainability.

Third, the firm encourages organisational freedom to challenge established thinking with the help of regular discussions among the CSR and Sustainability Coordination Team and departments involved in sustainability initiatives. These discussions are conducive to finding improvements to existing solutions. For instance, this was of particular importance in the course of the large-scale downsizing initiative which involved a large number of aspects ranging from lighter materials to energy-efficient engines. Since CAR LTD bundles its sustainability activities centrally in the CSR and Sustainability Coordination Team, the team members regularly discuss sustainability issues and therefore have deep insights and a good overview of which projects are running, what can be improved, what is needed in terms of knowledge for these projects to be successful and what the results and lessons learned are.

4.4.5 Achievements of sustainability management

CAR LTD's efforts in sustainability management create positive impact on various ends. Most importantly, the firm has already reduced average fuel-consumption and CO2-emissions of its vehicle fleet dramatically in response to tightening environmental regulation and customer demands. These attempts will continue into the future as fuel-efficiency is a dominant theme in the car industry. To advance these achievements

further, the firm focuses on downsizing which includes lighter materials and smaller and more efficient engines. This not only makes the product but also production processes more sustainable. In addition, it facilitates material recycling. As regards fuel-efficiency, the firm has also taken steps to develop alternative power-trains based on technologies such as hybrid, fuel cell and electric propulsion as well as range extenders. CAR LTD believes that the fierce competition in the car industry is highly supportive of fast technological progress in fuel-efficiency and CO2-reduction and -prevention which creates benefits for the wider society.

5 Cross-case analysis and discussion

This cross-case analysis and discussion chapter contributes to answering the sub-questions and the main question of this research. It draws together the findings of each individual case study and compares and contrasts these. Further, it synthesises the relevant literature with the findings in the case studies. This procedure helps to identify the areas where this research can contribute to the literature. This chapter is divided into the following sections:

- Relevant findings in the case studies and the literature are discussed to answer sub-question 1: "Which knowledge-related abilities are perceived to be important in order to detect opportunities to build knowledge?"
- Relevant findings in the case studies and the literature are discussed to answer sub-question 2: "Which knowledge types are perceived to be important in order to address the sustainability challenge?"
- Relevant findings in the case studies and the literature are discussed to answer sub-question 3: "Which knowledge-related abilities are perceived to be important in order to build, retain and apply knowledge continuously?"
- Success factors based on findings in the previous sections are summarised from which numerous activity-, structure-, and behaviour-related propositions are derived.
- Propositions are summarised and findings are aggregated in order to answer the main research question: "Which knowledge management aspects are needed in order to address the sustainability challenge?"

5.1 Detecting opportunities to build knowledge

This section addresses sub-question 1: "Which knowledge-related abilities are perceived to be important in order to detect opportunities to build knowledge?" Evidence from case studies suggests that before any knowledge can be created, the relevant opportunities in sustainability to build such knowledge need to be identified in the firm's market context. This includes the following abilities:

- Detection of opportunities in sustainability
- Understanding of stakeholder pressures as indicators for opportunities

5.1.1 Detection of opportunities in sustainability

While all sample firms point at the importance of being able to perceive internal and external opportunities for knowledge exploration, they take different approaches to opportunity detection. Especially the large players in the sample - CAR LTD, RETAIL LTD and CHEMICAL LTD - highlight the importance of scanning mechanisms and processes that build awareness of what is going on within and around the firm in order to discover opportunities for creation of knowledge that is conducive to future growth.

At the corporate level, the Corporate Centre of Sustainability and Environment at CHEMICAL LTD undertakes disciplined and well-structured "stakeholder checks" in the form of interviews with various stakeholders. The goal is to uncover the most important topics and challenges on the market and give an indication as to which stakeholders are most powerful and risky. Stakeholders (e.g. NGO) are then involved in discussions before an initiative is implemented such as the construction or extension of a manufacturing site. Such stakeholder involvement allows all parties to openly discuss the impact of that construction such as building a new access road or cutting trees. In addition, agreements can be found about the measures to keep the impact as small as possible such as constructing a CO2-neutral building or planting more trees along the road. As a complement to these corporate-level initiatives, all three subgroups have competitive intelligence units in place which closely monitor tomorrow's requirements in terms of sustainability and thus support the firm to identify opportunities. For instance, the vast market knowledge of each subgroup's sales forces arising from their closeness to the markets and continuous interactions is systematically collected. This is done at quarterly sales meetings where sharing of market knowledge including customer requirements, competitive activities, price elasticity and other issues are discussed. Moreover, sales people file weekly market reports containing these market observations which are administered and analysed by a large database.

Similar to CHEMICAL LTD's stakeholder check, RETAIL LTD operates an "issue monitor" which scans the market context for sustainability challenges and trends. This information is obtained by interviewing internal teams which are exposed to pressure. In addition, the firm operates the "food-screening" which includes regular and systematic interviews with different stakeholders. This allows the firm to tap into information and opportunities for knowledge creation that are perceived by its entire market context. That market context not only includes its customers but also other stakeholder groups such as regulators, suppliers, competitors, shareholders and others which will be discussed in more detail later. In order to enlarge the coverage of trend screening mechanisms to its entire product range, the firm has introduced the same exercise to non-food products which it refers to as "non-food-screening". In addition, the firm runs meetings with various experts in sustainability who are working in NGO, research institutions and other organisations related to sustainability. These meetings cover challenges such as water and energy consumption, CO2-emissions and ecological risks along the supply chain and therefore provide opportunities for knowledge creation in order to develop solutions to these challenges. At these occasions, RETAIL LTD's sustainability goals on these topics are discussed.

CAR LTD's approach to trend scanning is similar in that it involves market monitoring exercises and trend scouting. This also includes occasional interviews with stakeholders

which are conducted by corporate communications as well as the CSR and Sustainability Coordination Team. Nevertheless, these approaches are less interactive and involving with stakeholders compared to CHEMICAL LTD's "stakeholder check" and RETAIL LTD's "issue monitor". This suggests that RETAIL LTD and CHEMICAL LTD are more concerned with stakeholder involvement than CAR LTD is. Due to CAR LTD's size and influence as an employer, the firm is less prone to external pressures compared to RETAIL LTD and CHEMICAL LTD. CAR LTD notes that it is willing to discuss sustainability issues with NGO and try to find agreements but that it will also highlight its importance to the economy in these discussions to counter NGO pressure. Nevertheless, CAR LTD runs an internal workgroup on the future at the corporate level which employees responsible for sustainability across all departments participate in with the goal to detect opportunities from the widest possible angle. By "also looking at the other side of the coin", however, CAR LTD emphasises that it is not only about identifying opportunities but also risks through strong risk-management processes. These risks include reputational damage, for instance, that can be caused by negative media coverage or criticism from NGO. Accordingly, CAR LTD has tightly integrated risk-management processes with opportunity scanning mechanisms. Compared to these sample firms, OUTDOOR LTD adopts a less structured and rigorous approach in terms of opportunity detection and does not interact regularly with all stakeholder groups as RETAIL LTD and CHEMICAL LTD do. The firm puts special emphasis on the dialogue with suppliers as these are seen as a valuable source of knowledge in sustainable apparel material sciences. OUTDOOR LTD, by contrast, is in regular exchange with other firms and individuals in the outdoor industry. This makes it unlikely that it misses opportunities just because it does not have formal scanning mechanisms in place. An interesting extension to stakeholder dialogue is that the firm also practices the knowledge exchange with competitors. While this might be regarded as an uncommon approach since competitors hardly share any critical knowledge, OUTDOOR LTD argues that this exchange works to a certain degree. This is believed to be possible because firms in the outdoor industry want to jointly push the sustainability theme to ensure faster advances in sustainable material technologies. OUTDOOR LTD argues that this approach of knowledge sharing among competitors might be unique to the outdoor industry because industry players share a common passion for the outdoors and nature which makes the preservation thereof an important goal. Overall, OUTDOOR LTD notes that it can build its ability to detect opportunities by being well-positioned in the outdoor industry and having large exposure. One way to achieve this is to launch first-to-market initiatives such as the first backpack or sleeping bag on the market fulfilling the strict Greenshape criteria.

The importance of scanning mechanisms for opportunity detection is also discussed in

the literature. Firms require certain abilities in order to be able to successfully detect opportunities for knowledge creation in their market context (Lichtenthaler and Lichtenthaler, 2009; Shane, 2000). For instance, Teece (2007) and Katkalo et al. (2010) propose "sensing" as a knowledge-related capability critical for firms. Sensing of new opportunities and threats means that the firm scans its market context, detects important issues, learns and creates knowledge from it which it then interprets (Katkalo et al., 2010; Teece, 2007). The authors argue further that resulting information and knowledge can open up new horizons for the firm (by offering a new perspective) and therefore create new opportunities. This is in line with what Mitchell et al. (1997) propose. In order to be responsive to changing requirements in terms of sustainability, management should not exclusively focus on current stakeholder demands but also potential future demands as they may change over time which makes continuous monitoring of trends necessary (Mitchell et al., 1997). Thus, the analysis of exogenous stakeholder pressures corresponds to sensing new opportunities and threats. A thorough analysis of these stakeholder pressures is necessary in order for firms to "sense" these opportunities and threats.

While path dependency does not always hold in dynamic markets as suggested by Eisenhardt and Martin (2000), a given level of prior knowledge is helpful in order for sensing to work. When firms attempt to screen their market for pressures, the way they perceive opportunities and threats as well as the resulting trends in the past has an impact on how they screen and consequently understand their market today. In other words, their past experiences with the sustainability challenge contribute to today's understanding of the sustainability challenge, even though the pressures of that challenge might have changed. However, as Eisenhardt and Martin (2000) suggest, it is necessary to not only rely on existing knowledge and past experiences but also on newly created knowledge and experiences in order to be able to deal with new dynamics in changing market contexts. This is in line with the claim by Mitchell et al. (1997) that the focus on current dynamics should be complemented by a focus on future dynamics for which Eisenhardt and Martin's (2000) point on a continuous creation of new knowledge and experience is required. In support of this argument, Eisenhardt and Martin (2000) note that relying too much on past experiences can cause firms to miss newly arising challenges and resulting trends.

Being aware of knowledge-related opportunities assists firms in aligning their inventive and absorptive efforts with actual opportunities on the sustainability field. However, evidence from case studies also suggests that selection mechanisms for most relevant opportunities need to be in place. RETAIL LTD, CHEMICAL LTD and CAR LTD believe that prioritisation mechanisms are crucial in order to be able to focus on most important and relevant knowledge opportunities and resulting inventive and absorptive

efforts and ultimately to benefit from the newly created knowledge. For instance, CHEMICAL LTD uses the discussed "stakeholder check" to detect trends which helps the firm to set priorities in terms of sustainability initiatives. Based on this, the Corporate Centre of Sustainability and Environment works out issues of highest priority, which are then taken up by the three subgroups. Similarly, RETAIL LTD uses the discussed "issue monitor" as well as the "food-screening" and "non-food-screening" to assess and rank the importance of sustainability issues based on which the sustainability team makes recommendations for initiatives to be implemented by relevant units. CAR LTD uses various market research instruments such as market monitoring, customer surveys as well as banking analysts' reports which identify the degree of urgency of certain trends from which the firm then derives the prioritisation of activities. This is done by the CSR and Sustainability Coordination Team which reports findings and suggested initiatives to the Sustainability Steering Committee for final sign-off. While these three firms have systematic prioritisation mechanisms in place, the opposite is the case with OUTDOOR LTD. Since sustainability is not just an item on the management agenda but is integrated in the daily business of all departments rather well, many activities are pursued at the same time. Further, most individuals from the owner-family to the shop-floor worker are interested in sustainability topics and follow their lead. These behaviours make the coordination and prioritisation of activities a difficult task.

In terms of trend and opportunity detection, CAR LTD - unlike the other sample firms - focuses on establishing networks and cooperations with external parties such as research institutions. These networking efforts are meant to help the firm in screening the universe of trends and opportunities and identify the most promising ones to the business. Further, memberships in industry consortia play an important role for all sample firms which regularly gives them the opportunity to get other industry players' insights and perception of the sustainability challenge. This helps sample firms to filter out most important stakeholder pressures and related opportunities and interpret this information.

5.1.2 Understanding of stakeholder pressures as indicators for opportunities

As Table 8 illustrates, a number of exogenous and endogenous sustainability drivers can be identified in the academic literature. These drivers represented the starting point in the case study analysis in order to examine in detail why sample firms address sustainability in the first place.

Exogenous drivers	Regulation	Banerjee (2001), Carroll (1999), Cook and Farquharson (1998), Etzion (2007), Kemp and Andersen (2004), Porter and van der Linde (1995), Sharma and Henriques (2005)
	NGO	Eesley and Lenox (2006), Etzion (2007), Fineman and Clarke (1996), Wade-Benzoni et al. (2002), Wheeler et al. (2003)

	Media	Etzion (2007), Herzig and Schaltegger (2004), Wade-Benzoni et al. (2002), Wheeler et al. (2003)
	Politics	Delmas and Toffel (2004), Wheeler et al. (2003)
	Value-based networks	Wheeler et al. (2003)
	Customers	Delmas and Toffel (2004), Khanna and Anton (2002), Rivera-Camino (2007)
	Suppliers	Rivera-Camino (2007)
	Competitors	Garrod (1997), Greenley and Foxall (1996), Kemp and Andersen (2004), Maignan and Ferrel (2004), Rivera-Camino (2007)
	Shareholders	Rivera-Camino (2007)
	Market innovativeness	Etzion (2007)
	Industry self-regulation	Delmas and Toffel (2004), Etzion (2007), Potoski and Prakash (2004)
	Economic cycle	Rivera-Camino (2007)
Endogenous drivers	Strategy	Dyllick and Hockerts (2002), Etzion (2007), Mitchell et al. (1997), Worthington and Patton (2005), Ramanathan et al. (2009), Russo and Fouts (1997), Schaltegger and Burritt (2000)
	Culture	Andersen and Kemp (2004), Bansal and Roth (2000), Delmas and Toffel (2004), Dyllick and Hockerts (2002), Etzion (2007), Jiang and Bansal (2003), Lenox and King (2004), López-Gamero et al. (2009), Schaltegger and Buritt (2000), Schaltegger and Hasenmüller (2005), Schaltegger and Synnestvedt (2001), Sharma (2000), Sharma et al. (1999), Suchmann (1995)
	Resources	Etzion (2007)

Table 8: Identified sustainability drivers

Interestingly, the most important sustainability drivers perceived by sample firms are exclusively represented by exogenous stakeholders. Other exogenous drivers beyond stakeholders as well as endogenous drivers are not perceived to be among the most important sustainability drivers by sample firms. Therefore, this research refers to stakeholder pressures rather than drivers. In line with the ability to detect opportunities, sample firms believe that a thorough understanding of these stakeholder pressures in the context of the sustainability challenge is essential because they represent insightful indicators for opportunities to create knowledge. This understanding of pressures is based upon various market research exercises mentioned in the preceding section on the ability to detect opportunities in sustainability. In hierarchical order, these stakeholder pressures include NGO, customers and shareholders for CHEMICAL LTD, suppliers, customers and societal values and norms for RETAIL LTD and customers, NGO and societal values and norms for OUTDOOR LTD. For CAR LTD, the three most important stakeholder pressures are societal values and norms, environmental regulation and competitors but the firm has not provided a ranking for these. While sample firms recognise a similar set of sustainability drivers, differences exists regarding the degree of influence they have on these firms. This perceived importance of stakeholder pressures is expressed by different hierarchical rankings of these stakeholder pressures which originates from the respective industries the sample firms are operating in. Critical stakeholder pressures of the sustainability are shown in Table 9.

Stakeholder pressures	CHEMICAL LTD	RETAIL LTD	OUTDOOR LTD	CAR LTD*	Number of times selected as one of the three most important stakeholders
Customers	2	2	1		3
Societal values and norms		3	3	X	3
NGO	1		2		2
Environmental regulation				X	1
Shareholders	3				1
Competitors				X	1
Suppliers		1			1

Table 9: Important external stakeholders[7]

In some instances, a contrast between the current body of literature and the findings in this research can be identified. First, environmental regulation is widely seen as the single most important stakeholder pressure (e.g. Delmas and Toffel, 2004, 2008) as firms have no choice but to comply unless they are prepared to risk legal consequences and negative effects on image and reputation. However, the evidence from case studies suggests that this is only believed to be true by one firm, CAR LTD, while the others rank it among the least important pressures. This will be discussed in more detail in the section dedicated to state regulation. Second, the role of competitors as a stakeholder pressure is underestimated in the literature in that it is not regarded on a similar level of influence compared to regulation and customers. Yet, CAR LTD regards competitors as one of the three most important sustainability pressures. Apart from these instances, the importance of identified stakeholder pressures as a trigger for knowledge-related opportunities is more or less reflected in the literature. It is interesting to note that the specific literature on sustainability (e.g. Etzion, 2007; Delmas and Toffel, 2004; Rivera-Camino, 2007) as well as the generic literature on dynamic capabilities (e.g. Banerjee, 2001; Teece, 2007; Zollo and Winter, 2002) mainly identify the same set of pressures. For instance, Teece (2007) specifically mentions two groups of stakeholder pressures of market dynamism which are also frequently discussed in the sustainability literature. One proposed group of stakeholder pressures includes regulators, standard-setting bodies and laws which fall into the category "regulation" (e.g. Banerjee, 2001; Carroll, 1999; Etzion, 2007). The other group of exogenous stakeholder pressures includes social mores and business ethics which can be summarised in the category "social values and norms" (e.g. Wade-Benzoni et al., 2002; Wheeler et al., 2003). In addition to regulatory pressures and values and norms held in society, Wang and Ahmed (2007) identify technological innovation in the relevant industry, competitive pressures in the industry as

[7] Numbers in the table indicate the ranking of the three most important stakeholders to each sample firm from 1 (most important stakeholder) to 3; *No ranking given.

well as the economic cycle as important factors that shape the dynamic market context of a firm. Again, these stakeholder pressures are often discussed in the sustainability literature and mainly referred to as "innovativeness" (e.g. Etzion, 2007), "competition" (e.g. Rivera-Camino, 2007) and "state of the economy" (e.g. Rivera-Camino, 2007), respectively. These types of stakeholder pressures represent important influences in a firm's market context. Further, Zollo and Winter (2002) mention technological, regulatory and competitive conditions which drive rapid change and shape dynamic market conditions which corresponds to the above-mentioned pressures. All of these stakeholder pressures have been identified by researchers in the field of dynamic capabilities and correspond to a large extent to the stakeholder pressures that have been discussed in the sustainability literature. The fact that these stakeholder pressures have been dealt with by two different research streams - i.e. dynamic capabilities and sustainability management - validates the relevance and importance of the stakeholder pressures in this research. The most important stakeholder pressures identified in this work are examined in greater detail below.

Customers

Customers are believed to be a key-stakeholder pressure for sustainability and a crucial indicator in terms of which knowledge firms have to generate in order to deal with the sustainability challenge and related opportunities. Overall, customers are selected as one of the three most important stakeholder pressures by three sample firms: CHEMICAL LTD, RETAIL LTD and OUTDOOR LTD. Customers are highly important by definition since they choose to purchase the products and create demand. In addition to that basic role, OUTDOOR LTD notes that customers are a valuable source of feedback which helps to guide future product development. The firm observes that customers regularly get in touch with suggestions for improvements. An important facilitator for this behaviour among customers is that there are hardly any barriers to get in touch with the right employees at a smaller firm compared to a relatively impersonal multinational player with thousands of employees. OUTDOOR LTD's open culture positions the firm "close" to customers. Such an organisational culture would be hard to implement at considerably larger sample firms. In addition, it would be hard to imitate as it is a soft factor which is hardly traceable. While customer expectations at OUTDOOR LTD focus primarily on product sustainability, at CHEMICAL LTD and RETAIL LTD they also focus on processes. At OUTDOOR LTD, for instance, this is explained by the fact that customers attach the meaning of sustainability to conventional product characteristics such as functionality and design which causes a combination of requirements that have to be addressed in conjunction. More holistically, CHEMICAL LTD is faced with expectations that no child labour is involved in production processes, that emissions of

production are as small as possible (which does not only include CO2 but also hazardous substances) and that products and packaging can easily be recycled and do not represent a hazard after use (such as in the form of residual substances in sewage water). Similarly, RETAIL LTD's customers do not only increasingly demand sustainable products but also require more transparency into production processes and the wider supply chain. This includes issues such as CO2-emissions and the use of resources during manufacturing processes, for instance. Some customers also ask for more information to be displayed on products such as CO2-emissions from source to store.

OUTDOOR LTD reacts to these expectations by focusing its product development efforts on sustainability criteria without compromising functionality or design which makes sustainable performance textiles a critical success factor. CHEMICAL LTD also takes these customer requirements seriously and implements them in manufacturing processes and product development. The stakeholder check also represents a useful follow-up mechanism to see whether new solutions satisfy customer needs. This regular comparison of the actual situation and the target is critical in dealing with customers. Similarly, RETAIL LTD takes customer expectations into account by providing more transparency on CO2-emissions, for instance. However, the expectation to display more information on the packaging is not fulfilled if the firm does not see any added value or if the packaging simply is too small.

As discussed earlier, CHEMICAL LTD relies on the vast experience and knowledge of sales forces in the three subgroups as well as on the stakeholder check in order to obtain the required knowledge to address these customer needs. Similarly, RETAIL LTD collects the accumulated knowledge with the help of the issue monitor as well as the food and non-food screenings to proactively deal with customer expectations. Again, OUTDOOR LTD does not have a formal and structured approach in place in that the required knowledge is built through "learning by doing".

As before, all sample firms believe that customer requirements do not have a direct impact on strategy since they are incorporated for the long-term. Only unexpected events and sudden changes to customer behaviour would make strategy adjustments necessary.

The current body of literature addresses the significant influence that customers can impose on firms. For instance, Rivera-Camino (2007) argues that, based on certain values and norms, customers might respond favourably to a firm's sustainability initiative. Therefore, firms have to generate the knowledge required to find solutions in order to fulfil customer requirements. When a firm's image or reputation is negatively affected, customers might begin to avoid their products, which in the worst case can go as far as boycott. Again, this is a trigger for firms to think about possible solutions and generate the necessary knowledge to develop these solutions. By referring to a survey conducted among Canadian firms, Delmas and Toffel (2004) argue that customer values

and norms are the second most powerful source of pressure - next to regulation - to engage in sustainability initiatives.

By differentiating between retail customers (business-to-customer) and industrial customers (business-to-business), Khanna and Anton (2002) suggest that the values and norms of the former impose more pressure on firms to act in environmentally responsible ways and adopt more stringent environmental initiatives. However, this notion is not supported by evidence in this research. Only CHEMICAL LTD is engaged in business-to-business activities (material and crop sciences), however, it ranks customers among the three most important stakeholder pressures as OUTDOOR LTD and RETAIL LTD do which are mainly engaged in business-to-customer activities.

Since firms regularly and closely interact with customers, their expectations facilitate the detection of opportunities which supports firms in creating the knowledge needed to work on solutions in order to benefit from these opportunities.

Societal values and norms

Sample firms argue that values and norms held in society are a powerful stakeholder pressure for sustainability and that resulting expectations are a valuable gauge for what is needed in terms of knowledge in order to meet these expectations. This helps firms in decision-making processes as to which knowledge to focus on and to build. Overall, societal values and norms are selected as one of the three most important stakeholder pressures by three firms: RETAIL LTD, OUTDOOR LTD and CAR LTD. Societal values and norms are regarded critical by CAR LTD as they represent the longer-term trends and resulting expectations of society as a whole that need to be addressed. This allows the firm to formulate a relatively stable sustainability strategy that does not often need to be adjusted. Similarly, RETAIL LTD notes that these represent the framework requirement that the firm has to operate in. OUTDOOR LTD states a different reason for this importance. The firm as a family-owned business intrinsically wants to be a "good citizen" in society and a "good neighbour" in the communities it operates in by acting responsibly.

A major expectation of society as whole perceived by CAR LTD is downsizing through higher fuel-efficiency and CO2-reductions which the firm reacts to by expanding its knowledge base of necessary technologies. This knowledge is built through internal and external knowledge creation efforts as well as knowledge exchange for which its internal and external network is the source. For OUTDOOR LTD the main expectation of society is to stay on its path and become even more sustainable with a special focus on sustainable materials that also satisfy technical and design requirements and thereby maintain its leading position in the outdoor industry. This is achieved by constantly pushing outward technical boundaries. This is facilitated by making textiles and dyeing

processes more sustainable and at the same time focusing on functionality and design. The required knowledge is mainly built through tight cooperations with materials and textile suppliers but also with competitors. Similarly, RETAIL LTD notes that expectations concern the provision of ecologically and socially sustainable products, energy-efficient stores (concerning cooling and lighting) and compliance with environmental standards. The firm reacts by having in place high-level projects such as installing LED lighting in stores (currently in three test-stores) and offering an increasing array of organic food and non-food products. The knowledge to pursue these projects often comes from external partners such as lighting experts and organic product developers.

As noted earlier, societal values and norms give CAR LTD a valuable indication of longer-term trends such as downsizing. Therefore, this has had a significant impact on the firm's strategy when it was formulated a few years ago. Along these lines, the board of directors has made downsizing a priority which is also shown by the launch of the smallest car in its history. In case of OUTDOOR LTD, the impact of values and norms in society has been a sharpened effort in sustainability with a special emphasis on sustainable textiles. By contrast, RETAIL LTD notes that these issues have been part of the strategy for quite some time, therefore, do not have an impact on strategy which overall is adjusted very rarely.

These findings are confirmed by the existing body of literature. Firms need to be aware of values and norms in society as well as resulting opinions and expectations that are shaped by the collective power (e.g. Eesley and Lenox, 2006; Etzion, 2007; Wade-Benzoni et al., 2002; Wheeler et al., 2003). Typical interest groups include NGO (which will be discussed separately below since they are considered highly influential by sample firms), value-based networks, the media, politics and other environmentally interested bodies (Eesley and Lenox, 2006; Etzion, 2007).

Value-based networks represent a phenomenon which has gained momentum with the ongoing rise of the internet. It is critical for management to be aware of these pressures, deal with them and attempt to benefit from these opportunities when pursuing sustainability initiatives (Wheeler et al., 2003). Further, the creation and expansion of online communities and social networks which are united through a common sense of what is valuable can develop into an opportunity for firms (Wheeler et al., 2003).

Media coverage can cause pressure and partially shape public values and norms. It can have both, positive as well as negative impact on reputation and it is in the management's interest to benefit from the former. Herzig and Schaltegger (2004) argue that reputational strength is fundamentally supported by a firm's credibility in handling sustainability. They argue further that transparent reporting on sustainability issues is crucial to build trust and credibility.

The political debate on sustainability can shape values and norms which can cause public pressure on firms. Delmas and Toffel (2004) refer to that as the publicly perceptible level of political influence which has an impact on how firms deal with sustainability.

The pressures arising from these interest groups rapidly bring to surface changes in public opinions regarding sustainability and therefore transmit relevant information on arising opportunities for knowledge creation. The existence of such opportunities and their detection supports firms in aligning the build-up of the required knowledge with these opportunities in order to benefit from them. This in turn helps firms in narrowing their focus as to which knowledge to build in order to find solutions to societal expectations.

NGO

NGO represent one of the three most important stakeholder pressures for CHEMICAL LTD and OUTDOOR LTD. CHEMICAL LTD perceives NGO as influential since they closely scrutinise the chemical and pharmaceutical industries due to the potential environmental hazards they can cause. CHEMICAL LTD and OUTDOOR LTD note that NGO can gain deep-rooted support of the wider public (as these neither represent political nor businesses interests) which can represent a risk to the firm. If an NGO turns against a firm it can cause reputational damage. With shareholders in mind, CHEMICAL LTD also notes that this can also have a significant impact on the willingness of financial market participants to provide capital. This is not an issue for OUTDOOR LTD since it is family-owned.

Specific expectations of NGO experienced by CHEMICAL LTD include the early involvement of NGO in important initiatives. Following the notion that "prevention is better than remediation", CHEMICAL LTD tries to go beyond legal rules and regulation as these occasionally are believed to be insufficient by NGO. The firm reacts to these expectations by pursuing early stakeholder involvement in a given initiative. In contrast, expectations encountered by OUTDOOR LTD coming from a textile-focused NGO, namely the Fairware Foundation, are primarily related to higher transparency in the supply chain. OUTDOOR LTD reacted to this expectation by undertaking significant efforts to increase transparency in the supply chain in accordance with the Fairware Foundation. OUTDOOR LTD perceived the close interaction with this NGO as a beneficial experience in terms of learning and improvement.

In the case of CHEMICAL LTD, the required knowledge to address these expectations is built through the stakeholder check. A wide involvement of different internal departments into the stakeholder check such as teams in sustainability management, political affairs, communications and investor relations supports large-scale mutual learning. This involves analysing all stakeholder groups and identifying the most risky

ones, which risks they pose and if they occur regularly or not. This knowledge helps the firm to define ways to address NGO expectations. Again, OUTDOOR LTD does not have a structured approach in place. The required knowledge is built through the openness to challenge current approaches in dealing with NGO and thereby assess better ways of dealing with NGO. Regarding the impact of NGO expectations on sustainability strategy, CHEMICAL LTD notes that because strategy is set for the medium-term and should be stable, specific challenges usually do not have an impact on sustainability strategy. In addition, the biggest challenges are known and relatively easy to predict (consequences of a growing population on agriculture, water usage, food requirements, global warming, etc.) which facilitates their implementation in the medium-term strategy.

For OUTDOOR LTD, the impact of the NGO demanding higher transparency across the supply chain meant an adjustment to its strategy in the form of a heightened focus on supply chain issues which have been considered less important before.

In line with different interest groups that shape values and norms in society mentioned above, the literature addresses the influence that NGO have on firms. For instance, Etzion (2007) notes that NGO have the power to raise public awareness and interest, to engage the public into their initiatives and to win significant support which is aided by efficient and provocative communication techniques they apply. Greenpeace is a prominent example for these NGO. Eesley and Lenox (2006) find that if NGO manage to gain a high level of public awareness and involvement, their campaigns are more likely to alter corporate behaviour. In these instances when NGO succeed in altering a firm's behaviour, these changes will occur rapidly and with ground-breaking character (Etzion, 2007; Fineman and Clarke, 1996). Etzion (2007) points out, however, that NGO not only target corporations but also try to actively influence governments and regulators which can reinforce the pressure of regulation on firms.

Similar to the interest groups discussed in the section on societal values and norms, NGO can cause significant pressures. These pressures indicate opportunities for knowledge creation which can help firms to focus and respond to relevant opportunities by creating the knowledge to address these opportunities.

Environmental regulation

Environmental regulation not only represents a powerful stakeholder pressure but also highlights opportunities for firms by building the necessary stock of knowledge for possible solutions to arising regulatory requirements. However, only CAR LTD regards environmental regulation among the three most important sustainability drivers. This is because it can interfere with longer-term investments at any point in time, for instance, by changing requirements that have not been accounted for before. This is particularly

important in the automobile industry where large and long-term investments are necessary which is why regulatory risks are substantial. Specific expectations include the reduction of CO2-emissions, the improvement in recycling efforts and higher transparency in reporting processes. The firm reacts to these expectations by assessing priorities and then by actively pursuing measures in order to be able to meet these expectations. Such measures include massive investments into fuel-efficiency and CO2-reduction technologies. The required knowledge is built by sourcing from internal knowledge management workgroups that assess current expectations and the resulting need for knowledge and where it can be found. Internal knowledge is complemented by knowledge that exists in the firm's external network. The impact on the sustainability strategy is a heightened focus on certain sustainability initiatives such as fuel-efficiency. Along these lines, CAR LTD notes that "regulation acts as a highly effective amplifier" to advance initiatives internally.

The other sample firms do not rank regulation among the most important pressures. On the one hand, this is rooted in the fact that the automotive industry with the nature of its product is considerably more exposed to stringent regulation with a focus on reducing fuel consumption and CO2-emissions than firms in other industries. Indeed, CAR LTD undertakes significant efforts to be involved in various public initiatives with environmental protection organisations in order to show its efforts to fuel-efficiency. On the other hand, the other firms are dealing more proactively with sustainability and are thus ahead of regulation which makes regulation less of an urgent pressure. In fact, CAR LTD appears to be the least proactive and intrinsically motivated firm regarding sustainability in the sample. Nevertheless, regulation is highly valuable for firms as it clearly indicates not only what is expected today and in the future but also outlines the path trajectory to a given point in time. This makes predictable which solutions should be focused on over time which also helps firms in deciding which knowledge they need in order to achieve regulatory targets and benefit from these opportunities.

The evidence from case studies does not support the view held in the literature that regulation is (among) the most important sustainability pressures. Along these lines, the literature suggests that environmental regulation imposes pressure on firms as they have no choice unless they are prepared to risk legal consequences and negative effects on their image and reputation (e.g. Banerjee, 2001; Delmas and Toffel, 2004). Carroll (1999) argues that environmental regulations represent a restrictive power that firms are exposed to. Banerjee (2001) also suggests that regulatory requirements have a significant impact on firms' environmental approaches. According to Etzion (2007), regulation can take different forms: "It can dictate technologies that must be used, can stipulate specific environmental targets that must be achieved, can create economic frameworks for redistributing environmental costs and benefits and so on" (p. 651). This underlines the

importance of regulation as an indicator that helps firms to decide which knowledge needs to be acquired in order to find the required solutions. Porter and van der Linde (1995) argue further that regulation also represents a stakeholder pressure for environmentally positive innovation which again emphasises the importance to build the required knowledge stock. They suggest that "effective regulation should, among other things, be strict, stable and predictable, should focus on outcomes rather than means and should incorporate industry participation during the design process" (p. 124). Cook and Farquharson (1998) suggest that regulation can represent an incentive to perform sustainability initiatives. This is in line with what Kemp and Andersen (2004) say. In order to incentivise sustainability by seeking improvements on their own as part of their competitive strategy, they propose to make business aware of the potential of innovation, develop reward systems such as tax incentives and foster partnerships between the public and private sectors as well as non-governmental organisations (NGO). In line with this, DeSimone and Popoff (2000) argue that even though regulation is necessary, it should be more inspiring and foster a spirit of innovation and responsibility rather than being prescriptive and merely represent an obligation to comply with.

Another difference between the literature and the evidence in this research can be identified. Sharma and Henriques (2005) find that regulation appears to be a more powerful pressure to work on environmental initiatives, if management bears personal liability for environmental violations. While this is not surprising, it cannot be confirmed in this research. Among the sample firms in this research, OUTDOOR LTD is the firm where management - the owner family - bears most personal liability. Nevertheless, the firm does not see regulation as a critical sustainability pressure.

The views held by Kemp and Andersen (2004), DeSimone and Popoff (2000), Porter and van der Linde (1995) as well as Cook and Farquharson (1998) suggest that the potential of regulation as a trigger for firms to build knowledge necessary to pursue sustainability innovation can be exploited further even though it is not recognised as a key-stakeholder pressure in this sample of firms.

Shareholders

Only CHEMICAL LTD regards shareholders among the three most important stakeholder pressures while this perception is not shared by OUTDOOR LTD, RETAIL LTD and CAR LTD. The firm argues that shareholders are important since they are the owners and provide needed working capital. CHEMICAL LTD notes it is critical to be on good terms with shareholders in order to keep its license to operate. Further, the financial compensation of management is partially determined by the stock price which incentivises managers to act according to shareholder expectations. In general, shareholders expect that sustainability initiatives strengthen the firm along the

dimensions of additional turnover, cost savings through efficiency and risk mitigation (such as pre-emptively avoiding a conflict with an NGO that could cause reputational damage). The firm reacts to these expectations by pushing initiatives that are beneficial for each aspect of the triple bottom (e.g. energy-efficiency initiatives that reduce costs and negative environmental impact) and regularly updates shareholders on the results of these initiatives at press conferences. Due to the focus of the firm's strategy on the longer-term, shareholder expectations are by definition taken into account by the strategy which makes adjustments to strategy rare. RETAIL LTD, by contrast, is a large firm but is not listed and operates as a cooperative which explains why shareholders as such are not. Similarly, shareholders are irrelevant as a stakeholder pressure for OUTDOOR LTD since the firm is fully family-owned without any external shareholders. CAR LTD as a multinational stock-listed firm, however, does not rank shareholders among the three most important pressures. Given the influence of shareholders as capital providers, this is a surprising finding.

The importance of shareholders is also mentioned as a stakeholder pressure in the literature. They can take the form of financial and other institutions as well as individuals who provide funding and can exert pressure on firms to become more sustainable. Along these lines, Rivera-Camino (2007) argues that shareholders can negatively affect the operation of firms by refusing to extend loans or withdrawing capital if a firm's specific risk is expected to rise due to poor environmental practices and a resulting damage to its image.

It is questionable, however, whether shareholders represent a useful source for knowledge-related opportunities. The relationship between shareholders and the operations of the firm they are invested in is usually abstract and anonymous which suggests that the impact of shareholders on opportunity detection is likely to be limited.

Competitors

Competitors are believed to be among the three most important stakeholder pressures by CAR LTD only. The firm perceives competitors as a highly important pressure, specifically because firms in the automobile industry currently compete heavily on measures in fuel-efficiency and in reducing CO2-emissions. These measures receive highest attention by literally every stakeholder group. A major pressure emerges on the firm if efforts of a competitor are perceived to be superior in a certain market segment or product line. Competitors can be distinguished from other discussed stakeholder pressures in that they do not exert direct pressure (i.e. they do not explicitly tell the firm what they expect). Rather, competitors' activities pressurise a firm to keep up with them which drives the rate of change and innovativeness of the industry as a whole. Therefore, the firm reacts to this challenge by closely watching competitors' activities which is done

through various benchmarking projects within the automotive industry and other industries and other forms of market research. Resulting findings are analysed by the CSR and Sustainability Coordination Team and then discussed with R&D, manufacturing and product development of all relevant brands and regions for them to work on the actual implementation. The required knowledge to deal with these pressures is built through internal and external knowledge networks which support a regular knowledge exchange. This also includes an exchange with competitors themselves to a certain degree. However, it is conventional practice to "share knowledge only up to a certain level of depth" and "treat critical aspects that are considered imperative for competitive advantage confidentially". Since these requirements on the market are neither new nor surprising they have been integrated into the long-term strategy for a long time which suggests that the actual impact on strategy is limited. The firm argues that its sustainability strategy is made for the medium- to longer-term and thus needs adjustments only rarely.

While the role of competitors in the context of the sustainability challenge is mentioned in the literature to some degree, it does not regard customers on a similar level of influential power compared to regulation and customers. Further, the reaction to any stakeholder pressure such as customers, regulation, society and others is motivated not just to meet the very requirements of these respective stakeholder pressures but also to build competitive advantage. This suggests that any reaction to these stakeholder pressures partially is also a reaction to the pressure coming from competitors. Only few publications suggest that competitors belong to the most powerful pressures. For instance, Maignan and Ferrell (2004) as well as Greenley and Foxall (1996) emphasise that competitors along with customers are the most important pressures. The vast majority of publications, however, (e.g. Bansal and Roth, 2000; Etzion, 2007; Rivera-Camino, 2007) sees competitors in the wider context as one of many important pressures.

A firm's competition exerts pressure in that competitors' sustainability efforts may be perceived superior (e.g. Etzion, 2007, Rivera-Camino, 2007). For instance, a more proactive approach to sustainability by a competitor will likely increase its competitive advantage which can cause significant pressure on firms to act (Garrod, 1997; Kemp and Andersen, 2004; Rivera-Camino, 2007). Therefore, the success of firms' sustainability efforts depend on the ability to meet requirements of stakeholders in a more timely and suitable manner than their competitors (Rivera-Camino, 2007). This relates to firms' competitiveness which Bansal and Roth (2000) have identified as a critical factor. In the sustainability context, competitiveness is defined as "the potential for ecological responsiveness to improve long-term profitability" which can be achieved through resource and waste management, labelling, green marketing and the development of

products (Bansal and Roth, 2000: 724). In terms of competitiveness in the sustainability arena, Etzion (2007) highlights the importance of firm-specific and imperfectly imitable resources that can cause better environmental performance and competitive advantage. Among other attributes, this represents the basis of the RBV suggesting that firms require resources that are valuable, rare, inimitable and non-substitutable to build competitive advantage (Barney, 1991; Conner and Prahalad, 1996; Peteraf, 1993; Wernerfelt, 1984). However, as it has been discussed in the literature chapter, firms need to continuously extend, protect and ensure the relevance of their resources which is accounted for by the dynamic capabilities construct (Teece, 2007; Teece et al., 1997). Eisenhardt and Martin (2000) go further by suggesting that the RBV does not hold in highly dynamic environments which are characterised by an unpredictable duration of a firm's current competitive advantage.

Suppliers

Only RETAIL LTD regards suppliers among the three most important sustainability pressures. In fact, suppliers are the single most important stakeholder pressure for the retailer. Suppliers are considered to be powerful since the firm focuses on long-term relationships that need to be established and maintained to be truly beneficial for sustainability. The firm seeks to foster relationships with suppliers that are strong innovators in the sustainability arena. Large and powerful suppliers often demand cost sharing of sustainability training if RETAIL LTD expects them to comply with sustainability standards and to encourage their employees. In addition, suppliers expect to get merit (e.g. in media releases, the firm's customer magazine or even directly on the product) if their contribution to sustainability in the form of CO2-reduction or replacement of problematic ingredients, for instance, has had a significant impact. If these demands come from a strategic supplier, the firm tries to take that into account. The required knowledge in dealing with suppliers is built through long-term partnerships that provide stability and experience in dealing with these demands. However, increasing pressure from suppliers is a relatively new phenomenon and therefore needs to be dealt with more thoroughly going forward. Therefore, these developments are expected to have a stronger impact in the future. So far, the firm's sustainability strategy is only concerned with its own brands. However, in the context of increasing supplier power strategic adjustments will become necessary such as including a dedicated sustainability strategy for these suppliers' brands. In some cases this is already done but not across the board.

Suppliers are mentioned as a stakeholder pressure in the literature. On the one hand, involvement with environmentally cautious suppliers and distributors can drive sustainability initiatives and have a positive feedback on the firm's credibility in

managing sustainability (Rivera-Camino, 2007). In addition, suppliers with high environmental standards support firms in increasing transparency in their supply chains and making operations more sustainable overall (Linton et al., 2007). On the other hand, environmentally minded suppliers can exert pressure as they may discontinue delivering inputs for fear of losing their own reputation, if the purchasing firm is known for not seriously taking into account environmental considerations (Rivera-Camino, 2007). Another explanation why suppliers represent a critical stakeholder pressure in the case of RETAIL LTD is the fact that a large share of turnover is generated by food products which have a direct impact on consumers' health. Therefore, potential risks need to be managed carefully with suppliers for which the noted longer-term relationships are essential.

Suppliers as a stakeholder pressure can help firms to detect knowledge-related opportunities in that close involvement with them enhances the information flow. The closer and more regular this exchange takes place, the easier it is for the firm to discover arising opportunities for knowledge creation which helps to focus efforts on solutions to the sustainability challenge.

5.1.3 Summary

Overall, the above-mentioned stakeholder pressures highlight the influence of the sustainability challenge which firms are exposed to. Customers, societal values and norms and NGO are considered most important among sample firms. It is obvious that whatever customers expect regarding sustainability, firms will likely take it seriously. Similarly, societal values and norms as well as NGO can impose significant pressures that firms will likely address since any conflict in public attracts attention and affects reputation. Stakeholder pressures that are considered less important among sample firms include environmental regulation, shareholders, competitors and suppliers. These are considered to be among the three most important stakeholder pressures by only one sample firm each. The most surprising result, however, regards environmental regulation which is widely believed to be the most important stakeholder pressure in the literature. Nevertheless, most sample firms do not agree with that notion because of their proactive behaviour which positions them far ahead of regulatory pressures. In summary, Table 10 shows the discussed issues and findings:

Issues	Findings (sample firms)
Detection of opportunities in sustainability	• Identification of challenges and related opportunities in the context of the sustainability challenge **(All)** • Scanning mechanisms in place – stakeholder interviews **(CHEMICAL LTD, RETAIL LTD, CAR LTD)** – stakeholder involvement **(CHEMICAL LTD, RETAIL LTD)** – internal workgroups on the future **(CAR LTD)** – knowledge sharing with competitors **(OUTDOOR LTD)** • Prioritisation mechanisms in place based on... – market scanning mechanisms and other market research **(CHEMICAL LTD, RETAIL LTD, CAR LTD)**

	– industry consortia workgroups **(All)** – partnerships with research institutions focusing on urgency of issues **(CAR LTD)** – recommendations to management issued **(CHEMICAL LTD, RETAIL LTD, CAR LTD)**
Understanding of stakeholder pressures as indicators for opportunities	• Identification of particular pressures in the context of the sustainability challenge **(All)** • Dissection of sustainability challenge into various stakeholder pressures – customers **(CHEMICAL LTD, RETAIL LTD, OUTDOOR LTD)** – societal values and norms **(RETAIL LTD, OUTDOOR LTD, CAR LTD)** – NGO **(CHEMICAL LTD, OUTDOOR LTD)** – environmental regulation **(CAR LTD)** – shareholders **(CHEMICAL LTD)** – competitors **(CAR LTD)** – suppliers **(RETAIL LTD)**

Table 10: Findings on detection of opportunities to build knowledge

The findings in this section help to answer the sub-question of which knowledge-related abilities are perceived to be important in order to detect opportunities to build knowledge. In order for firms to achieve that, several findings in this research are highly relevant.

First, findings in the case studies suggest that the ability to detect opportunities in sustainability in the form of different screening mechanisms plays an important role because it highlights critical areas that firms need to focus on in knowledge management. This includes the ability to cooperate with external parties to exchange and broaden the horizon of opportunities and the ability to prioritise in order to focus on most relevant and useful opportunities for a given firm. In the context of the Lichtenthaler and Lichtenthaler (2009) framework, opportunity detection to build knowledge is related to exploration exclusively. Before firms are able to start building new knowledge internally and externally, they need to search for suitable opportunities for knowledge creation (e.g. Shane, 2000). This supports firms to focus on most relevant opportunities in the context of the particular sustainability challenge they encounter and to align their efforts. This is evident with the screening mechanisms that sample firms have set up such as stakeholder interviews, benchmarking studies and industry reports to name just a few. However, sample firms not only believe that the ability to detect opportunities for knowledge creation is related to knowledge exploration but also to exploitation which is not accounted for by the Lichtenthaler and Lichtenthaler (2009) model. This is because, depending on where the firm is in the knowledge management cycle with a given initiative, the application of existing knowledge can also play an important role to develop solutions that satisfy stakeholder expectations. For instance, a given technology which has an extensive history at a firm enabled it to accumulate a large body of knowledge over time. This knowledge can be exploited to a certain extent without always needing to explore entirely new knowledge or at least it can complement knowledge exploration. This can be about making existing knowledge and technologies better. This suggests that pressures - especially related to the sustainability challenge - often require solutions based on new knowledge but also require existing knowledge to be used in new ways. Based on this discussion, the following proposition can be derived:

Proposition 1: The higher the number of relevant opportunities for knowledge management the firm detects, the greater is the need for knowledge exploration and exploitation.

Second, case studies show that a thorough understanding of stakeholder pressures as indicators for these opportunities is critical for firms because it supports them to identify the key pressures they are exposed to. This understanding also helps firms to assess which pressures need to be dealt with most urgently and to what degree. In the context of the Lichtenthaler and Lichtenthaler (2009) model, this in turn assists firms to react by building the required knowledge to address these pressures. As discussed earlier, various exogenous and endogenous sustainability drivers can be identified in the literature (e.g. Bansal and Roth, 2000; Delmas and Toffel, 2004, 2008; Eesley and Lenox, 2006; Etzion, 2007; Rivera-Camino, 2007; Wheeler et al., 2003). Among these, customers, environmental regulation, values and norms in society, NGO, competitors, suppliers and shareholders receive most attention by sample firms. This suggests that sustainability drivers that are perceived to be most powerful among sample firms fall into the category of exogenous stakeholders. Based on these observations, the following propositions can be derived:

Proposition 2: Stakeholder pressures exert more power on firms to create knowledge than other sustainability drivers.

Proposition 3: Exogenous pressures exert more power on firms to create knowledge than endogenous pressures.

Proposition 4: The more powerful a stakeholder pressure, the greater is the need to create knowledge.

5.2 Knowledge types to address the sustainability challenge

This section addresses sub-question 2: "Which knowledge types are perceived to be important in order to address the sustainability challenge?" Sample firms agree that the possession of certain knowledge is conditional for the ability to find solutions to the sustainability challenge. In order to answer this sub-question, different knowledge types are discussed that sample firms focus on when dealing with the sustainability challenge. Other related issues are examined which are perceived to be critical by sample firms. The following topics will be discussed in this section:

- Knowledge types
- Prior knowledge
- Knowledge management
- Supporting factors to knowledge management
- Hindering factors to knowledge management

5.2.1 Knowledge types

In terms of different knowledge types, sample firms believe that technical, strategic and market knowledge is particularly important in order to address the sustainability challenge. While the evidence clearly indicates that these knowledge types are needed, only OUTDOOR LTD explicitly mentions that it encourages all employees to acquire pieces of all of these knowledge types to a reasonable degree. In line with its focus on inter-disciplinarity, all teams also need to acquire knowledge that is not typical to their daily business. For instance, a material scientist builds market and strategic knowledge while a sales person builds technical knowledge. An explanation for the fact that only OUTDOOR LTD as the small firm in the sample highlights this inter-disciplinarity is, that it does not have the resources to set up dedicated teams which are responsible for many different pieces of knowledge while large firms can do that.

In addition to these knowledge types, RETAIL LTD suggests human resource knowledge. This can play a role when hiring the right set of individuals into sustainability teams. Moreover, it can help to identify "sustainability champions" who are open to the topic and able to motivate others for it. RETAIL LTD identifies a sustainability specialist in each store who gets special training and spreads this knowledge to other employees in the store. This includes basic knowledge to save energy such as reducing the time when refilling the freezers or turning off the light. Further, the specialist also presents the monthly sustainability poster to staff in the store.

Market knowledge

Market knowledge primarily represents knowledge about stakeholders such as customer requirements, competitor activity and supplier offering. This knowledge is regarded critical in order to understand what the market context and resulting challenges in the context of sustainability look like before any action can be taken. However, the examples that sample firms give for market knowledge related to sustainability diverge. CAR LTD and CHEMICAL LTD mention customer-related aspects of market knowledge. CHEMICAL LTD, for instance, refers to the knowledge of which the current and potential future (groups of) customers are for each of the three subgroups. This differentiation is necessary since the products and the customer base of the three subgroups are entirely different. Along these lines, CAR LTD also highlights the knowledge about the future sales potential and the attractiveness of markets segments to expand in further or enter into. Since CAR LTD offers a vast spectrum of cars from budget to luxury, the firm also distinguishes the knowledge of each segment. In addition, CAR LTD and CHEMICAL LTD mention knowledge about which regions are attractive and have the largest growth potential. In that regard, emerging markets generally play an important role. Moreover, CHEMICAL LTD notes that knowledge about potential risks

is critical. This is especially the case for firms in the chemicals and pharmaceuticals industries with operations in emerging markets. For instance, such risks include an NGO discovering involvement of child labour in the firm's operations which the firm has not been aware of or a spill of hazardous substances. Overall, CHEMICAL LTD highlights the importance of knowledge about which product portfolio needs to be developed in order to satisfy customer requirements which includes considerations in terms of price, features and sustainability. In addition to the knowledge about customers (such as sales potential in market segments and regions, price elasticity to more expensive sustainable products, etc.), RETAIL LTD and OUTDOOR LTD note that knowledge about suppliers is critical. In the case of RETAIL LTD this is because food products have a direct impact on health of the population and in the case of OUTDOOR LTD this is because the firm attempts to solve sustainability challenges in collaboration with partners since not all knowledge is available in-house. For RETAIL LTD, this includes knowledge about which supplier can deliver sustainable products at the right quality and price and about how to deal with the rising power of some suppliers. For OUTDOOR LTD, it includes knowledge about which supplier has the ability to deliver sustainable textiles with the best functional characteristics at the right price. Moreover, this includes knowledge about which suppliers manage dyeing processes in a sustainable way, which still is a challenge across the textiles industry. Therefore, market knowledge also relates to the ability to detect opportunities in sustainability in the market context which was discussed earlier. Reasons why CHEMICAL LTD and CAR LTD do not mention suppliers in the context of market knowledge are twofold. First, the sheer number of their suppliers makes the accumulation of detailed knowledge literally impossible and second, their own vast market power significantly reduces their dependency on suppliers.

Strategic knowledge

Strategic knowledge relates to the knowledge that helps firms to make decisions and position themselves to build competitive advantage. Strategic knowledge is believed to be essential in the context of the sustainability challenge since it shapes the firm's course given the market knowledge it has. While the basic understanding of strategic knowledge is similar among sample firms, differences exist with the examples they provide. CAR LTD, for instance, regards strategic knowledge on a highly generic level and describes it as "knowledge about which directions to follow and focus on". A concrete example is strategic knowledge about downsizing. In this case, the board of directors has clearly decided strategically that the segment of very small, economical and fuel-efficient cars needs to be explored which resulted in the development of the smallest ever built by the firm. Strategic knowledge caused the expansion into this segment rather than focusing on the higher luxury segment. On a different note, OUTDOOR LTD argues that strategic

knowledge includes "what the firm can and wants to do in terms of sustainability initiatives". This view suggests that decisions are made in an inclusive and non-hierarchical manner which highlights a major difference between CAR LTD and OUTDOOR LTD. It also suggests that the firm carefully assesses what can be done in-house and what needs input from external sources such as in the case of sustainable textiles and dyeing processes. For OUTDOOR LTD, strategic knowledge emphasises products that are made of high-performance but yet sustainable textiles. More specifically, strategic knowledge leads the firm to focus on dyeing processes of textiles which is seen as a major differentiator. In comparison, CHEMICAL LTD offers a more holistic view on strategic knowledge. The firm notes that since requirements of a business and sustainability nature can diverge, it is critical to know "how to find the largest common denominator between the two in terms of a product portfolio". In other words, the firm notes that it is essential to know how to find the largest common denominator when moving from a single-stakeholder focus to a multi-stakeholder focus. This is critical, for instance, in a scenario when an NGO pressurises the firm to engage in a costly sustainability initiative which shareholders oppose to. In this case, strategic knowledge includes stakeholder involvement to discuss the issue at hand and find a mutually acceptable solution. Since the potentially hazardous pharmaceutical and chemical industries are exposed to attention by NGO, it is understandable that CHEMICAL LTD engages proactively in stakeholder involvement with the goal to find agreements to avoid public conflict. This also explains why CHEMICAL LTD believes that strategic knowledge needs to account for longer-term trends and shifting expectations to facilitate the search for such a common denominator. With a focus on the product portfolio, RETAIL LTD believes strategic knowledge to be about which new products (and categories) to add to the assortment in order to best be able to respond to market demand. For instance, this includes knowledge on how to respond to the increasing trend of single-households and corresponding shopping patterns (which makes smaller packages and ready-made convenience food an issue). Further, this includes sourcing-related knowledge about the optimisation of purchasing processes such as reduction in air-transported goods by sourcing from closer regions (e.g. asparagus from Greece rather than Peru). Finally, with a focus on accounting, OUTDOOR LTD adds that strategic knowledge about costs and benefits of sustainability initiatives is important which also includes knowledge if the creation of a new position is necessary to pursue a given initiative. It is fair to assume that the other sample firms - like any other profit-oriented firm - also focus on that.

Technical knowledge

Technical knowledge is needed to solve a specific task or problem. Sample firms note

that the sustainability challenge and the firm's related market and strategic knowledge force them to find technical solutions. The challenges these firms face are similar with major issues being energy and material consumption, CO2-emissions and water management. However, the approaches these firms take differ substantially due to the different nature of their products and processes. When talking about technical knowledge, the fields of CO2-reduction and of energy consumption are most important for CHEMICAL LTD. First, the firm notes that the technical knowledge about the "dream production project" is of highest importance. Dream production is path-breaking in that it uses CO2 as an ingredient for the production of polymers. This knowledge allows the firm to consume rather than produce CO2-emissions by using CO2 to build materials. Second, the knowledge leading to the development of an oxygen depolarised cathode is another path-breaking solution. It enables the firm to reduce energy consumption by 25% in its highly energy-intense chlorine production facilities. With a less manufacturing-focused and more product-focused approach, OUTDOOR LTD notes that technical knowledge of how to develop sustainable materials and textiles combined with the highest standards in terms of functionality and design at a reasonable price is critical. This knowledge in material science coupled with a thorough understanding of sustainable dyeing processes is considered priority since challenges and opportunities to gain competitive advantage are the biggest. While CHEMICAL LTD mentions technical knowledge primarily in connection with sustainable processes and OUTDOOR LTD in connection with sustainable products, CAR LTD explicitly mentions both. In terms of products, technical knowledge related to alternative power-trains and fuel-efficiency is regarded essential. In terms of processes, knowledge related to material- and energy-efficiency and water management are believed to be critical. Knowledge related to CO2-reduction mechanisms is related to both, its processes and the use of its products at the same time. Similar to CAR LTD, RETAIL LTD takes a wider view. More specifically, RETAIL LTD focuses on technical knowledge for processes (such as heating technologies in its bakeries using renewable energy) as well as for its retail space (such as energy-saving LED lighting technologies). Overall, sample firms note that technical knowledge needed to deal with the sustainability challenge is obtained through focused R&D and cooperations with external partners. In that regard, CHEMICAL LTD notes that innovation is a powerful stakeholder pressure of sustainability and not only vice-versa as it is commonly believed.

5.2.2 Prior knowledge

Sample firms agree that the knowledge required to address the sustainability challenge successfully already exists to a certain extent but also needs to be continuously aligned with a changing market context. Especially, the large multinationals CAR LTD and

CHEMICAL LTD note that the knowledge base needs to be adjusted continuously to ensure that they not only keep track with arising challenges but also are "ahead of the curve". In addition, CAR LTD explicitly highlights the necessity of well-established internal and external networks to access this knowledge.

The connection between knowledge that has been created in the past and knowledge that will need to be created to address new challenges sheds some light into the significance of prior knowledge. It can be observed that prior knowledge on certain issues can help sample firms to deal with today's challenges to some degree. CHEMICAL LTD, for instance, notes that its early beginnings of water management with the foundation of the "waste water commission" in 1901 has helped it in the past and helps it today to address the rising importance of water management. This is especially important for the chemicals and pharmaceuticals industry due to residuals of hazardous substances in waste water and the high water consumption in production processes. Such prior knowledge includes knowledge on how to purify waste water and eliminate residual substances as well as measures to save water in its production processes. In a similar vein, CAR LTD's early focus on fuel-efficiency and diesel engines - which started in 1973 in response to the oil crisis - represents a solid basis in order to master today's challenges in terms of fuel consumption and CO2-emissions. Similarly, RETAIL LTD introduced organic and fair-trade products (e.g. Max Havelaar) in response to an increasing demand for sustainable products in the 1990s. Establishing these product lines made the firm acquire knowledge about direct sourcing, sustainable supply chains and long-term relationships with critical suppliers. This helps the firm today to apply a similar direct sourcing approach with other products such as cocoa, soy and rice. A more recent example of the role of prior knowledge is given by OUTDOOR LTD. The arising need for environmental certification (such as EMAS) including documentation and implementation caused a significant challenge in 2008. However, the lessons learned substantially support the firm today to deal with issues related to certifications. Apart from the causal link of prior knowledge and current knowledge, CHEMICAL LTD notes that prior knowledge related to sustainability is also linked to a higher degree of awareness and better attitude to sustainability today. The fact that waste water has been a critical issue for so long has shaped the attitude towards that topic among employees in a positive way.

In summary, it can be argued that prior knowledge can help firms to address the challenges of today in the form of an "early entry ticket". It provides the firm with a temporary advantage over competitors which have not had that prior knowledge. However, this prior knowledge needs to be complemented continually by new knowledge that is not necessarily linked to prior knowledge. In that regard, CAR LTD notes that it also faces challenges today that are not directly linked to past experience

such as the emerging demand for alternative power-trains. While the firm's prior knowledge of diesel engines, fuel-efficiency and CO2-reduction helps to deal with current requirements to conventional combustion engines, this knowledge does not explicitly help do develop alternative power-trains. These demands can only be addressed by going far beyond prior knowledge and past experiences. As noted earlier, this is done though focused internal efforts and partnerships with experts in alternative propulsion technologies. Compared to historic developments, the acquisition of new knowledge for alternative power-trains occurs rather rapidly.

As with the ability to detect opportunities for knowledge creation, the discussion of prior knowledge in the literature is also relevant here. However, as with the literature on the dynamic capability construct, the related literature on path dependency does not offer one consistent view. Most importantly, the questions whether path dependencies exist and whether prior knowledge has an impact, cannot be answered clearly. Rather, these questions have to be addressed on a case-by-case basis as in some instances prior knowledge is critical while in others it is not (as CAR LTD's example of alternative power-trains illustrates). Therefore, as discussed in the literature review, this research follows Eisenhardt and Martin's (2000) view. The authors note that path dependencies cannot exclusively be described by a single path that is shaped by a firm's historic decisions and resulting prior knowledge as suggested by Teece et al. (1997). Rather, Eisenhardt and Martin (2000) propose that a firm's path can also be shaped and adjusted through learning mechanisms that create new knowledge and specific experiences. In other words, Eisenhardt and Martin (2000) argue that in dynamic market contexts the need for existing knowledge is replaced or at least complemented by a need for specific new knowledge which undermines the importance of prior knowledge. This supports the view in this research that while prior knowledge can be important it does not necessarily represent the most important stakeholder pressure of success in dealing with the sustainability challenge. Along these lines, Lichtenthaler and Lichtenthaler (2009) also highlight the importance of prior knowledge to create, retain and apply knowledge but the authors do not regard prior knowledge as the single success factor. As noted in the literature review, it is acknowledged that the sooner a firm builds knowledge, the better it is for competitive advantage. However, in market contexts characterised by rapid change (e.g. Argote, 1999; King and Tucci, 2002; Rindova and Kotha, 2001; Santos and Eisenhardt, 2005; Teece, 2007; Zott, 2003) as it is the case with the sustainability challenge, it is possible (and often necessary) to catch up and acquire the required knowledge with the help of rapid learning.

5.2.3 Knowledge management

Sample firms search for knowledge internally and externally. While internal knowledge

sources are used by all sample firms, they also highlight the importance of external partners for knowledge sourcing and exchange. This appears to be a common approach to complement internal knowledge by the necessary external knowledge in order to deal with stakeholder expectations. Most notably, CAR LTD and OUTDOOR LTD mention partnerships in the field of alternative power-trains and sustainable high-performance textiles, respectively. In both cases, these fields are linked to market trends related to sustainability which these firms want to respond to and benefit from.

An insightful way to analyse knowledge is to divide it into three dimensions as proposed by Lichtenthaler and Lichtenthaler (2009). These dimensions define possible temporary states that a given piece of knowledge can be found in, that is whether new knowledge is created, whether knowledge is stored and transferred to where it is needed or whether knowledge is applied and transformed into products or processes. Following Lichtenthaler and Lichtenthaler (2009) discussed in the literature review, these three states correspond to the dimensions of knowledge exploration, retention and exploitation, respectively. These three dimensions have both, an internal as well as an external focus.

Knowledge exploration

The dimension of knowledge exploration is concerned with knowledge creation and receives most attention among sample firms compared to knowledge retention and exploitation. While all sample firms note that they explore new knowledge internally as well as externally, the degrees to which they do one or the other and how they do it differ.

In terms of internal knowledge exploration, CHEMICAL LTD argues that knowledge and resulting solutions are created and developed with the help of an open exchange and feedback approach. This is done not only among employees within corporate R&D but also between the different R&D units at the corporate, subgroup and country level. Further, not only R&D staff but also all other employees are encouraged to contribute to improvement initiatives such as on energy-efficiency. This is open to employees and teams from all functions and hierarchical levels to ensure contributions from a wide angle. Prizes are awarded to best contributions. An exemplary result of internal knowledge exploration efforts is the oxygen depolarised cathode mentioned earlier. Similarly, RETAIL LTD's sustainability team sets up sustainability workgroups on important topics such as in-store energy saving training. Every year, the sustainability team selects a focus topic to be featured in internal knowledge building initiatives such as the monthly poster campaigns. The dedicated sustainability specialist in each store presents these posters to employees in the store and thereby regularly builds and extends the body of sustainability knowledge among them. With a wider focus than CHEMICAL

LTD and RETAIL LTD, CAR LTD goes beyond the role of R&D alone. Next to R&D, the firm also organises expert groups with participants from different units and interdisciplinary teams to share and build knowledge. This is complemented by internal conferences on various topics. In the case of CAR LTD, an example for internal knowledge exploration is diesel technology which the firm has vast and valuable experience in. By contrast, OUTDOOR LTD as the smallest firm in the sample does not have a systematic and structured approach to internal knowledge exploration. A recent example is the internal build-up of knowledge of the GRI criteria. An intern had the task to continuously expand the knowledge base by talking to the members of the sustainability team and other employees with knowledge in the GRI which was aggregated in the intern's master thesis. This intern is now a full employee in the sustainability team responsible for the firm's GRI issues.

In line with these findings, the literature on internal knowledge creation addresses the role of creation processes and the actual creation of knowledge. Knowledge exploration from internal sources is what Lichtenthaler and Lichtenthaler (2009) refer to as inventive capacity. It is "the firm's ability to internally explore new knowledge" (Lichtenthaler and Lichtenthaler, 2009: 1319). Once a challenge and a related opportunity for knowledge creation has been detected, knowledge exploration processes are established in order to generate new knowledge (Lichtenthaler and Lichtenthaler, 2009; Shane, 2000; Smith et al., 2005). Following knowledge creation, the literature also focuses on the integration of newly created knowledge into the existing knowledge base (e.g. Lichtenthaler and Lichtenthaler, 2009; Smith et al., 2005). In order to be able to integrate knowledge, the firm needs to establish links to existing knowledge (Helfat et al., 2007; Lichtenthaler and Lichtenthaler, 2009; Nonaka, 1994). The establishment of these links highlights the significance of prior knowledge (Khilji et al., 2006; Leonard-Barton, 1992). Along these lines, the firm's prior knowledge and experiences in a given area support the generation of new knowledge and its integration (Khilji et al., 2006; Lichtenthaler and Lichtenthaler, 2009).

In terms of external knowledge exploration, all sample firms rely on partnerships. CHEMICAL LTD, for instance, notes that cooperations at the intercept of business and research with a local energy firm, a research institution and the firm's R&D units (corporate, subgroup and regional) are critical. An example is the "dream production project" discussed above. Similarly, OUTDOOR LTD mentions the importance of cooperations with partners in the sustainability arena, namely with the WWF and Bluesign, in order to acquire the knowledge needed to deal with the sustainability challenge. These external partners provide a significant amount of knowledge. For example, they consult the firm on sustainable process adjustments such as energy- and material-efficiency. In addition, they help the firm to enhance transparency across the

supply chain. Moreover, they provide valuable information about suppliers regarding their sustainability practices, efforts to transparency and strengths and weaknesses in general. In the context of the firm's "energy vision" which seeks to reduce energy consumption dramatically, RETAIL LTD cooperates with external specialists on the fields of LED lighting technologies, solar technology and industrial heating systems using renewable energy. In these cases, an internal project coordinator is selected among the most suitable employees who is then responsible for the project and the relationship with external providers. CAR LTD also builds on diverse and strong partnerships in order to explore knowledge externally. Further, the firm has memberships in various industry associations and consortia and attends as well as organises conferences on different sustainability topics. Moreover, the firm cooperates with universities and other research institutions. An example for external knowledge exploration is the development of alternative power-trains. While the firm believes to have a vast knowledge base on conventional engines, it believes that it is necessary to explore external knowledge bases regarding alternative power-trains. The firm observes that developments on this field are highly dynamic which it can better participate in through partnerships.

While partnerships for external knowledge creation are believed to be essential by sample firms and in the body of literature, a discrepancy arises regarding the integration of new knowledge. Again, this is practiced by firms implicitly without talking explicitly about it. Otherwise, the knowledge base could not be continuously aligned with pressures arising from the sustainability challenge. External knowledge creation is referred to as absorptive capacity by Lichtenthaler and Lichtenthaler (2009). The authors note that it is "the firm's ability to externally explore new knowledge" (p. 1319). In other words, this is about exploratory learning and the external acquisition of knowledge (Lane et al., 2006; Lichtenthaler and Lichtenthaler, 2009; Zahra and George, 2002). Next to exploratory learning and external exploration per se, absorptive capacity also includes the integration of newly created knowledge in the existing knowledge base (Lichtenthaler and Lichtenthaler, 2009). The process of external knowledge creation requires firms to cooperate with other firms (Grant and Baden-Fuller, 2004). Along these lines, external knowledge creation represents learning by which the firm absorbs another firm's knowledge pool (Grant and Baden-Fuller, 2004). Along this line of thinking, Jansen et al. (2005) highlight the importance of cross-functional interfaces such as teams dedicated to knowledge exchange and liaison activities or specific taskforces which support absorptive capacity in the acquisition of external knowledge (Jansen et al., 2005). Often, this includes the exploration of complementary knowledge that is needed by the firm in order to deal with a given challenge (Grant and Baden-Fuller, 2004). It is argued that the external accumulation of knowledge over time supports firms in solving a given problem (e.g. Grant, 1996; Kale and Singh, 2007). Such external learning and

accumulation of knowledge takes place when firms make associations between past actions executed with past knowledge and future actions (Fiol and Lyles, 1985; Kale and Singh, 2007). Cohen and Levinthal (1990) argue that historic efforts (such as knowledge exploration through partnerships) determine a firm's development path which suggests prior knowledge affects absorptive capacity.

Knowledge retention

Although the dimension of knowledge retention is not understood as clearly as exploration or exploitation by sample firms, they engage in knowledge retention internally and externally. Knowledge retention involves the storage of created knowledge and the transfer from where it is stored to where it is needed. Differences exist as to how firms retain knowledge.

In terms of internal knowledge retention, OUTDOOR LTD, CAR LTD and RETAIL LTD maintain internal databases that contain sustainability information and knowledge accessible by all employees. RETAIL LTD, for instance, operates a "share-point" database which the sustainability team and other employees involved in sustainability workgroups use to store memos, presentations, research papers and other relevant items. In addition, the intranet is used to store and make available knowledge. This allows employees to access the existing internal body of knowledge wherever and whenever needed. By contrast, CHEMICAL LTD does not yet have internal sustainability knowledge storage in the form of databases or the intranet in place. However, the Corporate Centre of Sustainability and Environment issues a quarterly newsletter which includes contributions on sustainability topics of different regions and units and thereby represent to some extent internal knowledge transfer and sharing. In terms of human capacity to store knowledge, CAR LTD notes that project teams and focus groups - those developing alternative power-trains, for instance - also function as storage of sustainability knowledge. Similarly, OUTDOOR LTD notes that the sustainability coordinator and the sustainability team function as an informal knowledge storage which can be accessed by employees. This group of people ensures that knowledge is maintained centrally and that it can be deployed wherever needed. While only CAR LTD and OUTDOOR LTD explicitly mention knowledge storage among employees, it can be assumed that this is also the case at other sample firms.

The views in the literature on internal knowledge retention correspond to practical approaches by sample firms. Lichtenthaler and Lichtenthaler (2009) refer to internal knowledge retention as transformative capacity. It is defined as "the firm's ability to retain knowledge inside the firm" (Lichtenthaler and Lichtenthaler, 2009: 1320). Transformative capacity represents the capacity to choose relevant internal knowledge and technology, maintain that knowledge in the firm's knowledge base and retrieve

certain pieces of knowledge if the need arises (Garud and Nayyar, 1994; Pandza and Holt, 2007). Maintaining chosen pieces of internal knowledge can be referred to as a "knowledge store housing" to avoid losses of knowledge and preserve it for later application (Garud and Nayyar, 1994). Whenever a specific piece of stored knowledge is required, it needs to be reactivated and if necessary combined with additional knowledge (Lichtenthaler and Lichtenthaler, 2009; Pandza and Holt, 2007). Prior knowledge can also play a role in that as it can facilitate the process to maintain and retrieve knowledge (Garud and Nayyar, 1994; Lichtenthaler and Lichtenthaler, 2009; McGaughey, 2002).

In terms of external knowledge retention, sample firms also build on involvement with external partners. All sample firms mention memberships in industry associations, consortia and other bodies in order to be able to access external knowledge bases and engage in knowledge sharing. CHEMICAL LTD, for instance, has memberships in associations such as "Verband der Deutschen Industrie", Verband der Chemischen Industrie", Econsense and "Verband Forschender Arzneimittelhersteller". Like CHEMICAL LTD, CAR LTD is also affiliated with Econsense as well as with "Verband der Deutschen Industrie". In addition, the firm is member in advisory boards of projects with UN Global Compact and CSR Europe. Along these lines, OUTDOOR LTD is also member in industry associations such as the European Outdoor Group. RETAIL LTD mentions its membership with "Coopernic", a consortium of European retailers, which organises working groups to deal with issues such as the sustainability challenge. This consortium is a valuable source of knowledge that the firm has access to through a knowledge sharing relationship with other members.

As regards external knowledge retention, the evidence from case studies corresponds to findings in the literature in that alliances and knowledge sharing are regarded critical. However, firms mainly refer to industry associations when referring to alliances for knowledge retention purposes while that focus cannot be found in the literature. External knowledge retention is referred to as connective capacity (Lichtenthaler and Lichtenthaler, 2009). The authors define it as "the firm's ability to retain knowledge outside the firm" (p. 1320). Consequently, connective capacity includes elements of alliance and relational capability (Kale and Singh, 2007; Lichtenthaler and Lichtenthaler, 2009) as is the case with absorptive capacity. By contrast, the firm does not acquire and integrate knowledge to the internal knowledge base but rather keeps the option to access this knowledge (Grant and Baden-Fuller, 2004; Lichtenthaler and Lichtenthaler, 2009). Alliances can support firms to access each partner's knowledge base and thereby engage in knowledge sharing and exploiting complementarities (Grant and Baden-Fuller, 2004). Connective capacity benefits from prior knowledge in that the more knowledge a firm has in a given field, the better it understands potential issues and the easier it can manage inter-firm relationships on that field (Lichtenthaler and Lichtenthaler, 2009).

Knowledge exploitation

The dimension of knowledge exploitation relates to the internal and external application of sustainability knowledge in manufacturing processes and product development. Since all sample firms develop and produce products, they apply the created and transferred knowledge in one way or another. However, due to different product portfolios among sample firms, differences exist in the knowledge types used and the area of application (i.e. whether the knowledge is applied in sustainable processes or products).

In terms of internal knowledge exploitation, OUTDOOR LTD notes that newly created and transferred knowledge such as in the form of sustainable material science flows directly into product development. As mentioned earlier, however, product development does not only rely on sustainability knowledge but also takes into account performance and design considerations. Therefore, the firm's focus is on using sustainability knowledge in products rather than processes. By contrast, CHEMICAL LTD's focus primarily rests on the use of sustainability knowledge in manufacturing processes. Exemplary applications of such knowledge relate to new manufacturing technologies such as the discussed oxygen depolarised cathode and the "dream production". RETAIL LTD and CAR LTD, however, explicitly focus on the application of sustainability knowledge in product development as well as processes. In RETAIL LTD's case, created and transferred knowledge is used to develop new sustainable products such as fulfilling fair-trade and organic criteria in the same products like rice and cocoa and to adopt industrial heating systems based on renewable energies such as wood pellets. In CAR LTD's case, knowledge on alternative power-trains and fuel-efficiency of conventional combustion engines is transformed into next generation engines. Knowledge on water management as well as material- and energy-efficiency is transformed into new and more sustainable manufacturing technologies.

Evidence from case studies suggests that the understanding of internal knowledge exploitation is in line with the view in the literature. Lichtenthaler and Lichtenthaler (2009) refer to internal knowledge exploitation as innovative capacity. It is defined as "the firm's ability to internally exploit knowledge (Lichtenthaler and Lichtenthaler, 2009: 1321). Therefore, innovative capacity represents the internal application of knowledge that has been generated internally and externally (Lichtenthaler and Lichtenthaler, 2009). This includes the application of knowledge in the development of new manufacturing technologies as well as products with a focus on the alignment with market demand (Cohen and Levinthal, 1990; Lichtenthaler and Lichtenthaler, 2009). Prior knowledge supports innovative capacity. For instance, prior knowledge about a particular market including commercialisation opportunities and how to exploit these can help firms to discover how to use new knowledge to serve a given market today (Kogut and Zander, 1992; Lichtenthaler and Lichtenthaler, 2009; Shane et al., 2000; Smith et al., 2005).

In terms of external knowledge exploitation, which takes the form of an external use of knowledge such as selling licensing agreements, none of the sample firms are currently pursuing any activities. CHEMICAL LTD, however, might soon be the exception. The "dream production project" outlined earlier which enables the use of CO2 as an ingredient for the polymers production could become a solution that is licensed out to other firms if it proves to work at a larger scale in practice.

At this point in time, none of the sample firms engage in the external exploitation of knowledge in the form of selling licensing agreements as suggested by the literature. Lichtenthaler and Lichtenthaler (2009) refer to external knowledge exploitation as desorptive capacity. Lichtenthaler and Lichtenthaler (2009) define desorptive capacity as "the firm's ability to externally exploit knowledge" (p. 1322). Therefore, desorptive capacity is about transferring knowledge to beyond the firm's boundaries and deploying it (Fosfuri, 2006; Lichtenthaler and Lichtenthaler, 2009). Such external use of knowledge can take the form of selling technology licensing agreements which has become more popular in recent years (Lichtenthaler, 2007). Prior knowledge in technology licensing such as with identifying external opportunities for knowledge exploitation and with screening suitable partners can support the development of desorptive capacity (Fosfuri, 2006; Lichtenthaler, 2007; Lichtenthaler and Lichtenthaler, 2009).

5.2.4 Supporting factors to knowledge management

Sample firms argue that various conditions need to be met in order to develop the mentioned knowledge types and for knowledge management to be successful in addressing the sustainability challenge. While all these supporting factors are critical for knowledge management in any firm, each sample firm has a different focus. OUTDOOR LTD and CAR LTD mention the importance of internal and external networks which help the firm to tap into different knowledge sources if needed. More specifically, OUTDOOR LTD notes that an internal team structure which is conducive to knowledge sharing and building is essential. By this, OUTDOOR LTD refers to the inter-disciplinary approach it takes to sustainability management which is actively encouraged by management. On a different note, CHEMICAL LTD highlights that a critical distance from the daily business in the subgroups and a neutral position are necessary in order to manage knowledge for sustainability holistically. CHEMICAL LTD argues that if a team does not have any capacity beyond its primary task, it is hard to "lean back and assess which knowledge is needed for a given sustainability initiative, where it can be sourced from and how it can be best applied". This is where the value of the Corporate Centre of Sustainability and Environment lies which is independent and separate from the subgroups. By contrast, RETAIL LTD highlights the long-term focus among managers

and employees which is necessary to ensure continuity in addressing knowledge management for sustainability. In addition, openness for change is seen to be critical in that it enables the firm to examine the need for knowledge in a new context.

5.2.5 Hindering factors to knowledge management

Not only supporting but also hindering factors are identified by sample firms which represent obstacles to the development of the discussed knowledge types. Again, these hindering factors are important in their own right but differences exist among sample firms as to which hindering factors they face. For instance, CHEMICAL LTD notes that sustainability is not always treated with a longer-term view in mind and that it is therefore not always on the agenda of management when decisions are made such as which knowledge to build and where to source it from. By contrast, OUTDOOR LTD mentions hindering factors that tend to be typical for smaller firms. First, the lack of prioritisation skills and pragmatic behaviour as discussed before causes a blurred focus on most important sustainability activities. For instance, the firm pursued the short-term trend of hemp textiles which did not last in the end and blocked resources that could have been used for something more relevant such as to advance sustainable synthetic materials. Second, OUTDOOR LTD notes that the resignation of valuable employees can cause a loss of knowledge and of parts of the network used to source knowledge from. In such a case individual knowledge gets lost which is more severe with highly specified engineers and sales people with close links to their market. One would assume that this is less of an issue for larger firms due to the higher number of employees working on the same topic. However, also CHEMICAL LTD highlights the importance of not assigning responsibilities of initiatives to a single individual but rather to a group of individuals since a departure of that individual would mean substantial loss of know-how. CAR LTD mentions another hindering factor linked to firm size. Due to the firm's large size it can happen that one department (e.g. Finance and Controlling) does not see the same value of a particular sustainability initiative and required knowledge as the CSR and Sustainability Coordination Team or Corporate Communication do. Further, a few factors exist which likely affect all sample firms to a certain degree but are only mentioned by CHEMICAL LTD and RETAIL LTD. If employees do not understand the implications of sustainability, then they will unlikely be in the position to judge which knowledge is needed to address a given issue and how it can be generated and where it can be found. In addition, if key-people do not support sustainability in the first place and the necessary resources are not provided as a result, this will hinder knowledge management for sustainability.

5.2.6 Summary

In summary, Table 11 shows the discussed issues and findings:

Issues	Findings (sample firms)
Types of knowledge	• Market knowledge – product-related sales potential and market attractiveness **(CHEMICAL LTD, CAR LTD)** – geographic sales potential and market attractiveness **(CHEMICAL LTD, CAR LTD)** – consumption trends **(CHEMICAL LTD, RETAIL LTD)** – future product portfolio to meet customer requirements **(CHEMICAL LTD)** – supplier ability to deliver innovative sustainable (intermediate) products **(RETAIL LTD, OUTDOOR LTD)** • Strategic knowledge – finding most suitable strategic direction to focus on in the context of sustainability (downsizing) **(CAR LTD)** – finding largest common denominator between business and sustainability requirements (negotiations with NGO) **(CHEMICAL LTD)** – defining the best product portfolio to respond to market change (fair-trade and organic offering) **(RETAIL LTD)** • Technical knowledge – materials combining criteria in terms of sustainability, design, performance and price **(OUTDOOR LTD)** – (waste) water management **(CHEMICAL LTD, CAR LTD)** – Energy-efficiency and CO2-reduction in manufacturing processes **(All)** – LED lighting technologies **(RETAIL LTD)** – industrial heating using renewable resources (wood pellets) **(RETAIL LTD)** • Human resource knowledge – identification of internal "sustainability champions" **(RETAIL LTD)**
Historic knowledge	• Past experiences help firms to address today's sustainability challenge to a certain degree – waste water management **(CHEMICAL LTD)** – fuel-efficiency measures **(CAR LTD)** – development of fair-trade and organic products **(RETAIL LTD)** – obtaining environmental certifications (e.g. EMAS) **(OUTDOOR LTD)** • Prior knowledge continuously complemented by new knowledge to meet market change **(All)**
Knowledge management	• Build, retain and apply knowledge to address changing market requirements in the context of the sustainability challenge **(All)** • Focus on internal and external sustainability knowledge **(All)** • Knowledge exploration – exchange and feedback among units in R&D **(CHEMICAL LTD)** – expert workgroups **(RETAIL LTD, CAR LTD)** – dedicated person tasked with build-up of knowledge (e.g. GRI criteria) **(OUTDOOR LTD)** – partnerships **(All)** • Knowledge retention – intranet **(RETAIL LTD, OUTDOOR LTD, CAR LTD)** – databases **(RETAIL LTD, OUTDOOR LTD, CAR LTD)** – sustainability workgroup teams **(CAR LTD)** – partnerships **(All)** • Knowledge exploitation – development of sustainable products **(RETAIL LTD, OUTDOOR LTD, CAR LTD)** – development of sustainable manufacturing technologies **(CHEMICAL LTD, RETAIL LTD, CAR LTD)**
Supporting factors to knowledge management	• Internal and external networks for knowledge sharing **(All)** • Long-term horizon **(All)** • Interdisciplinary teams **(CHEMICAL LTD, OUTDOOR LTD)** • Management support **(All)** • Motivation for sustainability **(All)** • Mental distance from daily business **(CHEMICAL LTD)** • Openness to change **(All)** • Room for creativity **(CHEMICAL LTD, RETAIL LTD)**
Hindering factors to knowledge management	• Short-term view on sustainability **(All)** • Lack of prioritisation skills **(OUTDOOR LTD)** • Resignation of key-employees **(CHEMICAL LTD, RETAIL LTD, OUTDOOR LTD)** • Internal disagreements on value of sustainability initiatives **(CAR LTD)** • Lack of understanding of sustainability **(CHEMICAL LTD, RETAIL LTD)** • Lack of resources **(OUTDOOR LTD)**

Table 11: Findings on knowledge types and management to address the sustainability challenge

The findings in this section contribute to answering the sub-question of which knowledge types are perceived to be important to be able to address the sustainability

challenge. Going beyond knowledge types, however, other issues such as historic knowledge and knowledge management (including exploration, retention and exploitation) are examined which are perceived to be critical by sample firms and therefore provide more depth in answering the sub-question.

First, different knowledge types are discussed that sample firms focus on when dealing with the sustainability challenge. They believe that market, strategic and technical knowledge are of highest importance in order to master the sustainability challenge. In addition, human resource knowledge is proposed by one sample firm. Market knowledge focuses on expectations of current groups of customers, future sales potential and attractiveness of certain market segments and regions. In addition, this includes knowledge about suppliers in terms of their ability to innovate in sustainability. Strategic knowledge is mainly concerned with what supports firms to make decisions and to build competitive advantage. Technical knowledge is primarily concerned with how to find solutions to current challenges of which energy- and material-efficiency as well as the reduction of CO2-emissions are in focus. Human resource knowledge focuses on recruiting and internally identifying individuals who are capable of promoting the sustainability theme across the firm. Overall, larger firms tend to have specialist employees and teams in place focusing on one specific knowledge type. By contrast, smaller firms tend to encourage employees to acquire pieces of all of these knowledge types to a reasonable degree. This suggests that employees and teams need to acquire knowledge that is not typical to their daily business. This discussion leads to the following propositions:

Proposition 5: The more market knowledge a firm possesses, the higher is its ability to address the sustainability challenge.

Proposition 6: The more strategic knowledge a firm possesses, the higher is its ability to address the sustainability challenge.

Proposition 7: The more technical knowledge a firm possesses, the higher is its ability to address the sustainability challenge.

Proposition 8: The more human resource knowledge a firm possesses, the higher is its ability to address the sustainability challenge.

Second, historic knowledge often drives firms' current body of sustainability knowledge and its ability to expand on it. Looking at the significance of historic knowledge provides valuable insights in that it contributes to the understanding of how firms deal with the sustainability challenge. The evidence suggests that prior knowledge can help firms to address today's challenges to a certain degree which can generate competitive advantage if competitors do not own that knowledge. However, this knowledge needs to be

complemented continually by new knowledge that is not necessarily related to prior knowledge in order to be able to address changing market requirements. This is because these requirements can cause a need for knowledge that has not been traditionally generated by the firm. This suggests that while prior knowledge can be important, it does not guarantee long-term success in dealing with the sustainability challenge. Linked to the notion of prior knowledge, the evidence suggests that path dependencies exist but that path-breaking instances exist as well. Along these lines, Lichtenthaler and Lichtenthaler (2009) note that prior knowledge can assist firms to create, retain and apply knowledge. However, in a highly dynamic market context it might become necessary to acquire knowledge which is unrelated to prior knowledge with the help of rapid learning (e.g. Eisenhardt and Martin, 2000; Santos and Eisenhardt, 2005; Zott, 2003) which likely involves exploratory exercises (Lichtenthaler and Lichtenthaler, 2009). Again, this is linked to the notion of path dependencies. These can play an important role in shaping a firm's future path in some instances (e.g. Teece et al., 1997) while path-breaking instances exist in other more dynamic instances (e.g. Eisenhardt and Martin, 2000). Based on this discussion, the following can be derived:

Proposition 9: The higher the rate of change in a firm's market, the less it can rely on prior knowledge.

Proposition 10: The higher the rate of change in a firm's market, the higher the likelihood that it has to engage in path-breaking activities.

Third, the knowledge management processes that sample firms engage in can be analysed following the three dimensions of knowledge exploration, retention and exploitation as proposed by Lichtenthaler and Lichtenthaler (2009). This provides insights into how knowledge management is approached by sample firms in the context of sustainability. Knowledge exploration relates to the creation of new knowledge (Lichtenthaler and Lichtenthaler, 2009; March 1991). In order to acquire new knowledge internally, sample firms rely on focused R&D teams, expert groups and inter-disciplinary workgroups as well as dedicated sustainability education and training. In order to acquire new knowledge externally, sample firms are keen on building strong and long-term partnerships with external bodies such as research institutions, NGO, suppliers and others. This allows firms to complement internal with external knowledge in order to build the body of knowledge that is suited to address the sustainability challenge. Knowledge retention relates to the storage of knowledge and the transfer to where it is needed (Lichtenthaler and Lichtenthaler, 2009). For internal storage of knowledge, most sample firms have dedicated databases in place. Beyond databases, however, relevant employees and teams also store knowledge. For external storage of knowledge, sample firms highly emphasise partnerships with external parties as in the case of external

knowledge exploration. However, in this case, partnerships are primarily used to access external knowledge rather than to buy it. Industry associations and consortia are considered highly important for such knowledge sharing. Knowledge exploitation relates to the application of knowledge (Lichtenthaler and Lichtenthaler, 2009; March, 1991). Sample firms apply this knowledge internally in product development as well as manufacturing with the goal to make products and manufacturing technologies more sustainable. By doing this, they primarily focus on measures that reduce energy- and material-consumption as well as CO2-emissions. Sample firms do not apply knowledge externally in the form of licensing agreements.

All three dimensions as proposed by Lichtenthaler and Lichtenthaler (2009) are important in their own right. March (1991) suggests that firms should address knowledge exploration and exploitation simultaneously and keep an appropriate balance between the two since both have shortcomings in isolation. Exploration is concerned with the creation of new knowledge without applying it while exploitation is concerned with the application of existing knowledge without creating any new knowledge (e.g. Gupta et al., 2006; March, 1991). However, even though the literature suggests that many firms focus on exploitation because results are more predictable and occur faster compared to exploration of new solutions (e.g. March, 1991), the evidence in this research suggests that firms focus primarily on knowledge exploration. In a dynamic market context, the sustainability challenge often does not only require firms to do something in a new way but also to find entirely new solutions which require new knowledge that cannot simply be obtained by applying existing knowledge differently. In these instances, firms tend to focus on exploration rather than exploitation. The following propositions can be derived from this discussion:

Proposition 11: The higher the rate of change in a firm's market, the more it focuses on knowledge exploration compared to exploitation.

Proposition 12: The more recent the challenge a firm faces, the more it focuses on knowledge exploration compared to exploitation.

5.3 Knowledge-related abilities for continuous knowledge management

This section addresses sub-question 3: "Which knowledge-related abilities are perceived to be important in order to build, retain and apply knowledge continuously?" Sample firms are of the opinion that several knowledge-related abilities are needed which facilitate continuous knowledge creation, storage, transfer, re-alignment, re-adjustment and application. These knowledge-related abilities can be associated with explorative, retentive and exploitative knowledge capacities as proposed by the Lichtenthaler and Lichtenthaler (2009) framework. On a higher-level, the overall management and

coordination of these knowledge capacities is referred to as the knowledge management capacity which is regarded as the actual dynamic capability in this research (Lichtenthaler and Lichtenthaler, 2009).

There is wide agreement among sample firms that knowledge-related abilities have to be in place for the firm to build, retain and apply knowledge in order to address the sustainability challenge. Based on the evidence, these knowledge-related abilities can be separated into those

- which mainly relate to knowledge exploration,
- relate to March's (1991) two dimensions of knowledge exploration and exploitation (and in some cases also to the dimension of knowledge retention as proposed by Lichtenthaler and Lichtenthaler, 2009)
- and those that only relate to externally-oriented knowledge.

Since the characteristics of attitudes to and necessary efforts for each of these knowledge dimensions vary, this separation helps to highlight these differences. In other words, this separation supports the analysis of aspects that tend to be more tightly related to knowledge exploration and the other knowledge dimensions. This helps to sharpen the focus on the factors under investigation and provides an interesting contrast in the analysis. The accumulated list of knowledge-related abilities highlighted by sample firms will be discussed in detail below.

First, knowledge-related abilities mainly associated with knowledge exploration include the following:

- Working with a longer-term horizon
- Diversity and inter-disciplinarity among employees
- Readiness to challenge the status quo

Second, knowledge-related abilities associated with knowledge exploration and other dimensions include the following:

- Proactive behaviour in sustainability management
- Motivation for sustainability
- Sustainability training and education
- Integration of sustainability into overall strategy

Third, externally-oriented knowledge-related abilities include the following:

- Building alliances

5.3.1 Knowledge-related abilities associated with exploration

The findings in the case studies suggest that a number of knowledge-related abilities are linked to knowledge exploration exclusively. These enable the firm to create new knowledge that is required to successfully address various pressures arising from the sustainability challenge. This allows the firm to manage its knowledge base so that it is regularly realigned with the changing market context.

Working with a longer-term horizon

There is wide agreement among sample firms that a longer-term horizon is instrumental to build the required knowledge and fill the gaps in order to be able to deal with the sustainability challenge successfully. Sample firms argue that this is of particular importance for the exploration of new knowledge since benefits are not always known in advance and therefore need to be seen in a longer-term context.

For this reason, working with a longer-term horizon is necessary for knowledge exploration (inventive and absorptive capacities) as shown by Table 12 based on the Lichtenthaler and Lichtenthaler (2009) framework. Compared to knowledge exploitation, outcomes of exploration are less certain, occur later and less directly and are less clear to see (March, 1991). Therefore, in order for knowledge exploration efforts to be successful, firms need to have a longer-term horizon (Henderson and Cockburn, 1994; March, 1991). This is particularly important in the context of the sustainability theme. Dyllick and Hockerts (2002), for instance, argue that firms need to focus on longer-term goals and focus less on short-term benefits in order for sustainability initiatives to be successful.

	Exploration	**Retention**	**Exploitation**
Internal perspective	Inventive capacity	Transformative capacity	Innovative capacity
External perspective	Absorptive capacity	Connective capacity	Desorptive capacity

Table 12: Longer-term horizon following the classification of knowledge capacities[8]

As some sustainability initiatives show, sample firms consider a longer-term horizon to be essential. Good examples for longer-term initiatives are the ones that go through RETAIL LTD's long-term investment assessment tool. Potential investments are evaluated by comparing the costs of CO2-reduction with the costs of CO2-compensation whereby the entire life-cycle of investments is taken into account. Currently, this plays an important role with investments into energy-efficient LED lighting technologies in stores and the use of alternative energy sources. RETAIL LTD has equipped its largest bakery unit with heating technologies using wood-pellets rather than electricity or gas.

[8] Adopted from the Lichtenthaler and Lichtenthaler (2009) framework; The knowledge-related ability relates to shaded knowledge capacities of the framework.

This is also in line with March's (1991) point of view that it is not sufficient for firms to exclusively focus on exploitation of knowledge which is more predictable and shorter-term in nature as it is primarily concerned with refining and applying existing knowledge. Firms also need to put emphasis on exploration of knowledge which is riskier and longer-term in nature. This is because it is about creating knowledge from scratch in order to be able to deal with ever changing environments over the longer-term and thereby to secure sustained competitive advantage (Gupta et al., 2006; Jansen et al., 2006; March, 1991; Raisch, 2009; Rothaermel and Deeds, 2004). Therefore, the time horizon regarding sustainability initiatives is an essential ingredient for sustainability initiatives to be successful. Schaltegger and Hasenmüller (2005), for instance, argue that time horizon can be characterized by long-term thinking which is beneficial for sustainability initiatives as well as short-term thinking which turns out to be a major obstacle for sustainability management. Dyllick and Hockerts (2002) argue that firms often tend to overemphasise short-term gains as a result of their focus on stock markets where a certain dividend and a fast pay-back on the underlying investments are expected. They argue that "such an obsession with short-term profits is contrary to the spirit of sustainability" (p. 132).

It is questionable, however, how stock-listed firms like CAR LTD and CHEMICAL LTD can withstand pressures from shareholders and engage in initiatives without a high probability of fast return. By contrast, OUTDOOR LTD as a family-owned business and RETAIL LTD as a cooperative are not at all exposed to this type of pressure and therefore have more room for manoeuvre. Indeed, the evidence shows that these two firms are more intrinsically focused on the longer-term compared to the other two. This becomes apparent when analysing their true motivations for sustainability and their overall commitment towards protecting the environment and sustainability in general. By contrast, it is highly difficult for CAR LTD and CHEMICAL LTD to justify initiatives without an immediate and predictable benefit. This is in line with Andersen and Kemp (2004) who note that short-termism is a major barrier to sustainability. A possible explanation for this is given by Schaltegger and Hasenmüller (2005) who argue that the challenge of longer-term thinking lies in the time lag between the realisation of benefits derived from a sustainable initiative and of its costs. If that time lag is too long, the return on an initiative becomes uncertain and thus very likely to lose its appeal among stock-listed firms such as CHEMICAL LTD and CAR LTD.

Diversity and inter-disciplinarity among employees

While CHEMICAL LTD notes that diversity among employees is important for knowledge exploration, retention and exploitation, the other sample firms argue that it is mainly related to knowledge exploration. Since exploration is the least structured and

predictable stage of knowledge management, these sample firms believe that diverse teams increase the likelihood of success by seeing and understanding the most relevant aspects of sustainability in the market context. Therefore, when considering the knowledge capacities of the Lichtenthaler and Lichtenthaler (2009) framework in Table 13, diversity primarily relates to inventive and absorptive capacities on the exploration dimension.

	Exploration	Retention	Exploitation
Internal perspective	Inventive capacity	Transformative capacity	Innovative capacity
External perspective	Absorptive capacity	Connective capacity	Desorptive capacity

Table 13: Diversity and inter-disciplinarity among employees following the classification of knowledge capacities[9]

Another aspect of firm culture is the degree of diversity and inter-disciplinarity of employees in sustainability teams. The evidence from case studies suggests that the ability to fully understand the concept of sustainability, the need for knowledge, its relevance and usefulness, market change and the impact on the need for knowledge and how and where it can be applied to develop solutions to the sustainability challenge depends on the firm's employees. In the context of continuous knowledge management, employees occupy the role of receptors and agents who are exposed to existing and potential knowledge in the form of information and know-how and have to make choices as to which knowledge is essential and needs to be developed further as a basis for solutions. CHEMICAL LTD and RETAIL LTD, for instance, believe that highly diverse sustainability teams are crucial in order to be able to acquire knowledge, apply it as well as continuously adjust it to changing market requirements in support of sustainability. Both firms explicitly hire staff from different backgrounds who have acquired heterogeneous knowledge bases through previous positions and education. While OUTDOOR LTD neither explicitly mentions diversity nor has it anchored in its hiring strategy, the firm appears to make use of it too. This becomes visible at the emphasis the firm puts on employees' different backgrounds in material science, manufacturing, engineering, product management as well as marketing and general management which suggests a balance between more technical and scientific as well as more business-oriented backgrounds. CAR LTD, however, does not appear to focus on diversity explicitly.

In contrast to the importance of diversity, OUTDOOR LTD explicitly notes that employees need to have a common level of technical knowledge and understanding of sustainability in order for the firm as a whole to be able to grasp arising opportunities.

[9] Adopted from the Lichtenthaler and Lichtenthaler (2009) framework; The knowledge-related ability relates to shaded knowledge capacities of the framework.

Along these lines, CHEMICAL LTD argues that - while a diverse workforce is key - there needs to be a high degree of mutual understanding of important issues among different business units. The firm refers to that as "speaking the same language" and "sharing the same objectives" in terms of its sustainability initiatives. This common understanding is particularly important, since CHEMICAL LTD's operations are split into three subgroups (Health Care, Crop Science and Material Science) which all have entirely different products and processes in place which causes different foci among the respective workforces.

The notion of diversity is corroborated by the literature. As it is discussed in the literature section, the ability to recognise opportunities for knowledge creation depends to a large extent on the firm's employees. Along this line of thinking, it is believed that each individual identifies different opportunities due to individual prior knowledge and experience (Shane, 2000; Venkatarman, 1997). As with the ability to detect opportunities for knowledge creation discussed above, this also represents a causal link to the notion of path dependency as suggested by Eisenhardt and Martin (2000). In this case, past experiences of employees help them to grasp the concept of sustainability, the arising need for knowledge and how it can be used in order to deal with the sustainability challenge. Again, as Eisenhardt and Martin (2000) propose, existing knowledge and past experiences need to be complemented by new knowledge and experiences in order to keep track with newly arising pressures in the market. Kirzner (1997) argues that the success in discovering opportunities depends upon the distribution of information and therefore on the information that individuals possess. In addition to recognising opportunities, the ability to understand the value of new information and knowledge inside the firm is highly important (Cohen and Levinthal, 1990). Attaching a potential value to potentially new information and knowledge helps the firm to decide how to prioritise its knowledge creation activities and thereby increase its benefits from such activities.

Readiness to challenge the status quo

OUTDOOR LTD notes that the readiness to challenge the status quo relates to knowledge exploration as well as exploitation while the other sample firms link it to exploration only. This is because "leaving the beaten track" - as RETAIL LTD calls it - is most critical when building new knowledge to address the sustainability challenge. Therefore, this is where these sample firms see the greatest potential for change to what is conventionally believed. Thus, in the context of the Lichtenthaler and Lichtenthaler's (2009) framework illustrated in Table 14, the readiness to challenge the status quo mainly relates to the dimension of knowledge exploration.

	Exploration	Retention	Exploitation
Internal perspective	Inventive capacity	Transformative capacity	Innovative capacity
External perspective	Absorptive capacity	Connective capacity	Desorptive capacity

Table 14: Readiness to challenge the status quo following the classification of knowledge capacities[10]

Evidence from case studies suggest that certain organisational behaviours such as openness for change or freedom to experiment, for instance, support firms to challenge the status quo and to "think out of the box" as RETAIL LTD has proposed. RETAIL LTD and OUTDOOR LTD note that the creation of knowledge includes informal discussions among employees and teams "during coffee break" which often is a breeding ground for ideas regarding sustainability which are then pursued further. RETAIL LTD suggests that in order to be able to find innovative solutions that can address the sustainability challenge, an entrepreneurial corporate culture ("entrepreneurial spirit") is needed. Such a culture encourages freedom of thought and mental flexibility. This also includes the readiness to try out things, experiment and learn by doing and by making mistakes. This is in line with what OUTDOOR LTD notes, that the firm should encourage employees to do research, visit seminars and other sustainability events and to exchange ideas with other firms. To ensure that freedom, RETAIL LTD goes a step further and proposes relatively flat hierarchies that also allow the engagement of subordinates in decision-making processes.

CHEMICAL LTD notes that a certain degree of organisational openness (i.e. "keeping one's eyes open" and "being aware of the market context") is believed to be essential in order to see the organisation in the wider industrial context where challenges and opportunities originate. This corresponds to RETAIL LTD's and OUTDOOR LTD's view on entrepreneurial spirit and challenging established opinions. Along these lines, OUTDOOR LTD regards the mental openness, interest and buy-in of employees highly important, especially with issues concerning sustainability. This fits in well with the importance of an intrinsic conviction of sustainability which OUTDOOR LTD regards crucial in order for the firm to be able to detect trends and opportunities. Overall, organisational behaviours that challenge the status quo are less apparent in the case of large multinationals like CHEMICAL LTD and CAR LTD. Their sheer size and structural characteristics, namely CHEMICAL LTD's separation into three subgroups and CAR LTD's vast number of separate brands, is an explanation for that.

Sample firms actively encourage organisational openness among employees to varying degrees. At OUTDOOR LTD and RETAIL LTD, this is facilitated by flat hierarchies and the opportunity for everybody to give their opinion and talk to the sustainability

[10] Adopted from the Lichtenthaler and Lichtenthaler (2009) framework; The knowledge-related ability relates to shaded knowledge capacities of the framework.

team. In both cases, managers are accessible for employees and are open for new ideas and criticism. CHEMICAL LTD and CAR LTD approach this in a more structured manner. CAR LTD encourages organisational openness in that regular meetings between the CSR and Sustainability Coordination Team and any relevant department are organised where participants are encouraged to make suggestions for improvements to existing sustainability solutions. Suggestions are then analysed for feasibility and practicability and if they pass, they are implemented by the relevant departments. Along these lines, CHEMICAL LTD's Corporate Centre of Sustainability and Environment encourages organisational openness to ensure that existing knowledge and thinking are compared with new knowledge in the context of a rapidly changing market context. On a firm-wide scale, contests for best suggestions are organised for which all individual employees or teams are encouraged to participate. In addition, CHEMICAL LTD notes that the openness in a given team depends on the manager's preferences and views whether change is regarded as an opportunity or not.

This evidence of the readiness to challenge the status quo is not supported by the literature on path dependency and prior knowledge. While path dependency in the form of past experiences (e.g. Eisenhardt and Martin, 2000; Teece et al., 1997) plays an important role with the ability to detect opportunities for knowledge creation as well as the diversity and inter-disciplinarity among employees, the opposite is the case with the ability to challenge the status quo. Here, it is about breaking with the historic path including existing knowledge and experiences. This is in line with Eisenhardt and Martin (2000) who note that firms need to break with and undermine their current logic in order to be able to find radically new solutions.

5.3.2 Knowledge-related abilities associated with exploration and other dimensions

The evidence from the case studies suggests that a number of knowledge-related abilities relate not only to knowledge exploration but also exploitation and in some cases also to knowledge retention. These knowledge-related abilities are critical for knowledge management to work continuously.

Proactive behaviour in sustainability management

Proactive behaviour is believed to be critical for successful sustainability management among sample firms. This is because it sets them apart from lagging competitors and makes them less exposed to regulatory changes. CHEMICAL LTD, RETAIL LTD and CAR LTD argue that it is especially important for exploration which creates new sustainability knowledge and for exploitation which makes better use of existing knowledge. Proactive behaviour can be supportive of both. By contrast, OUTDOOR LTD disagrees with the connection to exploration and exploitation in that it views

proactive behaviour as a critical characteristic for knowledge retention as well. Since it is the only firm with this opinion and since it is plausible that especially exploitation and exploration require proactive behaviour, this research relates it to these two dimensions only.

In the context of the Lichtenthaler and Lichtenthaler (2009) framework, proactive behaviour in sustainability management primarily relates to knowledge exploration and exploitation as Table 15 indicates. While proactive behaviour is conducive to all six knowledge capacities of the framework to some degree, it is of highest relevance to knowledge exploration and exploitation. This is because knowledge exploration and exploitation require efforts of employees for which reactive behaviour does not suffice. As the name suggests, reactive behaviour only comes to action when it is demanded. However, action under proactive behaviour takes place before it is demanded which is critical for the creation of new knowledge and the better application of existing knowledge. If knowledge is only created or its application improved when it is demanded - in the form of regulation or customer expectations, for instance - then it is not really new anymore since other firms are creating it or have created it already.

	Exploration	**Retention**	**Exploitation**
Internal perspective	Inventive capacity	Transformative capacity	Innovative capacity
External perspective	Absorptive capacity	Connective capacity	Desorptive capacity

Table 15: Proactive behaviour in sustainability management following the classification of knowledge capacities[11]

All sample firms have adopted the concept of sustainability more or less proactively by responding to an arising need for action before regulation prescribes it rather than just reacting to changes in the legal framework. However, differences exist regarding the level of conviction for sustainability which is reflected in how far firms go beyond what is imposed by regulation, how far their initiatives truly reach and how significant the wider impact on sustainability is. In order to continually build, retain and apply knowledge, firms have to take initiative, take a proactive approach to sustainability and try to be ahead of regulation. If they were just tracking regulation, their knowledge management would be entirely dependent on regulatory advances. This in turn would mean that the firm has a hard time in keeping up with a tightening legal framework and eventually might even lose track in creating the required knowledge for sustainability innovation to keep up with these changes. Proactive behaviour (i.e. doing something pre-emptively and voluntarily) is critical for an ongoing knowledge management since it represents an intrinsic conviction of the sustainability theme. This is illustrated by the

[11] Adopted from the Lichtenthaler and Lichtenthaler (2009) framework; The knowledge-related ability relates to shaded knowledge capacities of the framework.

firms' different starting points of sustainability initiatives. The similarities among sample firms are rooted in the fact that these initiatives have been set up without any specific regulatory requirement in place, thus can be described as proactive. RETAIL LTD, for instance, started its cooperation with Max Havelaar Switzerland and introduced fair-trade coffee and bananas in response to protest movements of banana pickers for better working conditions and fair pay. Further, the firm introduced organic food- and non-food labels in response to changing consumer trends and pressures. OUTDOOR LTD's official starting point of sustainability was marked by the foundation of a separate firm engaged in the recycling of apparel made of polyester. The reason for this move was the wish to take responsibility for products' afterlife by recycling 100% of used material. The basic idea was to produce all components of goods entirely of polyester in order to facilitate the recycling process. New thread was produced out of the recycled material which was then used to manufacture new textiles. CHEMICAL LTD's first official initiative was the foundation of the "Waste-Water Commission" which focused on the improvement of the quality of waste-water of dye production. This initiative was launched in order to ensure a high quality of life for the increasing number of employees moving into the neighbourhood of the firm's headquarters. CAR LTD's starting point of sustainability was the launch of an initiative called "Formula E" which aimed at reducing fuel consumption by introducing technical changes as well as educating drivers. The thinking behind this preventive approach is that "intelligent technology also has to be used intelligently". This initiative was launched in response to the oil crisis. While all firms have dealt with these issues, differences in the level of conviction exist. CHEMICAL LTD and CAR LTD had to rapidly deal with toxic waste-water and the oil crisis, respectively, while RETAIL LTD and OUTDOOR LTD addressed issues that were far less fundamental and urgent in nature such as changing consumer trends and the idea of a closed material cycle approach (cradle-to-cradle). This suggests that sustainability action is more intrinsically driven at RETAIL LTD and OUTDOOR LTD.

Another difference lies in the timing of the first official sustainability initiatives. CHEMICAL LTD started its first initiative in 1901, RETAIL LTD in the early 1990s, OUTDOOR LTD in 1994 and CAR LTD in the early 1960s. This does not imply that these firms under study have operated unsustainably before, but it gives an indication as to when they made a first major step towards sustainability as the term is understood today. In explaining these differences, the industry plays an important role. For instance, the fact that CHEMICAL LTD and CAR LTD operating in industries which consume large amounts of materials and energy and considerable environmental side-effects and potential risks, has motivated them to engage in sustainability initiatives sooner. The large scale of their operations due to their size and the (related) public scrutiny by NGO, for instance, are other reasons to start to act in favour of sustainability sooner. By

contrast, firms in the retailing business such as RETAIL LTD have not felt the same sense of urgency since retailers largely source their products externally and sell them on. In recent decades, however, this has changed with the trend to increasingly produce in-house as well as the growing pressure to take the entire supply chain into account. Also, SME with smaller-scale operations like OUTDOOR LTD did not have the means or felt the urgency to start adopting sustainability at such an early stage.

The identified proactive behaviour when dealing with sustainability management is discussed in the literature by referring to self-regulation or self-policing (e.g. Delmas and Toffel, 2004, 2008; Etzion, 2007; Ramanathan et al., 2009). By not only looking at regulation but also at self-regulation as an behavioural extension, an important distinction can be made between firms that are just meeting the minimum criteria and those that go beyond legal requirements at their own will. It has been observed that those firms that take a proactive role with regards to sustainability often succeed by introducing sustainability innovations to products and processes and therefore gain competitive advantage (Ramanathan et al., 2009; Rivera-Camino, 2007). This highlights the importance of proactive behaviour for a knowledge management cycle since a firm's knowledge base needs to be adjusted regularly to changes in the characteristics of the sustainability challenge in order for the resulting innovations to be successful. In terms of the trend of proactive behaviour in sustainability management, Dyllick and Hockerts (2002) argue that the focus has gradually shifted towards businesses engaging in self-regulation and away from authorities simply enforcing regulation. Further, Worthington and Patton (2005) found in their analysis of the UK screen-printing sector that in responding to regulation, smaller firms tended to be in the reactive cohort while larger firms rather appeared to be in the proactive cohort. However, this cannot be confirmed by evidence from case studies in this research. OUTDOOR LTD as the only SME in the sample is by no means less proactive in terms of sustainability management than the large firms in the sample.

Motivation for sustainability

Without any disagreement, sample firms regard a high level of motivation among managers and staff as indispensable for knowledge management conducive to success in dealing with the sustainability challenge. Therefore, motivation for sustainability relates to all six knowledge capacities of the Lichtenthaler and Lichtenthaler (2009) framework as shown by Table 16. This is because motivation of staff and managers alike is crucial in every step of the knowledge management process and is also necessary for this knowledge management process to keep working. Relatively speaking, a higher degree of motivation is required for knowledge creation than retention and exploitation. However, the fact that the emitter as well as the receptor of knowledge need to be

motivated for the exchange of knowledge to take place (e.g. Szulanski, 1996) suggests that all six knowledge capacities are inter-linked whereby motivation always plays an essential role.

	Exploration	Retention	Exploitation
Internal perspective	Inventive capacity	Transformative capacity	Innovative capacity
External perspective	Absorptive capacity	Connective capacity	Desorptive capacity

Table 16: Motivation for sustainability following the classification of knowledge capacities[12]

Motivation for sustainability has proven to be a critical knowledge-related ability in building the required knowledge base for sustainability initiatives. Motivation is critical for the continuous readjustment and realignment of knowledge because valuable knowledge can only be generated by individuals who are willing to do so and derive some satisfaction from it. For that to happen, individuals need to understand the value of that knowledge and need to be aware of how this knowledge can be applied in order to advance sustainability such as in the form of a given technology, for instance. Without the necessary motivation for the sustainability cause, individuals will not be interested to understand the value or potential areas of application of such knowledge but rather be ignorant of it. However, while it is a widely held belief among practitioners and academics alike that such motivation is critical, only OUTDOOR LTD and RETAIL LTD have explicitly mentioned it while CAR LTD and CHEMICAL LTD have not. A plausible explanation for this is the fact that OUTDOOR LTD and RETAIL LTD are more intrinsically motivated for sustainability which is also related to their ownership structure (i.e. family-owned and cooperative, respectively) while considerably larger stock-listed multinational CAR LTD and CHEMICAL LTD take a more pragmatic approach to motivation. More specifically, the former group understands that motivation is critical to achieve better results - especially with topics that might not have an immediate benefit such as sustainability - while the latter group takes it for granted that employees fulfil their duties and do not need to be motivated explicitly for it. Along these lines, OUTDOOR LTD emphasises that an intrinsic conviction of sustainability is pre-conditional for motivation among the workforce to create relevant knowledge and implement it. At family-owned OUTDOOR LTD, key-people are convinced of the importance of strong management buy-in which spreads across the whole organisation and therefore has a positive effect on employee buy-in as well. Along this line of thinking, RETAIL LTD argues that key-people within the organisation, namely the CEO, members of the board and department heads need to fully buy into sustainability

[12] Adopted from the Lichtenthaler and Lichtenthaler (2009) framework; The knowledge-related ability relates to shaded knowledge capacities of the framework.

before this can be expected of lower-rank employees. For this to work, it is believed that management has to "credibly bring this message across" to all employees. Similarly, OUTDOOR LTD believes that management needs to do a good job at authentically convincing employees of the sustainability theme and credibly "transmitting a good spirit". Hence, like RETAIL LTD the firm argues that motivation for sustainability has to take its roots at the management level before it is taken up by all employees. Regular events and meetings are used by management to discuss sustainability topics and highlight its importance for the firm's reputation. In addition, flat hierarchies are believed to facilitate the spreading of that spirit. At RETAIL LTD, top-down motivation is implemented through various channels such as monthly poster campaigns, newsletters, focus meetings and the employee magazine. For RETAIL LTD, the thinking behind using different channels is that each group of employees perceives and interprets information differently and hence forms values, norms and opinions of sustainability differently. Therefore, motivational approaches for the sustainability theme are individually tailored to different audiences. For example, the monthly sustainability posters behind the scenes in stores and manufacturing sites are primarily targeted at workers while sustainability conferences are meant to address managers.

On a slightly different note, CAR LTD argues that in order for sustainability to be truly successful, a high level of management commitment is required in the form of willingness to make available necessary resources for sustainability. Therefore, this opinion on management support diverges from the ones held by RETAIL LTD and OUTDOOR LTD in that it exclusively focuses on financial commitments in the form of resources and not on the intrinsic belief in the importance of sustainability. Nevertheless, OUTDOOR LTD mentions the importance of providing sufficient resources in the form of additional time and funds to motivate employees to engage in sustainability initiatives. If it has to be done in employees' leisure time then engagement will be weaker. Additionally, sustainability will not be perceived as a serious topic if management only sees it on the sidelines without allocating appropriate resources to it.

An important formal mechanism for motivational purposes is an appropriate incentive structure that motivates employees to engage in sustainability and the related knowledge creation. Some sample firms have explicitly mentioned the importance of incentives, most notably RETAIL LTD and to a lesser extent CAR LTD. RETAIL LTD argues, for instance, that members of the sustainability team are regularly approached by other teams and employees having questions and ideas on sustainability. This potential of ideas is absorbed by a formal structure the firm has established, namely its sustainability fund. This fund has a budget of CHF 15m per year which is spent on internal project proposals from teams and individual employees. This structure is meant to incentivise employees to proactively work on sustainability issues and develop knowledge and ideas

for solutions. RETAIL LTD reports that employees have been highly motivated to submit proposals to get funding for a sustainability project. Recent examples include projects with supplying farmers in India and Thailand to complement the social requirement (such as fair pay) of Max Havelaar produce by ecological requirements (such as reforestation and avoidance of pesticides). RETAIL LTD is currently working on an incentive system that is based on certain sustainability KPI with a stronger impact on financial compensation for managers. The sustainability team will agree on sustainability targets such as energy savings and turnover of sustainable products with the directors of respective departments or sales regions. At OUTDOOR LTD, the different product teams are measured by financial KPI that focus on their share of sustainable products of overall turnover. By contrast, CAR LTD and CHEMICAL LTD do not reward sustainability performance of individual subgroups, sites, products, departments and projects. The reason is that some units produce more CO2 by definition and have less room for improvement than other units which makes them hard to compare. Along this line of thinking, CAR LTD and CHEMICAL LTD do not engage in benchmarking practices to measure performance among different business units or regions. The reason for this lies in the different characteristics of each region or business unit (in terms of environmental regulation or the availability of alternative resources, for instance) which would make any competitive comparison overly fair for some and unfair for others.

Motivation can also work the other way round. As RETAIL LTD notes, it is not only about "motivating employees to buy into the sustainability theme" but also about "using the sustainability theme to motivate employees". This motivation in the form of a positively re-enforcing feedback loop can have different sources. First, RETAIL LTD argues that from their experience it is highly motivational for employees if they understand that sustainable operations and products positively affect the environment and that it has an impact on reputation and brand loyalty among customers. Second, if employees also understand that they are part of this equation and that they can contribute to these benefits, this gives an additional boost to motivation. Third, RETAIL LTD notes that employee commitment for sustainability can be supported even further when the concrete success of sustainability becomes "visible" such as in the form of charts and numbers. The strong sales growth of sustainable product lines that RETAIL LTD has achieved since their inception, for instance, has proven that the focus on sustainability is the right approach and therefore motivates employees further. The key ingredient in this example seems to be the established link between "sustainability" and "business success". CHEMICAL LTD especially agrees with the third source of motivation proposed by RETAIL LTD and suggests that sustainability has to be made a tangible asset by illustrating its impact on overall performance. Being able to show the impact of

sustainability in financial terms is expected to raise employee motivation. CHEMICAL LTD also perceives the importance of sustainability among employees. An internal survey conducted in 2009 has shown that employees expect the firm to perform well in terms of sustainability.

The discussed examples of motivation for as well as through sustainability focus on the existing workforce. However, evidence from case studies also suggests that a firm's sustainability practices play an important role in attracting talent to the firm. CHEMICAL LTD, for instance, agrees that its efforts in environmental preservation increasingly become a key argument in its hiring process. Today, human resource personnel observes a growing trend that the sustainability theme attracts interest among candidates and that it represents an essential factor in supporting their decisions which employer they want to work for. CHEMICAL LTD and OUTDOOR LTD refer to this behaviour as "taking pride in the employer one works for" and "living the employer's values", respectively. This belief has been supported in discussions with other firms in the course of this research.

The importance of management and employee buy-in into the sustainability theme is discussed in the academic literature. Management buy-in has a significant impact on how knowledge creation, retention and application for sustainability initiatives are approached by firms as a whole. To pursue the ongoing creation of valuable knowledge for sustainability purposes, management needs to lead the way and represent a good example for employees in order for them to follow suit (e.g. Melville, 2010). López-Gamero et al. (2009) suggest that managers' environmental attitude is a significant factor shaping a firm's focus on sustainability. This corresponds to the view by Schaltegger and Synnestvedt (2001) who note that personal values of management can influence a firm's views and actions in terms of sustainability. The above-mentioned approach of proactive rather than reactive sustainability management or a shift to a more proactive approach, for instance, requires substantial management commitment to generous resource allocation and expansion of employees' skills. These efforts in sustainable management depend to a large extent on the degree to which the management in charge sees sustainability as an opportunity to build competitive advantage (López-Gamero et al., 2009). A critical complement to management buy-in is the support of lower-rank employees (Etzion, 2007; Jiang and Bansal, 2003). Management needs to take into account that it is not enough to practice and promote sustainability at the top level exclusively (Etzion, 2007; Jiang and Bansal, 2003). In order to pursue sustainability initiatives it needs employees to buy into the idea as well. Jiang and Bansal (2003) find that enhanced awareness on the workforce's part leads to individual behaviour and practices that are conducive to sustainability. Etzion (2007) argues, however, that individual concern as proposed by Bansal and Roth (2000) is not enough and that it

equally needs to be congruent with the overall values of the firm in question. Sharma (2000) finds that in order for firms to act more progressively with respect to sustainability, arising challenges need to be optimistically regarded as an opportunity for future business success rather than as a threat to the business. This supports the earlier discussion on the importance of opportunity detection as the sustainability challenge offers various opportunities for relevant knowledge creation that firms can use to meet expectations by stakeholders.

In an extensive study, Bansal and Roth (2000) have revealed three major types of motivation: competitiveness, legitimation and ecological responsibility. To a large extent, these types of motivation correspond to the discussion of management and employee buy-in above. First, competitiveness is defined as "the potential for ecological responsiveness to improve long-term profitability" which can be achieved through various sustainability initiatives such as the development of technologies and the reduction of resource use and waste generation (Bansal and Roth, 2000: 724). Second, legitimation refers to "the desire of a firm to improve the appropriateness of its actions within an established set of regulations, norms, values or beliefs" (Bansal and Roth, 2000: 726). Examples for legitimation include compliance with legislation as well as the establishment of an environmental committee or management position to push sustainability and developing networks with the community. This has implications on a firm's approach to knowledge creation. With regards to the moral commitment of managers, Schaltegger and Buritt (2000) note that leaders who intrinsically believe that attempting to achieve sustainability is critical can act as powerful drivers. They argue further, that "this phenomenon whereby personal values of firm leaders have a large influence on corporate activities can be seen very often among entrepreneurs" (p. 205/206). Delmas and Toffel (2004) note, that similar cognitive frames can appear and manifest themselves across an organisation through the influence of management. Third, Bansal and Roth (2000) define a firm's environmental responsibility as "the motivation that stems from the concern that a firm has for its social obligations and values" (p. 728). Melville (2010) notes that organisational responsibility as well as beliefs in sustainability are shaped by the perception of this responsibility at the individual level that is then aggregated to the organisational level. Examples include the redevelopment of brown-field sites into green-field sites, donations to environmental interest groups and the use of recycled materials (Bansal and Roth, 2000).

In addition to these three types of motivation, Bansal and Roth (2000) have also identified three contextual conditions which drive a firm's motivation for ecological responsiveness and thus sustainability initiatives. Issue salience can be defined as "the extent to which a specific ecological issue has meaning for organisational constituents" (p. 729). Field cohesion represents "the intensity and density of formal and informal

network ties between constituents in an organisational field" (p. 730). Individual concern is defined as "the degree to which organisational members value the environment and the degree of discretion they possess to act on their environmental values" (p. 731). As with the three types of motivation proposed by Bansal and Roth (2000), these three contextual conditions are closely related to the discussion of management and employee buy-in.

Sustainability training and education

As with motivation for sustainability, sample firms believe that sustainability training and education positively affect the understanding of the sustainability challenge among employees which has an impact on their ability to create, maintain and apply the required knowledge. While CHEMICAL LTD and OUTDOOR LTD see training and education to be beneficial primarily for knowledge exploration and exploitation, it also helps firms to become better in knowledge retention. Therefore, sustainability training and education relate to all six knowledge capacities of the Lichtenthaler and Lichtenthaler (2009) framework as shown by Table 17.

	Exploration	**Retention**	**Exploitation**
Internal perspective	Inventive capacity	Transformative capacity	Innovative capacity
External perspective	Absorptive capacity	Connective capacity	Desorptive capacity

Table 17: Sustainability training and education following the classification of knowledge capacities[13]

Discussions with sample firms have shown that emphasis is laid on training and further education in order for employees and the firm as a whole to build an appropriate level of knowledge necessary to deal with the sustainability challenge. This is regarded as a complement to employees' existing knowledge and as a measure to keep the knowledge stock up to date. Approaches to training and education as well as the depth and level of integration of sustainability issues differ among sample firms. In terms of depth of sustainability training, CAR LTD is located on the lower end of the scale while the other three firms in the sample, especially RETAIL LTD and CHEMICAL LTD are on the higher end. CAR LTD runs an onsite-academy ("CAR LTD Coaching") focusing on continuing education for employees. Moreover, academic education is pursued by the "in-house university" which closely collaborates with various universities of the region as well as consultants and has an extensive global network. Further, the firm has a large apprenticeship scheme and a PhD program. However, training and education are of a general nature and not focused on sustainability to which only one module is dedicated. RETAIL LTD and CHEMICAL LTD use a similar approach but it goes further than that.

[13] Adopted from the Lichtenthaler and Lichtenthaler (2009) framework; The knowledge-related ability relates to shaded knowledge capacities of the framework.

More specifically, CHEMICAL LTD has recently decided to increase the weight of sustainability in the training scheme that new hires have to go through which is to be implemented soon. This decision is in line with the firm's perception that its sustainability activities are a motivational factor and that potential new hires are increasingly interested in sustainability as well. RETAIL LTD's training has also been increasingly tailored to sustainability which is done through regular training modules that employees have to complete. The firm operates an education centre where these trainings are run. OUTDOOR LTD goes beyond formal training modules. In addition, the sustainability team operates a database containing information material, presentation slides and other related content in order to support employees in working on sustainability issues. The firm actively tries to implement work instructions so that employees use this source of information when dealing with sustainability issues. OUTDOOR LTD believes that these efforts support employees to develop a consistent level of knowledge and understanding of sustainability which helps them to deal with expectations from various stakeholders. In general, firms agree that training, especially for new hires, needs to have an appropriate share of sustainability content in order to - as CHEMICAL LTD puts it - "sow the seed of sustainability spirit" as soon as possible. For this to work, the sustainability theme needs to represent an integral part of overall training next to other subjects. This corresponds to the notion that for a firm's sustainability strategy to be successful, it needs to be well integrated into the overall strategy which is discussed in more detail in a dedicated section later.

In terms of the nature of skills, CHEMICAL LTD and RETAIL LTD agree that it needs hard and soft skills or in other words, technical and business knowledge in order to deal with the sustainability challenge. To keep the right balance is a particularly important task for CHEMICAL LTD whose business is split into three subgroups and therefore needs to ensure that balance across all subgroups separately. In addition to the mentioned skills, RETAIL LTD emphasises analytical skills which are regarded important in order to be able to assess the impact of certain sustainability measures to meet constantly changing market requirements. In line with the differentiation between technical and business knowledge, OUTDOOR LTD engages in technical and sustainability-related training for its sales force. The firm notes that especially with topics such as sustainability, the level of detail and complexity needs to be tailored to the respective audience so that everybody can understand while at the same time avoiding to omit important detail. Along these lines, RETAIL LTD's sustainability modules take into account job requirements (i.e. management staff versus retail outlet staff) and are therefore tailored to the level of depth needed for different groups of employees. This also corresponds to RETAIL LTD's view that different levels of depth need to be applied in motivating different groups of employees (discussed in the section on motivation).

Integration of sustainability into overall strategy

Similar to the motivation as well as training for sustainability, consensus among sample firms exists that the integration of sustainability into overall strategy is fundamental to successful knowledge management. This is believed to be the case because a high degree of integration causes barriers in strategic decision-making to fall. This in turn determines the approaches to sustainability including the required knowledge. Sample firms note that knowledge management in this case spans knowledge exploration, retention as well as exploitation. Therefore, the integration of sustainability is a supporting factor for all six knowledge capacities of the Lichtenthaler and Lichtenthaler (2009) framework as depicted in Table 18.

	Exploration	**Retention**	**Exploitation**
Internal perspective	Inventive capacity	Transformative capacity	Innovative capacity
External perspective	Absorptive capacity	Connective capacity	Desorptive capacity

Table 18: Integration of sustainability into overall strategy following the classification of knowledge capacities[14]

Rather than having a separate sustainability strategy, all sample firms have the sustainability theme integrated into their overall strategy with OUTDOOR LTD and RETAIL LTD going beyond the approaches of CHEMICAL LTD and CAR LTD. A high degree of integration is believed to facilitate progress in sustainability practices which also includes the ability to build the knowledge needed to deal with challenges. If sustainability is entirely separate from the firm's strategy, then any approach to sustainability such as knowledge creation will face obstacles since these are not aligned with the overall strategy and therefore appear irrelevant and do not justify the allocation of resources. However, if sustainability is an integral part of strategy then there will be fewer obstacles to build relevant knowledge. Along these lines, the balance between commercial success, the impact on the environment and the needs of society are at the heart of CHEMICAL LTD's sustainability strategy. In order to achieve that, the firm constantly seeks to provide innovative solutions such as in the form of "Lighthouse Projects" which focus on improving resource efficiency, supplying alternative energy feedstock, and promoting partnership networks for sustainable buildings. Along these lines, CAR LTD's sustainability strategy aims at becoming the leader in economic and environmental sustainability by 2018 across the automotive industry which clearly entails the economic as well as the environmental aspect in combination. In order to achieve that, the firm seeks to expand its product portfolio and presence in emerging markets, save costs, drive continuous efficiency improvements and push conventional as

[14]Adopted from the Lichtenthaler and Lichtenthaler (2009) framework; The knowledge-related ability relates to shaded knowledge capacities of the framework.

well as alternative power-train technologies in parallel. In order to facilitate the implementation of the chosen sustainability strategy, a high level of integration of sustainability in overall strategy is needed.

However, significant differences exist as to how these firms integrate their sustainability strategy into overall strategy. This shows that OUTDOOR LTD and RETAIL LTD clearly go beyond what CHEMICAL LTD and CAR LTD do in terms of integrative efforts. OUTDOOR LTD, for instance, does not differentiate between its sustainability strategy and overall strategy. Rather, both are regarded as the same which - in theory - can be interpreted as a perfect overlap or complete integration of sustainability. RETAIL LTD uses the term "sustainability concept" rather than "sustainability strategy". The rationale behind this is that the concept should be integrated in all strategies and activities across the firm and lie in the responsibility of involved employees, rather than being a separate and abstract strategy in the hand of one or few owners in management. CHEMICAL LTD and CAR LTD are less explicit and more conformist in that they argue that their sustainability strategy is well integrated into overall strategy as shown by the connectedness of economic aspects of the triple bottom line with ecological and social aspects.

The importance of integration of sustainability into overall strategy is discussed in the literature. For sustainability management to be successful, the tight integration of sustainability into the overall firm strategy is critical (Etzion, 2007; Schaltegger and Burritt, 2000). However, many authors observe a poor degree of integration of sustainability into overall strategy which does not correspond to the findings in this research. For instance, Schaltegger and Burrit (2000) find that in many cases sustainability management functions in parallel to conventional management which can create sub-optimal business solutions where "environmental management corrects problems through end-of-pipe developments which impede attempts to find innovative products and other sustainability oriented process-based innovations" (p. 194). Etzion (2007) agrees that organisations often tend to see sustainability as a separate aspect of strategy that is not aligned with the core business strategy. Etzion (2007) argues that the implementation of an sustainable strategy, "rather than being a by-product of overall organisational strategies and attributes, becomes a driver for the development of human resources and organisational capabilities as organisational resources" (p. 641).

5.3.3 Externally-oriented knowledge-related abilities

There is wide agreement among sample firms that it is critical to go beyond their own boundaries in order to acquire and access knowledge that does not exist within the firm. Therefore, alliances are indispensable for firms to have a knowledge base that is suitable and capable to meet changing requirements in the context of the sustainability challenge.

Building alliances

All sample firms strongly agree on the critical role of partnerships in order to be able to source complementary knowledge beyond the firm's boundary. This is actively practiced by all sample firms in order to manage and align their knowledge base to deal with the sustainability challenge successfully. Sample firms note that alliances are necessary to create and retain knowledge externally. Therefore, following the Lichtenthaler and Lichtenthaler (2009) framework depicted in Table 19, building alliances in this research corresponds to absorptive capacity on the knowledge exploration dimension and connective capacity on the knowledge retention dimension.

	Exploration	**Retention**	**Exploitation**
Internal perspective	Inventive capacity	Transformative capacity	Innovative capacity
External perspective	Absorptive capacity	Connective capacity	Desorptive capacity

Table 19: Building alliances following the classification of knowledge capacities[15]

Sample firms have highlighted the importance of alliances and partnerships for the purpose of knowledge acquisition (absorptive capacity) and of knowledge access without acquiring it (connective capacity). In most cases, gaining access to a partner's knowledge without acquiring it requires some sort of agreement as the knowledge-emitting firm wants to get something in exchange from the knowledge-receiver. This usually takes the form of knowledge sharing and jointly working on projects, for instance. This knowledge is regarded complementary to internal knowledge and believed to be highly important for firms to address specific sustainability challenges. While absorptive and connective capacities are regarded critical, desorptive capacity whereby firms sell their knowledge in the form of licensing agreements, for instance, is not. This is because sample firms hardly supply intermediate goods. Among sample firms, only CHEMICAL LTD supplies intermediate goods to other firms but desorptive capacity has not been mentioned explicitly. As suggested, all sample firms agree that networking is essential in order to survive in a market context characterised by rapid change due to the sustainability challenge. However, differences exist regarding the types of partners these firms liaise with and the exact task the desired knowledge has to perform. Among all sample firms these partners include research institutions, sustainability experts, NGO, suppliers, customers, consultants and others. However, OUTDOOR LTD is the exception by suggesting that the willingness to cooperate with selected competitors can prove to be helpful. Along these lines, the firm has shared information of a supplier capable of more sustainable dyeing processes with competitors. On the one hand, OUTDOOR LTD gave away some competitive advantage but on the other hand, the firm

[15] Adopted from the Lichtenthaler and Lichtenthaler (2009) framework; The knowledge-related ability relates to shaded knowledge capacities of the framework.

gained knowledge that these competitors share in return. This exchange is believed to dynamically advance efforts with sustainability among all involved parties.

As noted, differences exist as to which tasks the knowledge gained (or accessed) through partnerships has to perform. Identified knowledge-related tasks include the following:

- Building technological solutions (RETAIL LTD, CAR LTD)
- Developing product offering (CHEMICAL LTD, RETAIL LTD, CAR LTD)
- Provision of training (RETAIL LTD, OUTDOOR LTD, CAR LTD)
- Obtaining sustainability standards and certifications (OUTDOOR LTD)

In terms of building technological solutions, RETAIL LTD and CAR LTD believe in the importance of partnerships. For CAR LTD, the willingness and ability to enter cooperations is highly important, especially in the emerging field of alternative power-trains such as battery technology. The firm explicitly joins such cooperations with external players in order to build its knowledge stock whereby external research institutions play a key role in order to complement its internal knowledge stock. Along this line of thinking, RETAIL LTD regards co-operations necessary for technological advances on the sustainability front. For example, the firm cooperates with the WWF on CO2-compensation projects in the context of its goal to become CO2-neutral by 2023.

In terms of developing the product offering, CAR LTD and RETAIL LTD highlight the role of cooperations with NGO while CHEMICAL LTD argues that focused cooperations with customers are essential. CAR LTD, for instance, offers its fleet customers the opportunity to support environmental projects by paying a premium on the usual leasing contract. This concept has been established a collaboration with the "Naturschutzbund Deutschland" (NABU). Similarly, RETAIL LTD has established close ties with an NGO, namely with Max Havelaar Switzerland in order to introduce fair-trade coffee and bananas. In cooperating closely with customers, CHEMICAL LTD engages in so called "Food Chain Partnerships" along the entire food value chain with a focus on farmers. The goal of these initiatives is to help farmers increase crop yields and therefore income with the help of more efficient and resistant crops such as "direct seeded rice". This type of seed only requires a fraction of the water that usual rice seeds require to mature.

In terms of the provision of training, RETAIL LTD, OUTDOOR LTD and CAR LTD agree that cooperations with external training providers are an important complement to in-house training. RETAIL LTD, for instance, actively works with external training and knowledge providers such as consultants, experts, scientists and others. Rather than running trainings on-site, OUTDOOR LTD tends to send employees to seminars and training sessions which not only provides training but also the opportunity to extend personal networks and to join focused workgroups. At the higher end of the spectrum in

terms of educational networks is CAR LTD. The firm's "Auto University", for instance, closely collaborates not only with local universities but also with foreign institutions that are part of its extensive global network.

In terms of obtaining sustainability standards and certifications, OUTDOOR LTD notes that collaborations with auditors are indispensable. Special emphasis is on the necessary preparation for EMAS certification which has a large impact on the sustainability of the firm's operations. The close relationship with the main auditor helped the firm to comply with the EMAS criteria long before it has become compulsory in the outdoor apparel industry.

The evidence that all sample firms highly value partnerships in order to perform a number of tasks around knowledge management is corroborated by the literature. For instance, Grant and Baden-Fuller (2004) note, that alliances can help firms to acquire knowledge and to learn from each partner's knowledge base. The authors further suggest that alliances can support firms to simply share knowledge without the need to acquire that knowledge. Along these lines, Henderson and Cockburn (1994) highlight the importance of the ability to access new knowledge beyond a firm's boundaries and the ability to integrate that knowledge within the existing knowledge base of the firm. The distinction between acquiring and accessing knowledge can have a significant impact on how efficient the knowledge management process works (Grant and Baden-Fuller, 2004; Henderson and Cockburn, 1994). This is because knowledge acquisition usually entails a considerable commitment in terms of time and cost and because uncertainty often exists in terms of future knowledge requirements which might make obsolete knowledge that has been acquired over time (Grant and Baden-Fuller, 2004). Alliances enable firms to avoid these disadvantages by not only engaging in knowledge acquisition but also in knowledge sharing with partners. To summarise, Henderson and Cockburn (1994) refer to alliances as a critical source of competitive advantage. Building alliances in order to complement internal with external knowledge and applying it to perform a given task supports firms to get better at managing that task over time (Collis, 1996; Grant, 1996; Henderson and Cockburn, 1994; Kale and Singh, 2007).

5.3.4 Summary

In summary, Table 20 shows the discussed issues and findings:

Issues	Knowledge-related ability associated with...	Findings (sample firms)
Working with a longer-term horizon	exploration	• Investment decisions based on cost comparisons of CO2-reduction and CO2-compensation **(RETAIL LTD)** • Ownership structure conducive to sustainability initiatives with longer-term horizon **(RETAIL LTD, OUTDOOR LTD)** • Justification of initiatives without predictable payoff more difficult due to shareholders' return expectations (**CHEMICAL LTD, CAR LTD)** • Time lag between incurring costs and reaping benefits of sustainability investment cannot be too long **(CHEMICAL LTD, CAR LTD)**
Diversity and inter-disciplinarity among employees	exploration	• Highly diverse sustainability teams to optimise knowledge exploration and continuous adjustment of knowledge base **(CHEMICAL LTD, RETAIL LTD)** • Hiring from different backgrounds **(CHEMICAL LTD, RETAIL LTD)** • Common understanding of sustainability to ensure alignment across different business units **(CHEMICAL LTD)**
Readiness to challenge the status quo	exploration	• Organisational openness to change **(All)** • Freedom to experiment **(RETAIL LTD)** • Informal discussions **(RETAIL LTD, OUTDOOR LTD)** • Flat hierarchies **(RETAIL LTD, OUTDOOR LTD)** • Continuous improvement initiatives **(CHEMICAL LTD, RETAIL LTD, CAR LTD)**
Proactive behaviour in sustainability management	exploration and exploitation	• Proactive development of sustainable products **(RETAIL LTD, OUTDOOR LTD)** • Proactive efforts in water management **(CHEMICAL LTD)** • Proactive efforts in fuel efficiency **(CAR LTD)** • Initiatives more intrinsically driven **(RETAIL LTD, OUTDOOR LTD)**
Motivation for sustainability	exploration, retention and exploitation	• Explicit commitment to motivation for sustainability among employees **(RETAIL LTD, OUTDOOR LTD)** • Management conviction and commitment to sustainability pre-conditional to employee motivation **(RETAIL LTD, OUTDOOR LTD)** • Intrinsic motivation for sustainability related to ownership structure **(RETAIL LTD, OUTDOOR LTD)** • Regular campaigns and events to ensure motivation for sustainability **(RETAIL LTD, OUTDOOR LTD)** • Management commitment in the form of financial resources **(CAR LTD)** • Financial KPI on sustainability performance **(RETAIL LTD, OUTDOOR LTD)** • Sustainability fund supporting best projects **(RETAIL LTD)** • Not only motivation of employees for sustainability but also sustainability as a motivator for employees **(CHEMICAL LTD)**
Sustainability training and education	exploration, retention and exploitation	• On-site academy **(RETAIL LTD, CAR LTD)** • Close partnerships with universities and research institutions **(CHEMICAL LTD, CAR LTD)** • Increasing weight of sustainability modules in overall training **(CHEMICAL LTD, RETAIL LTD)** • New hires going through introductory training on sustainability **(CHEMICAL LTD)**
Integration of sustainability into overall strategy	exploration, retention and exploitation	• High degree of integration facilitates progress of sustainability practices **(All)** • Balance between economic, environmental and social aspects of the triple bottom line **(CHEMICAL LTD)** • Focus on the economic and environmental aspect of the triple bottom line **(CAR LTD)** • No differentiation between sustainability strategy and overall strategy to ensure highest possible alignment **(OUTDOOR LTD)** • Sustainability concept rather than sustainability strategy to ensure responsibility of all involved employees rather than just one "owner" **(RETAIL LTD)**

Building alliances	external view of exploration and retention	• Partnerships built to survive in dynamic market context characterised by the sustainability challenge **(All)** • Partners include research institutions, sustainability experts, NGO, suppliers, customers and consultants **(All)** • High-level knowledge sharing with competitors **(OUTDOOR LTD)** • Partnerships facilitate various tasks – identification of discussed sustainability stakeholder pressures **(RETAIL LTD, CAR LTD)** – building technological solutions **(RETAIL LTD, CAR LTD)** – developing product offering **(CHEMICAL LTD, RETAIL LTD, CAR LTD)** – provision of training **(RETAIL LTD, OUTDOOR LTD, CAR LTD)** – obtaining sustainability standards and certifications **(OUTDOOR LTD)**

Table 20: Findings on knowledge-related abilities for continuous knowledge management

The findings in this section contribute to answering the sub-question of which knowledge-related abilities are perceived to be important in order to build, retain and apply knowledge continuously. Several knowledge-related abilities can be derived from the findings that are conducive to knowledge management in the context of the sustainability challenge. As noted earlier, these can be split into three groups depending on which dimensions of the Lichtenthaler and Lichtenthaler (2009) model they relate to.

First, knowledge-related abilities that are mainly associated with knowledge exploration are identified. For instance, a longer-term horizon is essential for continuous knowledge management which suggests that it is not enough to focus on the existing body of knowledge but that it is also necessary to create new knowledge for future solutions. Further, diversity and inter-disciplinarity among employees are important since individuals accumulate different pieces of knowledge and understand it differently which on the aggregate firm level means a wider array of knowledge to source from. Also, the readiness to challenge the status quo is critical because an established and habitual way of thinking does not always suffice in order to create the knowledge necessary to meet arising pressures of the sustainability challenge.

Second, knowledge-related abilities associated with knowledge exploration and other dimensions are identified. For instance, proactive behaviour in sustainability management is critical in order for firms to acquire and use knowledge before environmental regulation makes it necessary. In addition, a high level of motivation for sustainability among staff and managers alike is instrumental for active knowledge management. This is because individuals who are not interested in sustainability and do not see the value of it are unable to contribute to a firm's body of knowledge. Further, sustainability training and education are direct approaches to support the expansion of employees' knowledge base. Moreover, the integration of sustainability into overall strategy is essential for all goals to be aligned and therefore to avoid obstacles in knowledge creation.

Third, externally-oriented knowledge-related abilities are identified. Building alliances, for instance is seen as critical in order to go beyond the firm's boundary and complement internally with externally sourced knowledge.

As discussed earlier, March (1991) as well as Lichtenthaler and Lichtenthaler (2009) note that firms have to simultaneously deal with knowledge exploration and exploitation in order to ensure continuous knowledge management and to secure sustained competitive advantage. This is because exploration and exploitation focus on the creation of new knowledge and the application of existing knowledge without creating anything new, respectively (Lichtenthaler and Lichtenthaler, 2009; March, 1991). Therefore, neither exploration nor exploitation creates sustained performance without the other (Lichtenthaler and Lichtenthaler, 2009; March, 1991). Putting this view of the literature into the context of the findings on knowledge-related abilities, the following can be proposed:

Proposition 13: The more balanced a firm's knowledge-related abilities, the greater is the knowledge accumulation in the longer-term.

In summary, however, the findings clearly suggest that sample firms emphasise knowledge exploration. Without exception, the eight identified knowledge-related abilities are related to knowledge exploration and exploitation (in some cases also retention) while three of them relate to knowledge exploration exclusively. Since the sustainability challenge is still a relatively new phenomenon, it makes sense that firms' activities are clustered around knowledge exploration to rapidly gain understanding and build new knowledge. This is the case, even though activities in exploration compared to those in exploitation are considerably more uncertain and unpredictable which March (1991: 73) refers to as the "vulnerability of exploration". While exploitation focuses on refinement of solutions based on existing knowledge, exploration is concerned with the creation of new solutions based on newly created knowledge (Gupta et al., 2006; March, 1991). In order for firms to be able to address newly arising challenges in dynamic market contexts, they need knowledge-related abilities to focus on building new knowledge that represents the groundwork for future solutions. However, it is likely that firms will start to increasingly focus on knowledge exploitation, the less "surprising" and challenging the phenomenon becomes which allows them to shift their attention towards using the knowledge they have built during the more challenging times. Based on this discussion, the following proposition can be derived:

Proposition 14: The more established the challenge a firm faces, the more its focus shifts from knowledge exploration to knowledge exploitation.

5.4 Summary of success factors

Based on the findings discussed in the cross-case analysis, several success factors in knowledge management for sustainability can be identified. Firms require these factors

in order to engage in knowledge exploration, retention and exploitation to ensure that their body of knowledge is regularly aligned to keep up with the sustainability challenge. Following the St. Galler Management Concept (Bleicher, 1996), these success factors can be grouped into three pillars:

- Activities
- Structures
- Behaviour

To ensure holistic management, these three pillars need to be addressed in conjunction and integrated (Bleicher, 1996). Therefore, the identified success factors of one pillar in isolation will unlikely contribute to success in knowledge management for sustainability without having counter-parts in the other two pillars. For instance, activity-related success factors will likely be of limited use if the required structures and behaviours for implementation are neglected or entirely missing (Bleicher, 1996). In the context of this research, a firm may decide that it needs specific knowledge to address a given stakeholder requirement related to sustainability. In this scenario, an example for activity is the management of its knowledge portfolio by taking into account exploration, retention and exploration. An example for structure is its independent sustainability team which is dedicated to sustainability issues and coordinates knowledge management and the implementation of sustainability initiatives. An example for behaviour is its deep-rooted motivation for and commitment to sustainability among management which can take the form of the provision of sufficient resources to the involved teams. This integration of a given complex problem across all three pillars illustrates the holistic nature of the St. Galler Management Concept which supports ongoing corporate development and builds competitive advantage (Bleicher, 1996).

5.4.1 Activities

For the firm to be successful, activities need to be in place, which are supported by structures and behaviour (Bleicher, 1996). The following success factors in knowledge management for sustainability related to activities can be identified based on this research.

Managing the knowledge portfolio

Managing a firm's portfolio of knowledge so that it is aligned with requirements in the context of the sustainability challenge is essential. This requires firms to focus simultaneously on knowledge exploration, retention and exploitation which relates to the creation of new knowledge, the storage and transfer of that knowledge and the application of that knowledge, respectively. Since knowledge exploration is exclusively

concerned with the creation of new knowledge and knowledge exploitation with the application of existing knowledge without creating anything new, both dimensions need to be addressed in conjunction. In isolation, neither exploration which ignores the application of knowledge, nor exploitation which ignores the creation of new knowledge can create competitive advantage in the longer-term. Further, knowledge retention is needed to ensure that knowledge does not get lost and is available when needed. This discussion leads to the following proposition:

Proposition 15: The better a firm balances knowledge exploration and exploitation, the greater is knowledge accumulation in the longer-term.

Fostering partnerships

Internal knowledge needs to be complemented with external knowledge. Therefore, partnerships with external bodies such as research institutions, suppliers, consultants and NGO, for instance, are essential. This is particularly important when - due to changed circumstances - firms require knowledge that they have not previously focused on. These partnerships do not only relate to knowledge acquisition but also knowledge access. Especially in the case of the latter, a higher degree of organisational openness is necessary that supports networking and knowledge sharing. This is because the source of knowledge will likely want to get some knowledge in return. Based on this, the following can be proposed:

Proposition 16: The larger a firm's network, the greater the ability to accumulate the knowledge needed to deal with the current sustainability challenge.

Providing training

Sustainability training and education ensures that the firm's knowledge base is regularly aligned in order to meet arising requirements caused by the sustainability challenge. On the one hand, this has a direct impact since it supports individuals, teams and the firm as a whole to build and extend the required knowledge in order to address the sustainability challenge. On the other hand, however, this also has an indirect impact since it builds the understanding of sustainability among employees which influences their potential to explore, retain and exploit knowledge in order to create competitive advantage. Therefore, building such a consistent understanding of sustainability is critical in order to benefit from sustainability. This leads to the following proposition:

Proposition 17: The higher a firm's efforts in sustainability education, the higher is the potential to explore, retain and exploit knowledge.

Scanning the market

Market scanning activities need to be in place in order to recognise opportunities that lie

in the challenges the firm encounters. This needs to be coordinated by the central sustainability team in collaboration with other relevant teams such as market intelligence, sales and external relations. The sustainability team needs to have disciplined scanning and prioritisation mechanisms (i.e. stakeholder interviews, benchmarking studies and industry reports) in place in order to build understanding of the challenge (i.e. pressures coming from stakeholders), to detect related opportunities for knowledge creation and to prioritise among the resulting most important sustainability initiatives. Based on this discussion, the following can be proposed:

Proposition 18: The more elaborate a firm's scanning mechanisms, the greater is the likelihood to detect opportunities to create knowledge.

Integrating sustainability in decision-making

In order to succeed in sustainability management, overall strategy decisions need to be made by taking into account sustainability considerations. If these strategic decisions are made separately, sustainability considerations will unlikely have the same weight as in the case when strategy decisions are made holistically. Based on the notion of an involved strategy setting process, the following proposition can be derived:

Proposition 19: The better integrated sustainability considerations in a firm's overall strategy setting process, the greater is the potential for achievements in sustainability management.

Working towards longer-term goals

In order for knowledge management to be successful, the firm needs to focus on the longer-term rather than the shorter-term. This is because longer-term objectives are needed in order to be able to accumulate knowledge in a disciplined and consistent way over time and thereby achieve the objectives that have been set in the strategy. If firms focus too much on short-term benefits when pursuing sustainability initiatives, objectives will shift over time which hinders a rigorous and consistent knowledge accumulation process and implementation of strategy. This long-term focus is particularly important for the discussed knowledge exploration because it is usually unclear in advance whether, when and how firms can ultimately benefit from newly explored knowledge. From this discussion, the following proposition can be derived:

Proposition 20: The longer a firm's horizon, the greater is the potential for achievements in sustainability management.

5.4.2 Structures

For the firm to be successful, several structures need to be in place which support activities and are themselves supported by appropriate behaviour (Bleicher, 1996). The

following success factors in knowledge management for sustainability related to structures can be identified in this research.

Independent sustainability teams

Dedicated and independent teams for sustainability management (i.e. sustainability teams) need to be in place in order to ensure that sustainability is addressed sufficiently to pursue important sustainability initiatives from start to end. Otherwise, it is likely that the sustainability theme is constantly undermined by the daily business which limits - if not eliminates - the potential for success along the sustainability theme. These teams need to consist of highly motivated individuals who thoroughly understand sustainability which primarily means that they are willing to promote the theme throughout the firm to raise awareness and interest in wider circles. In addition, these individuals need to be perceptive and attentive to the market context the firm is exposed to in order to be able to see the opportunities that lie in the challenges the firm encounters. Based on this discussion, the following can be derived:

Proposition 21: The more independent a firm's sustainability team, the lower the risk that the daily business distracts and delays sustainability initiatives.

Close ties with management

The sustainability team must have a direct link to management. This can take different forms. On the one hand, a manager can be directly involved in the sustainability team and its activities. On the other hand, the sustainability team can be embedded at the highest possible organisational level such as the board of directors. In addition, both forms in conjunction can be found among some firms. These structural characteristics enable the sustainability team to act with an appropriate level of seniority that is necessary in order to convince all involved employees and teams. If the sustainability team did not have that level of seniority, it would likely not be taken seriously enough among employees. This leads to the following proposition:

Proposition 22: The higher the hierarchical level of the firm's sustainability team, the faster it can pursue sustainability initiatives.

Liability of project teams

Implementing teams or workgroups need to be held liable for the implementation of sustainability initiatives and not the coordinating sustainability team or general management. This can be ensured by setting up small, clearly arranged and centrally embedded teams rather than large project teams so that actions of each individual employee are highly visible and transparent. In this case, each involved employee has to contribute a fair share to the implementation of initiatives and cannot hide behind a vast

number of other employees as it is possible in large teams where transparency of individual efforts becomes blurred. In addition, a smaller team size prevents that the team deviates from its original focus and the overall aims of the project which could cause tensions with other involved teams. The sustainability team provides assistance to these teams whenever needed and coordinates all initiatives in order to keep the overview across the firm. For these reasons, knowledge exploration, retention and exploitation mainly take place at the project level with the coordinating and managing role being executed by the sustainability team. Based on these findings, the following can be proposed:

Proposition 23: The smaller and more centrally embedded the implementing team, the greater is the sense of responsibility for sustainability among team members.

Resources for sustainability initiatives

A sufficient level of resources needs to be made available to the sustainability team and involved project teams and workgroups. These resources can take the form of direct financial funding for initiatives and of extra time for employees to be spent on knowledge management for sustainability initiatives as well as on thinking about the future of the firm in the context of sustainability and the required knowledge. While a sufficient level of funding is critical by definition, this research clearly shows that having reserved extra time (away from the daily business) is particularly important to manage knowledge for sustainability. In addition, a generous amount of allocated resources gives involved teams and their sustainability initiatives the necessary credibility. If insufficient resources are allocated, sustainability initiatives will likely be perceived as unimportant. This notion underlines the importance of a dedicated sustainability team as mentioned earlier because this team can "afford" to deal with sustainability exclusively. This discussion about resources leads to the following proposition:

Proposition 24: The higher the level of resources a firm provides for sustainability initiatives, the better is sustained knowledge management facilitated.

Integration of sustainability strategy

The degree of integration of sustainability into overall strategy is critical since it signals a high importance of sustainability. If the sustainability strategy is separate from the general strategy, barriers in sustainability management will be considerably higher. This is because the general strategy is considered to be "the" strategy which makes aspects of the sustainability strategy appear as something that is not aligned with the general strategy and therefore less relevant. Again, this point highlights the importance of a dedicated sustainability team that is embedded as high up in the hierarchy as possible. The following proposition can be derived from this discussion:

Proposition 25: The deeper a firm's sustainability strategy is rooted in overall strategy, the more integrated the overall strategy becomes.

Long-term orientation of project teams

Having a longer-term horizon is critical for firms in general and relevant project teams in particular in order to facilitate sustained knowledge management for sustainability and the implementation of initiatives. Along this line of thinking, task-force teams which are rapidly set-up when a given need arises are insufficient for continuous knowledge management in the context of changing stakeholder pressures over time. In order to ensure continuous knowledge management, project teams need to be established for the longer-term. Therefore, the following proposition can be derived:

Proposition 26: The longer a project team's horizon, the better is sustained knowledge management facilitated.

Diversity among team members

Diversity and inter-disciplinarity among employees in the sustainability team and related teams need to be developed. Diverse individuals in terms of specific traits, education and experience not only perceive different issues but also perceive a given issue in different ways. This enables the sustainability team to acquire the broadest possible understanding of the most relevant aspects of sustainability. This spans everything from the interpretation of pressures in the market context and the related need for knowledge, the detection of opportunities for knowledge creation, the analysis of potential partners and the identification of suitable sustainability initiatives. This leads to the following proposition:

Proposition 27: The more diverse a firm's sustainability team, the broader is the understanding of the sustainability challenge.

5.4.3 Behaviour

For the firm to be successful, certain behaviours need to be in place which support the development of structures and ultimately activities (Bleicher, 1996). The following success factors in knowledge management for sustainability related to behaviour can be identified in this research.

Deep-rooted motivation

A high degree of motivation for sustainability among management and employees alike must be in place. This goes beyond the notion discussed above that a manager is involved in the sustainability team or that the sustainability team reports to the board of directors. Motivation among management means that managers intrinsically believe in

the potential of sustainability to create competitive advantage. In addition, it means that managers commit to sustainability by providing the required structure such as in the form of sufficient resources as noted above, by giving sustainability the required moral support and by "living" sustainability as an example for employees to follow. Managers need to be motivated themselves before they can motivate employees to engage in sustainability. If managers are not supportive of sustainability, it will be highly unlikely that employees are. The importance of the sustainability theme for the firm needs to be anchored not only in the minds of employees in the sustainability team and related teams but also in the minds of wider groups across the firm. This is particularly important for knowledge management because valuable and relevant knowledge can only by generated by employees who are willing to do so, understand its value and see how the firm can benefit from it. The discussion about motivation for sustainability leads to the following proposition:

Proposition 28: The better the motivation for sustainability of a firm's managers, the better is the motivation for sustainability among employees and the firm as a whole.

Critical thinking

Employees need to be willing to challenge the status quo, especially in conditions of fast change as it is the case with the sustainability challenge. For this to work, certain aspects of organisational behaviour need to be in place. For instance, openness for change and an entrepreneurial culture are needed which enable teams to try new approaches, make mistakes and learn from them. If nobody questions established thinking and everybody agrees on everything, then the firm will likely miss important signals in the market context and develop inertia. From this, the following can be derived:

Proposition 29: The stronger a firm's ability to question established thinking, the lower is the likelihood that it develops inertia.

Proactive behaviour

Proactive behaviour is necessary to ensure that firms not only comply with regulation but are ahead of it. If a firm was just following regulation, its knowledge management would be fully exposed to and unprepared for changes in environmental regulation. This could mean that the firm loses track with requirements of a tightening regulatory framework and falls behind competitors. This could take the form of delays in creating the required knowledge for sustainability innovation to keep up with these changes. Therefore, proactive behaviour is critical to ensure continuous knowledge management, to significantly reduce the risk of legal consequences and to help firms to position themselves in a way to derive competitive advantage. A firm's emphasis on proactive behaviour is comparable to the notion that sustainability workgroups and project teams

need to be held responsible for the sustainability initiatives discussed earlier. This discussion leads to the following proposition:

Proposition 30: The further a firm goes beyond regulatory requirements, the lower becomes the risk of ad-hoc adjustments to regulatory changes.

Taking responsibility in small implementation teams

Small and centrally embedded implementing teams without strict hierarchical structures ensure that responsibility rests with involved employees at the project level and is not transferred to management. If employees feel responsible for the efforts they put into sustainability initiatives, it gives them a sense of empowerment and room for action on the one hand and it represents an incentive to perform better on the other hand. An important distinction to be made here is that employees are not explicitly held responsible by management for the sustainability initiatives they are involved in but rather implicitly take responsibility themselves. Based on this, the following proposition can be derived:

Proposition 31: The higher the degree of responsibility for sustainability initiatives in a given team, the greater is the potential for achievements in sustainability management.

5.5 Knowledge management to deal with the sustainability challenge

In summary, the following propositions are derived for further research throughout this work:

Proposition 1: The higher the number of relevant opportunities for knowledge management the firm detects, the greater is the need for knowledge exploration and exploitation.

Proposition 2: Stakeholder pressures exert more power on firms to create knowledge than other sustainability drivers.

Proposition 3: Exogenous pressures exert more power on firms to create knowledge than endogenous pressures.

Proposition 4: The more powerful a stakeholder pressure, the greater is the need to create knowledge.

Proposition 5: The more market knowledge a firm possesses, the higher is its ability to address the sustainability challenge.

Proposition 6: The more strategic knowledge a firm possesses, the higher is its ability to address the sustainability challenge.

Proposition 7: The more technical knowledge a firm possesses, the higher is its ability to address the sustainability challenge.

Proposition 8: The more human resource knowledge a firm possesses, the higher is its ability to address the sustainability challenge.

Proposition 9: The higher the rate of change in a firm's market, the less it can rely on prior knowledge.

Proposition 10: The higher the rate of change in a firm's market, the higher the likelihood that it has to engage in path-breaking activities.

Proposition 11: The higher the rate of change in a firm's market, the more it focuses on knowledge exploration compared to exploitation.

Proposition 12: The more recent the challenge a firm faces, the more it focuses on knowledge exploration compared to exploitation.

Proposition 13: The more balanced a firm's knowledge-related abilities, the greater is the knowledge accumulation in the longer-term.

Proposition 14: The more established the challenge a firm faces, the more its focus shifts from knowledge exploration to knowledge exploitation.

Proposition 15: The better a firm balances knowledge exploration and exploitation, the greater is knowledge accumulation in the longer-term.

Proposition 16: The larger a firm's network, the greater the ability to accumulate the knowledge needed to deal with the current sustainability challenge.

Proposition 17: The higher a firm's efforts in sustainability education, the higher is the potential to explore, retain and exploit knowledge.

Proposition 18: The more elaborate a firm's scanning mechanisms, the greater is the likelihood to detect opportunities to create knowledge.

Proposition 19: The better integrated sustainability considerations in a firm's overall strategy setting process, the greater is the potential for achievements in sustainability management.

Proposition 20: The longer a firm's horizon, the greater is the potential for achievements in sustainability management.

Proposition 21: The more independent a firm's sustainability team, the lower the risk that the daily business distracts and delays sustainability initiatives.

Proposition 22: The higher the hierarchical level of the firm's sustainability team, the faster it can pursue sustainability initiatives.

Proposition 23: The smaller and more centrally embedded the implementing team, the greater is the sense of responsibility for sustainability among team members.

Proposition 24: The higher the level of resources a firm provides for sustainability initiatives, the better is sustained knowledge management facilitated.

Proposition 25: The deeper a firm's sustainability strategy is rooted in overall strategy, the more integrated the overall strategy becomes.

Proposition 26: The longer a project team's horizon, the better is sustained knowledge management facilitated.

Proposition 27: The more diverse a firm's sustainability team, the broader is the understanding of the sustainability challenge.

Proposition 28: The better the motivation for sustainability of a firm's managers, the better is the motivation for sustainability among employees and the firm as a whole.

Proposition 29: The stronger a firm's ability to question established thinking, the lower is the likelihood that it develops inertia.

Proposition 30: The further a firm goes beyond regulatory requirements, the lower becomes the risk of ad-hoc adjustments to regulatory changes.

Proposition 31: The higher the degree of responsibility for sustainability initiatives in a given team, the greater is the potential for achievements in sustainability management.

Table 21: Summary of propositions

Having answered the three sub-questions of this research in previous chapters, the main research question of which knowledge management aspects are needed in order to address the sustainability challenge can now be dealt with. In summary, the following critical knowledge management aspects can be identified throughout this work:

- Using market scanning mechanisms to detect threats and opportunities and thereby build up market knowledge in order to understand the sustainability challenge
- Using prioritisation mechanisms to select the most relevant and beneficial opportunities for knowledge accumulation
- Fostering diversity and inter-disciplinarity among employees to enlarge single-disciplinary knowledge and gain broad understanding of the sustainability challenge
- Managing knowledge by balancing explorative, retentive and exploitative approaches to ensure continuous evolution of the knowledge base
- Building alliances in order to be able to access partners' knowledge bases and fill internal knowledge gaps
- Complementing prior knowledge continually to be able to keep up with changing market requirements
- Working with a longer-term horizon to accumulate knowledge in a disciplined and consistent way

- Challenging established thinking to follow new directions in knowledge management and to avoid organisational inertia
- Motivating employees for sustainability in order to benefit from their full potential in knowledge management
- Providing sufficient resources for sustainability initiatives and related knowledge building to facilitate initiatives and build credibility for sustainability
- Embedding sustainability at a high hierarchical level to ensure support for initiatives and knowledge building and to establish credibility
- Providing sufficient sustainability training in order for employees to build the required sustainability knowledge
- Establishing a sense of individual responsibility for sustainability and required knowledge building among employees
- Integrating sustainability into overall strategy in order to underline its importance and thereby facilitate knowledge management
- Establishing independent sustainability teams to be able to dedicate sufficient attention to the sustainability topic and related knowledge
- Behaving proactively in sustainability management and knowledge building in order to be ahead of the curve

When looking at these knowledge management aspects, it becomes apparent that they correspond to the knowledge-related abilities identified earlier. Contrasting these findings with the literature on knowledge management as discussed earlier illustrates that these aspects are not embedded on the knowledge management level but rather related to knowledge-related abilities on the project-level where the actual operationalisation takes place. For instance, Lichtenthaler and Lichtenthaler (2009) note that knowledge capacities (such as inventive and absorptive capacities) and the associated knowledge-related abilities (such as market scanning instruments and alliance building as listed above) represent activities and processes that help the firm to achieve their goals in sustainability management. By contrast, knowledge management capacities are seen as dynamic capabilities which enable the firm to adjust and realign their knowledge capacities to changing market requirements (Lichtenthaler and Lichtenthaler, 2009). Therefore, knowledge management is embedded at a higher (managerial and coordinative) level where operationalisation itself does not take place. This suggests that the sustainability challenge cannot directly be addressed by knowledge management but rather indirectly via the discussed knowledge-related abilities on the project level.

To summarise, the main research question can therefore be answered with the help of the findings that were used to answer the three sub-questions. An important addition to these answers, however, is the importance of the coordinative and managerial role knowledge management capacities play in continuously realigning and reconfiguring knowledge-related abilities at the project level to changes in the market context (Helfat et al., 2007; Lichtenthaler and Lichtenthaler, 2009).

6 Conclusion

The conclusion is structured as follows:

- Generic and specific theoretical implications are summarised and integrated into the research model.
- Practical implications are examined to assist firms in addressing knowledge management for sustainability.
- Limitations are discussed to be taken into account in further research.
- Based on general observations and on specific propositions derived throughout this research, directions for further research are addressed.

6.1 Theoretical implications

Based on the research questions and the research model, this work contributes to theory in different ways. This includes theoretical implications which are generic and specific.

Generic theoretical implications relate to the research gap as well as the data set. First, the literature on sustainability management suggests that dynamic capabilities are necessary for firms to address the requirements resulting from a fast-paced market context. Putting this into the context of the sustainability challenge which generates highly dynamic market conditions as shown by the multitude of different stakeholder pressures, opens up an interesting area for research. As the evidence in this research suggests, knowledge-related capabilities in particular play an important role. This is because firms need to have knowledge at their disposal that is suitable to find solutions to sustainability challenges. However, it is not enough to have that knowledge at the project-level. On a higher level, firms need to be able to coordinate and manage (i.e. readjust and realign) this knowledge in such a way that it is keeping up with changes in the market context. In order to succeed on this higher level, firms require knowledge-related dynamic capabilities such as the knowledge management capacity which has been discussed in detail throughout this work. This knowledge management capacity entails internal and external knowledge exploration, retention and exploitation to ensure that the body of knowledge is continuously kept up to date with changing market requirements in the context of the sustainability challenge. While plenty of research has been done on the dynamic capability construct with a focus on knowledge management, there is little understanding on the use of dynamic capabilities in the context of the sustainability challenge. Consequently, the resulting research gap of this work has important theoretical implications. As discussed earlier, it has been noted in the literature that the dynamic capabilities construct should be integrated with other research streams in order to support its ongoing development, to widen its potential of applicability as well as to benefit the research stream it is combined with.

Second, with the help of empirical evidence, this research attempts to fill this research gap and thereby contribute to theory. Empirical evidence is derived from four case studies conducted in the course of this research. These case studies provide a new dataset at the intercept of knowledge-related dynamic capabilities and sustainability management which helps to uncover important insights in order to advance research on knowledge-related sustainability management. This data makes it possible to derive new insights. Direct interactions in the form of in-depth interviews with research objects at sample firms helped to uncover important detail on knowledge management in the context of the sustainability challenge. At each sample firm, research objects included the global head of sustainability as well as members of the sustainability team.

Specific theoretical implications relate to numerous research propositions which have been formulated in the cross-case analysis and discussion. First, the literature widely regards regulation as the most significant pressure in the sustainability context since firms have no choice but to comply unless they are prepared to risk legal consequences. While this notion appears obvious, it cannot be confirmed by the evidence in this research. In fact, other stakeholder pressures are considered far more powerful than regulation. Examples for these include customers, NGO and shareholders, for instance. Judging from the evidence in the case studies, an explanation can be that sample firms are proactively ahead of regulation which takes out the pressure which less proactive firms encounter. For this reason, the issue of regulation offers interesting implications since it causes firms to go beyond what it prescribes and build the knowledge necessary to find solutions on a level which is not yet enforced.

Second, it is interesting to note that while a large number of sustainability drivers are discussed in the academic literature, sample firms consistently regard one group of drivers as distinctively critical. More specifically, sample firms perceive exogenous stakeholder pressures to be most powerful. These include customers, societal values and norms, NGO, environmental regulation, shareholders, competitors and suppliers. Other exogenous and endogenous sustainability drivers are not explicitly mentioned by sample firms when asked about the forces which motivate them to engage in sustainability.

Third, a theoretical implication can be derived from the fact that the discussion in the literature on knowledge exploration and exploitation cannot be confirmed by the findings in this research. For instance, it is noted in the literature that in order for firms to create sustained competitive advantage, they should address knowledge exploration and exploitation simultaneously in good balance since both have drawbacks on their own. On the one hand, exploration is concerned with the creation of new knowledge without applying it. On the other hand, exploitation is concerned with the application of existing knowledge without creating any new knowledge. Further, the literature suggests that firms often tend to focus on exploitation because results are more predictable and occur

faster compared to exploration of new solutions. Yet, the evidence in case studies suggests that firms focus primarily on knowledge exploration. In a market context characterised by fast change and newly arising requirements as it is the case with the sustainability challenge, firms tend to focus on exploration in order to be able to accumulate new knowledge which is required to find new solutions which cannot simply be obtained by exploitation of existing knowledge.

Fourth, the findings regarding prior knowledge have theoretical implications. While this research acknowledges that path dependencies exist and that prior knowledge can be beneficial for firms in some instances (e.g. diverse employees with their own experiences and knowledge that have an impact on which knowledge they build, how they build it and how they understand and use it), it also suggests that path-breaking instances exist (e.g. challenging the status quo, fast learning and building of newly required knowledge to meet arising different challenges). This research contributes to the dynamic capabilities literature in that the notions of path dependency and prior knowledge can be relevant as well as absent at any point in time at the example of a particular firm or in a given instance. As opposed to the existing literature, this research shows that it is not so much about the question whether path dependencies exist or not but rather about the question in which instances they do and do not exist. On the one hand, this research shows that path dependencies in the form of prior knowledge can play an important role in cases, when a given technology is improved which the firm has a rich body of knowledge and experience in. For instance, a car manufacturer might improve the fuel-efficiency of conventional combustion engines. On the other hand, however, this research also implies that fast-paced market contexts might make it necessary to enter an area of knowledge in which the firm does not possess any prior knowledge. The mentioned car manufacturer, for instance, might decide to develop alternative power-trains for the first time without having any prior knowledge in alternative propulsion technologies. The firm might have at least some related knowledge, however, the essentials do not exist compared to the above case of improving fuel-efficiency of a conventional combustion engine. In order to cope with such a context, firms have to create that knowledge rather rapidly or acquire and access it from external parties. This requires path-breaking efforts in that it is required to learn fast, to think differently, to follow another logic which has been referred to as "thinking outside the box" and to accumulate entirely new knowledge accordingly.

To summarise the theoretical implications of this research, Figure 6 illustrates the original research model introduced earlier with the main findings and relevant propositions integrated.

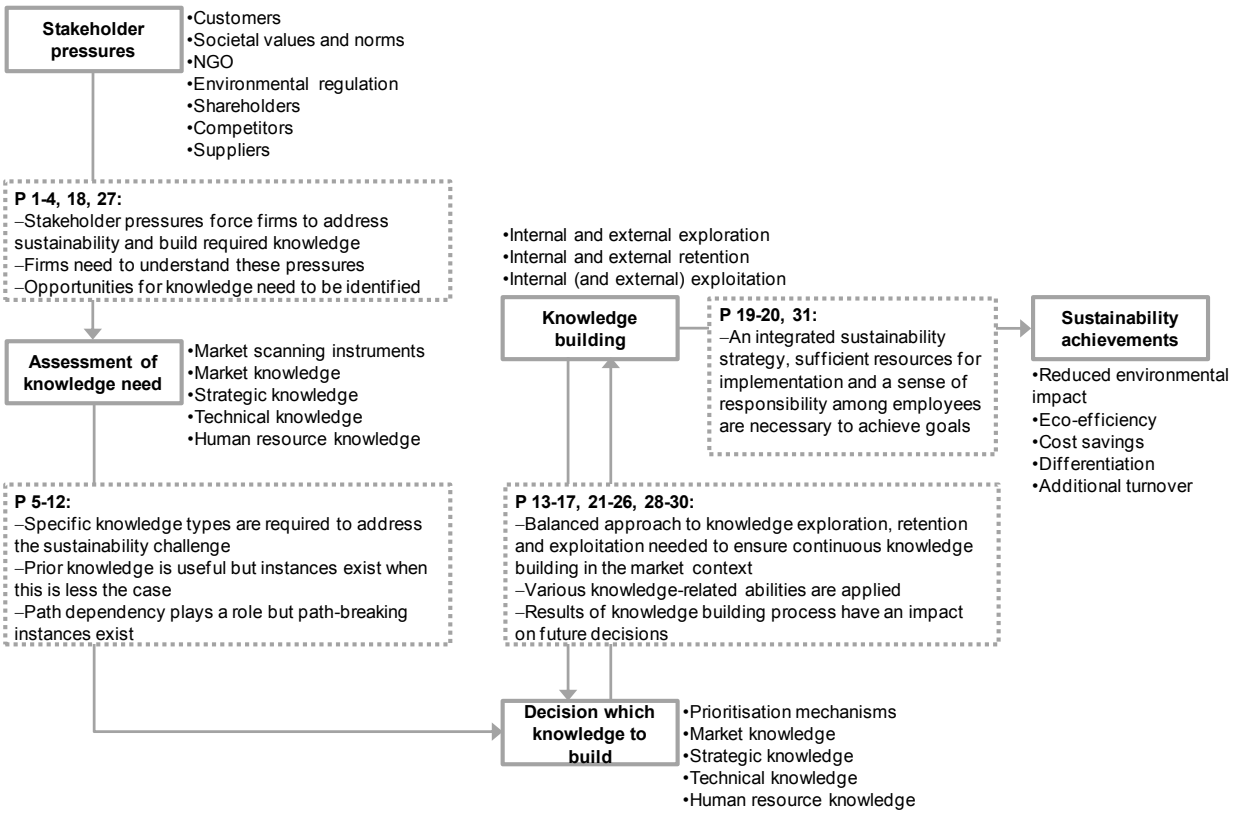

Figure 6: Research model including findings and propositions

6.2 Practical implications

Based on the success factors in sustainability management which have been identified and the research propositions which have been derived in the cross-case analysis and discussion, a number of managerial implications evolve.

First, it is essential that firms focus their knowledge management efforts on both, exploitation and exploration in a suitable balance. This is because exploration is exclusively concerned with the creation of new knowledge while exploitation is exclusively concerned with the application of existing knowledge without creating anything new. Neither exploration which ignores the application of knowledge, nor exploitation which ignores the creation of new knowledge can create competitive advantage in the longer-term on their own. The balance between explorative and exploitative efforts should be determined based on the circumstances that firms encounter in the context of the sustainability challenge. For instance, if changes are expected to occur in market contexts that shift knowledge requirements substantially, a firm has to increase explorative efforts as it might not yet have the knowledge do address newly arising issues.

Second, partnerships are critical for two reasons. On the one hand, in times of heightened market pressure in the form of new requirements caused by the sustainability challenge, firms might find themselves in a position where they do not possess a sufficient level of

knowledge in order to address these requirements. Since building this knowledge internally might take too long thus causing the firm to lose track with requirements and competitors, the only option is to search for that knowledge externally. Often these partners own specialist knowledge on a given field which is worth to be tapped into. Whether this knowledge is acquired or accessed and shared with external partners depends on the partners and the types of knowledge. On the other hand, partnerships are essential in order to expand the network with customers, suppliers, competitors, NGO and other stakeholder groups and to be kept updated about what is happening on the market.

Third, firms need to have dedicated sustainability teams. These teams need to be largely independent in order to have the time and room to think about the sustainability theme and the resulting implications for the firm. If they were too much involved in the daily business, sustainability initiatives would be at risk to get distracted from their course. While these teams need the mentioned independence, they should also have close links to the teams that implement initiatives in order to keep an overview of different initiatives across the firm's operations. In terms of organisational structure, these teams need to be embedded at the highest possible level in order to ensure credibility across the firm and to get top-management support. Having a management member in the sustainability team facilitates sustainability management further.

Fourth, firms need these dedicated sustainability teams to develop and operate elaborate market scanning mechanisms. This is necessary in order to build understanding of the challenge and the specific pressures coming from stakeholders. This in turn is essential in order to recognise related opportunities for knowledge creation and to prioritise among different initiatives to ensure that the most relevant directions are pursued. This is particularly important since the sustainability challenge tends to create an overflow of information that firms have to cope with. Diversity and inter-disciplinarity among employees in the sustainability team and related teams also plays an important role. This is because diverse individuals in terms of specific individual traits, education and experience see different opportunities, thereby enabling the team to accumulate a broader understanding of sustainability. In addition, the willingness to challenge established thinking is critical in conditions of fast change as it is the case with the sustainability challenge. Critical for this are openness for change and entrepreneurial spirit which allow teams to try new approaches. To ensure that not only the sustainability team and related workgroups are aware of and able to understand the sustainability theme and detect opportunities, sufficient education and training need to be provided to wider audiences within the firm. Such training needs to be specifically aligned to the respective target groups in order to ensure understanding at every level.

Fifth, the degree of integration of sustainability considerations in overall strategy is

essential in order for sustainability to be regarded as an integral part of the business. This integration always needs to be practiced when strategic decisions are made. It not only ensures that decisions are made holistically but also that sustainability considerations get the appropriate degree of visibility. This in turn generates the necessary attention for and credibility of sustainability initiatives among employees.

Sixth, it is critical for firms to have a longer-term horizon for sustainability management. This is to avoid that project goals change over time which is an obstacle to successful implementation. This is often observed in cases when short-term thinking dominates. Longer-term thinking is essential for a disciplined knowledge accumulation process in the context of sustainability and particularly important for the knowledge exploration compared to exploitation since its benefits in terms of timing and magnitude are less predictable. For sustainability initiatives and related knowledge management to be thoroughly implemented and for changing stakeholder pressures to be taken into account over time, established workgroup teams are required rather than rapidly created task-force teams.

Seventh, it is essential that the workgroups and teams which implement sustainability initiatives are held liable for their projects from start to end. Small and centrally embedded rather than large de-central and hard to monitor implementation teams ensure that the contributions of each involved employee are highly transparent which prevents employees from becoming inefficient and inactive. It creates a certain sense of responsibility among involved individuals which is highly conducive to the achievements of these individuals and their teams. This also ensures that the team does not deviate from its path towards achieving the set goals.

Eighth, motivation for sustainability among managers as well as wider circles of employees is essential for sustainability initiatives to evolve successfully. In terms of managers, this means that they believe in the business potential of sustainability and credibly buy into the theme as an example to employees. To underline this message, they need to allocate an appropriate amount of resources to initiatives which gives them the necessary credibility. In addition, these resources allow involved employees to spend time thinking about sustainability and its implications. In terms of employees, motivation means that they follow the example of managers, buy into the idea of sustainability and are therefore willing to work towards set goals. Employee motivation needs to go beyond sustainability teams and related teams towards wider groups. Valuable knowledge can only by generated by employees who understand its importance and value. Motivation also plays an important role for firms because it supports proactive behaviour. This is required for firms to not only comply with regulation but also to be ahead of it which takes out regulatory risk and gives firms more room for manoeuvre. It also prevents firms to lose track with tightening regulation and to fall behind

competitors. Therefore, proactive behaviour also helps firms to ensure continuous knowledge management ahead of regulatory requirements.

6.3 Limitations

Several limitations exist that should be discussed. First, as mentioned in the introduction, this research does not explicitly take into account the social and economic aspect of the triple bottom line. The reasons for the focus on the ecological aspect (with the economic one assumed to be included anyway) have been discussed in the introduction.

Second, sustainability achievements have not been researched in detail. Sustainability achievements are broadly defined as the extent to which a firm's sustainability initiatives result in a reduced environmental impact. This aspect is discussed in all case studies, however, it would be interesting to go into more detail about the economic, ecological and social impact of sustainability initiatives. Sample firms note that a clear indication of the benefits of sustainability initiatives would provide substantial support to sustainability teams in building credibility of the sustainability theme.

Third, other success factors than those identified in the cross-case analysis might exist that help firms to manage their body of knowledge successfully in order to master the sustainability challenge. These success factors result from close interactions with the four introduced sample firms but other sample firms might well perceive other success factors as critical.

Fourth, case study research in general as applied in this qualitative work is exposed to limitations. While qualitative research methods are well suited to instances when relatively little is known (e.g. Eisenhardt, 1989; Voss et al., 2002; Yin, 1994) as it is the case in this research, the ability to generalise will remain relatively weak due to smaller sample sizes compared to quantitative research (e.g. Wilson, 1982). Further, the criteria of objectivity, reliability and validity might be partially undermined due to direct interactions with humans in the course of the research (e.g. Wilson, 1982).

Fifth, the fact that sustainability is a topic that polarises opinions among people can lead to bias in the results which is linked to the methodological limitation discussed above. It is quite likely that only those individuals have responded to the survey who are interested and open for sustainability. The others might not have responded at all which causes positive bias. The same is true for case studies as only interested and engaged firms were prepared to be interviewed and invited the research team to workshops at their site (Eisenhardt, 1989; Voss et al., 2002). Further, bias might arise because it is morally expected by society today that firms take into account sustainability which does not necessarily reflect intrinsic views of respondents and interviewees (Voss et al., 2002; Yin, 1994).

6.4 Further research

Directions for future research can be derived from general observations as well as from specific propositions made throughout this research.

One avenue for further research is to extend the application of the dynamic capabilities construct in the context of the sustainability challenge. While this research represents a first attempt to formally combine these two research streams, this is only the starting point. For instance, this research focuses on knowledge-related dynamic capabilities because the data indicates that these are regarded most important by sample firms. However, this is one of a few clusters of dynamic capabilities. It is therefore worthwhile to explore other clusters such as the one related to strategic decision-making.

While the dynamic capabilities construct fits into the dynamic market context caused by the sustainability challenge as presented in this research, the debate whether dynamic capabilities are necessary at all and whether they can be substituted by plain capabilities or abilities is worth to be continued in research. Along these lines, the debate whether dynamic capabilities can be operationalised at all is also worthwhile. In this research, they are regarded as higher-order coordinating capabilities at the management level which are referred to as knowledge management capacities which do not create knowledge directly and therefore cannot be operationalised. However, they assist operationalisation at the project-level where knowledge capacities actually do create knowledge.

Further, the reasons why external stakeholders are considered most important among the large group of sustainability drivers identified in the literature should be examined in more detail. It appears obvious that stakeholders are powerful, nevertheless, the fact that all sample firms from family-owned to stock-listed multinational share that view, deserves more attention.

More specifically on stakeholder pressures, the reasons why environmental regulation has not been perceived to be as powerful by sample firms as the literature suggests should be examined further. There are some potential directions this can take. On the one hand, it might simply be that regulation in practice is not as stringent in terms of requirements and not as strictly imposed as proposed in the literature. This suggests that firms can find their way around it conveniently and therefore do not regard regulation as an important pressure. On the other hand, it might be that sample firms in this research are relatively far ahead of regulation which makes it less of an issue for them compared to other pressures coming from customers or NGO, for instance. This notion corresponds to the fact that sample firms have been selected due to high standards in sustainability management and related successful approaches in the first place. In either case, analysing regulatory pressures in a larger sample of firms could generate additional insights.

Another interesting direction for further research is to thoroughly examine the reasons why firms focus more on knowledge exploration than on exploitation in some instances. As noted earlier, this research illustrates that sample firms emphasise activities and abilities related to exploration while exploitation receives less attention. Therefore, the evidence in this research suggests the opposite of what is commonly believed in the literature, namely, that firms often tend to rely on knowledge exploitation (i.e. the application of existing knowledge) since its outcomes are more predictable and up-front costs are considerably lower. A possible explanation for this conflicting view is that firms might perceive exploration in the sustainability context to be more risky and perhaps more costly due to less predictable outcomes and its emphasis on the longer-term which might lead them to conclude that exploration is more difficult and therefore needs more attention. This is linked to the degree of novelty of a given aspect of the sustainability challenge. When an aspect of the challenge is relatively new, firms might attempt to gain competitive advantage by creating new knowledge and solutions through exploration. The more firms (and their competitors) adjust to that aspect, the more they shift from exploration to exploitation. However, these assumptions need to be researched in more detail before any conclusions can be made.

In addition, the role of prior knowledge is another avenue for future research, especially in those instances when prior knowledge becomes substantially less relevant. As discussed earlier, prior knowledge can be highly useful in instances when it is sufficient to rely on the traditional body of knowledge and to focus on expanding it and making better use of it. In the "normal" course of business, this is usually the case. However, in instances when rapidly arsing challenges require the firm to build entirely new knowledge by taking a direction it has hardly any experience in, the significance of prior knowledge diminishes. Especially new phenomena such as the sustainability challenge can cause situations in which prior knowledge simply is not enough. These instances should be researched in more detail in order to advance the understanding of a suitable balance between established knowledge and entirely new knowledge from the firm's perspective.

Moreover, extending this research to other geographic regions could be interesting since geographic differences exist in terms of understanding for and approaches to sustainability. All sample firms are headquartered in Western Europe of which one is based in Switzerland and the other three are based in Germany. While sample firms are heterogeneous in terms of industry type (i.e. four different industries), additional insights can be gained by extending this analysis to other industries. For instance, firms of the cement, mining and oil and gas industries would be highly interesting cases in terms of sustainability management as these industries are considered particularly harmful to the environment. For instance, this would support understanding of the differences in

regulatory requirements among different regions and industries and therefore help to explain why some firms (or divisions) are able and willing to address regulation more proactively than others.

Further, evidence in this research is based upon sample firms which address sustainability issues successfully. Therefore, it would be worthwhile to extend the sample by conducting case studies with firms that are performing badly. Provided that these underperformers are willing to talk about the reasons why they are not engaging in sustainability and their weaknesses in general, this would represent a valuable contrast to successful firms and highlight practices that can be done better. In this context, it would be worthwhile to analyse the discussed supporting and hindering factors in knowledge management for sustainability in more detail. This would improve the understanding of the reasons why some firms behave more in favour of sustainability than others.

Finally, the derived findings and propositions should be tested quantitatively with a larger and broader sample in order to overcome the noted shortcomings of the qualitative research design.

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APPENDIX

Contact dates with sample firms

Sample firms	Questionnaire returned	Telephone interview	Site visit	Follow-up interview
CHEMICAL LTD	18.11.2010	11.01.2011	30.03.2011	21.10.2011
RETAIL LTD	16.12.2010	03.01.2011	08.04.2011	31.10.2011
OUTDOOR LTD	22.11.2010	20.12.2010	23.02.2011	19.10.2011
CAR LTD	03.11.2010	21.12.2010	10.03.2011	20.10.2011

Table 22: Contact dates with sample firms

Questionnaire

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Gaining competitive advantage by successfully addressing the sustainability challenge

A survey conducted by the Transfer Center of Technology Management
at the University of St.Gallen (HSG), Switzerland.

This survey globally analyses companies to identify successful practices in dealing with the sustainability challenge. The questionnaire targets sustainability managers and other functions related to sustainability. Our trials have shown that it takes approximately 45 minutes to complete.

Confidentiality and data security:

- We ensure that all data will be treated with utmost confidentiality. The names of companies, business units, products, and persons will not be published!
- All data will only be published in anonymous and accumulated form. Therefore, inferences to your company won't be possible.
- Project follows international benchmarking code of conduct.

Your benefits:

- Respondents who fully complete the questionnaire will participate in a prize draw for a wellness weekend for two people.
- You can be among the five firms selected as successful practice partners and receive an award.
- We will disclose our findings in a report which you will receive free of charge in early 2011.

Should you have any question or criticism concerning this questionnaire, please contact us on +41 71 224 7310.

Thank you very much in advance for participating in our survey!

Institute of Technology Management

University of St.Gallen

Andreas Hinz
Chair of Production Management
University of St. Gallen
CH - 9000 St. Gallen

E-Mail: andreas.hinz@unisg.ch

Tips & tricks:

1. ☒ ☒ ☐ Multiple choices possible ● ○ ○ Single choice
2. Adjust this PDF document to the size of your screen.
3. It is possible to save this document, so completion of the questionnaire can be stopped and resumed later. In this case we would ask you to submit the completed questionnaire by email (andreas.hinz@unisg.ch). If it is impossible to complete the questionnaire online, please print it out and fax it to the Chair of Production Management (+41 71 224 73 11).

Your Company

Your company*

Contact for questions / delivery of report:

Your first name* | Your last name*

Your job position within your company*

Name of your division / business unit*

Place* | Country*

Phone number | E-mail address*

For how many years have you been working in the field of sustainability?

* Compulsory entry

A General Information on Company

A.1 General company information

In which region does your company operate? (Multiple answers possible)

	Western Europe	Eastern Europe	North America	South America	China	Rest of Asia	Rest of the world
Headquarters	☐	☐	☐	☐	☐	☐	☐
Research & Development	☐	☐	☐	☐	☐	☐	☐
Sales	☐	☐	☐	☐	☐	☐	☐
Manufacturing	☐	☐	☐	☐	☐	☐	☐
Sustainability Management	☐	☐	☐	☐	☐	☐	☐

- What is your company's size (number of employees worldwide)?
- How many employees are working in sustainability management?
- Does the position of corporate sustainability officer (CSO) exist in your firm?
  ○ No ○ Yes
- If the position of corporate sustainability officer (CSO) doesn't exist in your firm, which department is responsible for sustainability?

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A2 **Industry Sector**

In which sector(s) does your company operate? (Multiple answers possible; Numbers refer to OECD's ISIC Codes, Rev.)

Production of...

- ☐ 10 - ... food products
- ☐ 11 - ... beverages
- ☐ 12 - ... tobacco products
- ☐ 13 - ... textiles
- ☐ 14 - ... wearing apparel
- ☐ 16 - ... wood and products of wood, cork, except furniture; ... articles of straw and plaiting materials
- ☐ 17 - ... paper and paper products
- ☐ 18 - ... printing and reproduction of recorded media
- ☐ 19 - ... coke and refined petroleum products
- ☐ 20 - ... chemicals and chemical products
- ☐ 21 - ... basic pharmaceutical products and pharmaceutical preparations
- ☐ 22 - ... rubber and plastic products
- ☐ 23 - ... other non-metallic mineral products
- ☐ 24 - ... basic metals
- ☐ 25 - ... fabricated metal products, except machinery and equpiment
- ☐ 26 - ... computer, electronic, and optical products
- ☐ 27 - ... electrical equipment
- ☐ 28 - ... machinery and equipment not elsewhere classified
- ☐ 29 - ... motor vehicles, trailers, and semi-trailers
- ☐ 30 - ... other transport equipment
- ☐ 31 - ... furniture
- ☐ 33 - Repair and installation of machinery and equipment
- ☐ Other/s (please specify): _____

A3 **Sustainability management**

Please select the option that best answers the following issues

Our sustainability strategy is ...	○ centrally managed	○ de-centrally managed		○ don't know
If de-centrally managed, are the same standards applied globally?		○ yes		○ no
Our sustainability strategy is ...	○ standardised for all regions	○ customised for specific regions		○ don't know
Our sustainability strategy is ...	○ separate from our overall strategy	○ well embedded into our firm strategy		○ don't know
Our support structure for sustainability management is ...	○ standardised for all regions	○ customised for specific regions		○ don't know
Our sustainability support structure is ...	○ separate from the business	○ well embedded into the business		○ don't know
Which form of sustainability reporting does your firm engage in?	○ separate sustainability report	○ sustainability integrated in business report	○ other _____	○ don't know
Do you follow the Global Reporting Initiative (GRI) for auditing purposes?		○ yes		○ no

If yes, by what percentage do you fulfil the GRI criteria? _____

B Three aspects of sustainability

B1 The triple bottom line

Explanation

Sustainability includes ecological, economic as well as social aspects which is commonly referred to as the triple bottom line. The ecological aspect refers to a firm's environmental practices (sustainability of natural capital). The economic aspect focuses on a firm's profitability (sustainability of economic value added). The social aspect focuses on a firm's people (sustainability of human capital).

Please indicate whether you agree with the following statements:

1 = totally disagree
2 = disagree
3 = hardly agree
4 = agree
5 = totally agree
0 = not applicable

	Ecological Aspect						Economic Aspect						Social Aspect					
	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5	0
Aspect has affected our decisions over the last year	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aspect has affected our decisions over the last 3 years	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aspect has affected our decisions over the last 5 years	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aspect has affected our decisions over the last 10 years	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aspect currently is our main focus of sustainability	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aspect has large potential for us to generate turnover	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aspect has large potential for us to generate product differentiation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aspect has large potential for us to generate image/reputation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aspect has large potential for us to save costs	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aspect has large potential for our risk management regarding sustainability	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
We expect this aspect to affect our decisions over the next year	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
We expect this aspect to affect our decisions over the next 3 years	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
We expect this aspect to affect our decisions over the next 5 years	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
We expect this aspect to affect our decisions over the next 10 years	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Please name the three most important sustainability initiatives your firm currently pursues (e.g. investments into renewable energy, cars emitting less CO2)?

B2 Different impacts on sustainability considerations

Please indicate whether you agree that the recent economic crisis has ...	Strongly disagree				Strongly agree	Don't know
... caused you to think more in the longer-term rather than the shorter-term.	○	○	○	○	○	○
... caused you to question the concept of profit-maximisation.	○	○	○	○	○	○
... internally triggered higher awareness of sustainability.	○	○	○	○	○	○
... caused you to better act in favour of sustainability.	○	○	○	○	○	○
... forced you to save costs and cancel sustainability initiatives.	○	○	○	○	○	○

Please indicate which period the following statements are most relevant to	1 year	3 years	5 years	10 years	Don't know
We have increased spending on sustainability initiatives over the last ...	○	○	○	○	○
We expect to increase spending on sustainability initiatives over the next ...	○	○	○	○	○

Please indicate whether you agree with the following statement	Strongly disagree				Strongly agree	Don't know
Disasters such as the oil spill in the Gulf of Mexico have caused us to act more sustainably.	○	○	○	○	○	○

From this point, the questionnaire focuses on the ecological aspect of sustainability exclusively!

C External drivers for ecological sustainability

C1 Main external drivers for ecological sustainability

Please rank the following external drivers influencing your firm's sustainability initiatives from 1 to 7 in order of importance by ticking the appropriate box (note that each number can only be selected once) (1 = most important driver, 7 = least important driver)

	1	2	3	4	5	6	7
State regulation	○	○	○	○	○	○	○
Values and norms in society	○	○	○	○	○	○	○
Competitors in our market environment	○	○	○	○	○	○	○
Customers in our market environment	○	○	○	○	○	○	○
Suppliers in our market environment	○	○	○	○	○	○	○
Shareholders in our market environment	○	○	○	○	○	○	○
Non-governmental organisations (NGOs) in our market environment	○	○	○	○	○	○	○

Which other external drivers for ecological sustainability are important?

C2 State regulation for ecological sustainability

Please select the option that best corresponds to the following statement	0%	0-3%	3-5%	5-10%	>10%	Don't know
We are ahead of regulatory requirements by ...	○	○	○	○	○	○

Please indicate whether you agree with the following statements	Strongly disagree				Strongly agree	Don't know
The state can efficiently impose sustainability regulation through incentives for firms (subsidies, tax reduction etc).	○	○	○	○	○	○
The state can efficiently impose sustainability regulation through strict enforcement (controls, penalties etc).	○	○	○	○	○	○

C3 Values and norms in society as regards ecological sustainability

Please indicate for which period the following statement is most relevant to	1 year	3 years	5 years	10 years	Don't know
Values and norms in society have become more powerful over the last...	○	○	○	○	○

C4 Market environment (including competitors, customers, suppliers and shareholders)

Please indicate whether you agree that your firm's market environment is influenced by ...	Strongly disagree				Strongly agree	Don't know
... the market participant's values and norms of sustainability	○	○	○	○	○	○
... high innovativeness on the market	○	○	○	○	○	○
... the market participants' attempts to be better than what is expected by regulation	○	○	○	○	○	○

C4 Market environment (including competitors, customers, suppliers and shareholders) (continued)

Please indicate whether you agree that your firm's market environment is influenced by ...

	Strongly disagree				Strongly agree	Don't know
... the state of the economy	○	○	○	○	○	○
... material and energy prices	○	○	○	○	○	○
... the market's competitive dynamism	○	○	○	○	○	○

Which other drivers affect your firm's market environment?

Which driver motivated you to launch the first sustainability initiative and in which year was that?

Year

C5 Customers in the light of ecological sustainability

Please indicate whether you agree with the following statement

	Strongly disagree				Strongly agree	Don't know
We are perceived as a sustainable firm by our customers.	○	○	○	○	○	○

Which factors change customer awareness of sustainably?

Please indicate for which period the following statements are most relevant to

	1 year	3 years	5 years	10 years	Don't know
Customer awareness for sustainability has been increasing over the last ...	○	○	○	○	○
We expect customer awareness for sustainability to increase over the next ...	○	○	○	○	○
Customers have become more demanding as regards sustainability considerations over the last ...	○	○	○	○	○
Customers' willingness to pay a premium for sustainable products has been increasing over the last ...	○	○	○	○	○
We expect customers' willingness to pay a premium for sustainable products to increase over the next ...	○	○	○	○	○
We expect customers to increasingly become interested in the sustainability of our entire supply chain over the next ...	○	○	○	○	○

C6 External barriers to sustainability strategy

Please indicate whether you agree that the following barriers to sustainability exist in your case

	Strongly disagree				Strongly agree	Don't know
Our customers are not interested in sustainability	○	○	○	○	○	○
Our industry does not focus on sustainability	○	○	○	○	○	○
We depend upon large quantities of resources	○	○	○	○	○	○
We have to work with resources that are not environmentally friendly	○	○	○	○	○	○

Please specify, which other external barriers to sustainability strategy exist

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D Internal drivers for ecological sustainability

D1 Main internal drivers for ecological sustainability

Please rank the following three internal drivers influencing your firm's sustainability initiatives from 1 to 3 in order of importance (1 = most important driver, 3 = least important driver)

	1	2	3
Our firm culture	○	○	○
Our resources	○	○	○
Our strategy	○	○	○

Which other internal drivers for ecological sustainability are important?

D2 Firm culture in the light of ecological sustainability

Please indicate how important the following aspects are in your firm with regard to sustainability

	Very important				Not important	Don't know
Motivation and values of staff	○	○	○	○	○	○
Efficient top-down dissemination of information	○	○	○	○	○	○
Management buy-in	○	○	○	○	○	○
Employee buy-in	○	○	○	○	○	○

Which other factors affect your firm culture as regards sustainability?

D3 Resources for ecological sustainability initiatives

Please indicate how important the following aspects are in your firm with regard to sustainability

	Very important				Not important	Don't know
Our shop-floor staff's level of qualification	○	○	○	○	○	○
Our shop-floor staff's willingness for improvement	○	○	○	○	○	○
Suitable set of technology and equipment resources	○	○	○	○	○	○

Which other factors affect your resources for sustainability initiatives?

D4 Strategy in the light of ecological sustainability - general information

Please indicate how important the following aspects are in your firm with regard to sustainability

	Very important				Not important	Don't know
Degree of strategic integration of sustainability in overall strategy	○	○	○	○	○	○
Commitment to be ahead of state regulation	○	○	○	○	○	○
Responsiveness to change	○	○	○	○	○	○

Which other factors affect your sustainability strategy?

D4 **Strategy in the light of ecological sustainability - general information (continued)**

Please indicate whether you agree with the following statements	Strongly disagree				Strongly agree	Don't know
We have a focused sustainability strategy in place	○	○	○	○	○	○
Our sustainability strategy is communicated efficiently to all our subsidiaries in all regions	○	○	○	○	○	○
Our sustainability strategy is communicated efficiently to all our subsidiaries in all business units	○	○	○	○	○	○
We have identified lead factories for sustainability initiatives	○	○	○	○	○	○
Our external communication on process initiatives for sustainability makes customers aware of our sustainability initiatives	○	○	○	○	○	○
Our external communication on product initiatives for sustainability makes customers aware of our sustainability initiatives	○	○	○	○	○	○
Our external communication on sustainability initiatives helps us to increase the value of our brand and products	○	○	○	○	○	○
We plan to increase the external communication of our sustainability initiatives	○	○	○	○	○	○
We take sustainability seriously because we believe it to be an important topic	○	○	○	○	○	○
We are willing to invest in a sustainability initiative even though the benefits are unknown	○	○	○	○	○	○
Our sustainability initiatives have a positive impact on job satisfaction of our staff.	○	○	○	○	○	○
Our sustainability initiatives have a positive impact on employee retention.	○	○	○	○	○	○
Our sustainability initiatives have attracted talent to the firm.	○	○	○	○	○	○

Please select the option that best corresponds to the following statement (Multiple answers possible)

Which channels do you use for internal sustainability communication (disclosure)?	☐ sustainability reporting	☐ information on intranet	☐ staff presentations	☐ other	
Which channels do you use for external communication (disclosure)?	☐ sustainability reporting	☐ advertising	☐ promotional events	☐ internet	☐ other

D5 **Internal barriers to sustainability strategy**

Please indicate whether you agree that the following barriers to sustainability exist within your firm

	Strongly disagree				Strongly agree	Don't know
Tight cost focus	○	○	○	○	○	○
Short-term thinking of management	○	○	○	○	○	○
Short-term thinking of shareholders	○	○	○	○	○	○
Lack of management buy-in	○	○	○	○	○	○
Lack of employee buy-in	○	○	○	○	○	○
Lack of awareness of sustainability issues	○	○	○	○	○	○
Lack of willingness to act with emphasis on sustainability issues	○	○	○	○	○	○
Lack of internal resources to address sustainability	○	○	○	○	○	○
Lack of understanding of sustainability issues	○	○	○	○	○	○
Lack of interest in sustainability issues	○	○	○	○	○	○

Please specify, which other external barriers to sustainability strategy exist

E Research & Development in the light of ecological sustainability

E1 Eco-effectiveness and eco-efficiency

Explanation

Eco-efficiency is a concept focusing on the efficient use of resources (material and energy) with the goal to reduce overall ecological impact. It is a relative measure and means "doing things right" as regards ecological sustainability.
Eco-effectiveness is a concept that goes beyond eco-efficiency in that it supports ways to find substitutes that aim to truly reduce ecological impact. It is an absolute measure and means "doing the right things" as regards ecological sustainability.

Please indicate whether you agree with the following statements with respect to the concepts of eco-efficiency and eco-effectiveness:

1 = totally disagree
2 = disagree
3 = hardly agree
4 = agree
5 = totally agree
0 = not applicable

	Eco-efficiency						Eco-effectiveness					
	1	2	3	4	5	0	1	2	3	4	5	0
Our management supports ...	○	○	○	○	○	○	○	○	○	○	○	○
Our employees support ...	○	○	○	○	○	○	○	○	○	○	○	○
Our R&D focuses on ...	○	○	○	○	○	○	○	○	○	○	○	○
Our manufacturing processes take into account ...	○	○	○	○	○	○	○	○	○	○	○	○
Considering the product life-cycle, R&D offers significant potential for ...	○	○	○	○	○	○	○	○	○	○	○	○
Considering the product life-cycle, the use of technology in manufacturing offers significant potential for ...	○	○	○	○	○	○	○	○	○	○	○	○
Considering the product life-cycle, the shop-floor layout offers significant potential for ...	○	○	○	○	○	○	○	○	○	○	○	○
We cooperate with research institutions to become better in...	○	○	○	○	○	○	○	○	○	○	○	○
We cooperate with customers to become better in...	○	○	○	○	○	○	○	○	○	○	○	○
We cooperate with suppliers to become better in...	○	○	○	○	○	○	○	○	○	○	○	○
Our company strategy drives ...	○	○	○	○	○	○	○	○	○	○	○	○
Our company culture drives ...	○	○	○	○	○	○	○	○	○	○	○	○
Our human and technological resources for sustainability initiatives drive ...	○	○	○	○	○	○	○	○	○	○	○	○
We expect ... to help us differentiate our products	○	○	○	○	○	○	○	○	○	○	○	○
We expect ... to build our image/reputation	○	○	○	○	○	○	○	○	○	○	○	○
We expect ... to support our risk management	○	○	○	○	○	○	○	○	○	○	○	○
We expect ... to save costs	○	○	○	○	○	○	○	○	○	○	○	○
We expect ... to create new products	○	○	○	○	○	○	○	○	○	○	○	○
We expect ... to create new markets	○	○	○	○	○	○	○	○	○	○	○	○

E2 Innovation for ecological sustainability

Explanation

Incremental innovation generally involves modest technological changes and builds upon existing knowledge and resources which enhances a firm's competencies.
Radical innovation generally involves large technological advancements and builds upon new knowledge and resources which makes obsolete existing competencies.

Please indicate whether you agree with the following statements	Strongly disagree				Strongly agree	Don't know
We believe that incremental sustainability innovation is not enough to maintain competiveness	○	○	○	○	○	○
We encourage our employees to pursue innovation with a focus on sustainability	○	○	○	○	○	○
We attempt to achieve radical sustainability innovation	○	○	○	○	○	○

E2 **Innovation for ecological sustainability (continued)**

What are typical measures and actions you take to focus on radical sustainability innovation?

What is the current percentage of incremental innovation of overall innovation?

What is the current percentage of radical innovation of overall innovation?

E3 **Other issues related to R&D for ecological sustainability**

Please indicate whether you agree with the following statements	Strongly disagree				Strongly agree	Don't know
We design our products with the sustainability of the manufacturing process in mind	○	○	○	○	○	○
We design our products so that they save energy during use	○	○	○	○	○	○
We design our products so that they consume less materials during use	○	○	○	○	○	○
We design our products so that they generate less emission during use	○	○	○	○	○	○
We design our products so that they generate less waste during use	○	○	○	○	○	○
We design our products so that their recycling is facilitated after their use	○	○	○	○	○	○
We believe that design for sustainability is important in R&D activities	○	○	○	○	○	○
Our R&D frequently discusses with our manufacturing unit to make our products more sustainable	○	○	○	○	○	○

F Manufacturing in the light of ecological sustainability

F1 **Manufacturing in the light of ecological sustainability - general information**

Please indicate whether you agree with the following statements	Strongly disagree				Strongly agree	Don't know
We have projects in place to reduce energy consumption in our manufacturing processes	○	○	○	○	○	○
We have projects in place to reduce materials consumption in our manufacturing processes	○	○	○	○	○	○
We have projects in place to reduce emissions in our manufacturing processes	○	○	○	○	○	○
We have projects in place to reduce waste in our manufacturing processes	○	○	○	○	○	○
We aim to increase the share of renewable energy used in our manufacturing processes	○	○	○	○	○	○
We aim to increase the share of renewable materials used in our manufacturing processes	○	○	○	○	○	○
Saving costs is the main driver to make our manufacturing processes more sustainable	○	○	○	○	○	○
We don't produce sustainable products because the extra costs for new manufacturing technologies is too high	○	○	○	○	○	○
We don't consider sustainability in manufacturing because the extra costs for new manufacturing technologies is too high	○	○	○	○	○	○
We constantly try to adopt tighter sustainability standard certifications	○	○	○	○	○	○

Which sustainability standard certifications have you put in place?

F2 **Supply chains in the light of ecological sustainability**

Please indicate whether you agree with the following statements

	Strongly disagree				Strongly agree	Don't know
Cooperation with partners of our supply chain helps our processes to become more sustainable	○	○	○	○	○	○
Cooperation with partners of our supply chain helps our products to become more sustainable	○	○	○	○	○	○
We select suppliers according to their commitment to sustainability	○	○	○	○	○	○
We select logistics providers according to their commitment to sustainability	○	○	○	○	○	○
Customers increasingly seek to get transparency of our entire supply chain	○	○	○	○	○	○
We have insights into sustainability initiatives of our direct suppliers (1st tier)	○	○	○	○	○	○
We have insights into sustainability initiatives of our 2nd tier suppliers	○	○	○	○	○	○
We have insights into sustainability initiatives of our 3rd tier suppliers	○	○	○	○	○	○
We actively seek to make our supply chain more transparent in terms of sustainability (such as energy used, CO2 emissions etc)	○	○	○	○	○	○
Compliance with sustainability standards in the supply chain becomes more important	○	○	○	○	○	○
We experience high barriers when attempting to cooperate with other players in the supply chain in order to jointly achieve better sustainability performance	○	○	○	○	○	○

Which are these barriers?

G The business case of ecological sustainability

G1 **Turnover and EBIT**

Please fill in the required information for the following periods

- Please quantify your company's total turnover:

  Currency: | 2007: | 2008: | 2009:

- Please quantify your company's EBIT:

  Currency: | 2007: | 2008: | 2009:

- Please quantify the approximate share in % of turnover attributable to your company's ecological sustainability initiatives:

  2007: | 2008: | 2009:

- Please quantify the approximate share in % of EBIT attributable to your company's ecological sustainability initiatives:

  2007: | 2008: | 2009:

Please indicate the period which is most relevant to the following statements

	1 year	3 years	5 years	10 years	Don't know
We expect the contribution of sustainability initiatives to turnover to increase over the next ...	○	○	○	○	○
We expect the contribution of sustainability initiatives to EBIT to increase over the next ...	○	○	○	○	○

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G2 **Key Performance Indicators (KPIs) for ecological sustainability**

Please indicate whether you agree with the following statements

	Strongly disagree				Strongly agree	Don't know
We have identified appropriate Key Performance Indicators (KPIs) for sustainability	○	○	○	○	○	○
We use other KPIs for sustainability than what is commonly used in our industry	○	○	○	○	○	○
Which KPIs for sustainability do you use?						
Our KPIs for sustainability are formulated and embedded centrally for all business units	○	○	○	○	○	○
We use specific KPIs for sustainability for different product lines	○	○	○	○	○	○
We validate our KPIs for sustainability regularly	○	○	○	○	○	○
We have measurable goals in terms of our sustainability performance in place	○	○	○	○	○	○
We take disciplined counter-measures if we don't achieve our targets in term of sustainability	○	○	○	○	○	○
Our KPIs have generally improved since introduction	○	○	○	○	○	○

G3 **Spending for ecological sustainability initiatives**

Please indicate whether you agree that the following aspects help you to internally justify spending on sustainability initiatives

	Strongly disagree				Strongly agree	Don't know
Product differentiation	○	○	○	○	○	○
Image/reputation	○	○	○	○	○	○
Risk management	○	○	○	○	○	○
Cost savings	○	○	○	○	○	○
Increasing turnover	○	○	○	○	○	○
Increasing EBIT	○	○	○	○	○	○
Creating new products	○	○	○	○	○	○
Creating new markets	○	○	○	○	○	○

Please specify, which other internal barriers to sustainability strategy exist.

What is the percentage of your products that are less than 5 years old?

Of your products that are less than 5 years old, what is the percentage with sustainability considerations integrated?

Of your products that are less than 5 years old with sustainability considerations integrated, what is the share of radical innovation?

What is R&D spending as a percentage of turnover?

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G4 **Future challenges in the light of ecological sustainability**

Please indicate whether you agree that the following aspects will be an important future driver of sustainability

	Strongly disagree				Strongly agree	Don't know
Meeting tighter regulatory standards	○	○	○	○	○	○
Meeting higher customer requirements	○	○	○	○	○	○
Meeting more stringent values and norms in society	○	○	○	○	○	○

Which future driver of sustainability do you expect to become most important to your firm?

G5 **Competitive comparison in the light of ecological sustainability**

Please indicate whether you agree that the following aspects differentiate your firm from competitors with regard to sustainability ...

	Strongly disagree				Strongly agree	Don't know
Sustainability is integrated in our overall strategy	○	○	○	○	○	○
Our management is in favour of sustainability	○	○	○	○	○	○
Our employees are in favour of sustainability	○	○	○	○	○	○
We invest heavily into R&D for sustainability	○	○	○	○	○	○
We succeed in creating radical innovation for sustainability	○	○	○	○	○	○
We listen to our employees	○	○	○	○	○	○
We buy market research on sustainability	○	○	○	○	○	○
We do market research on sustainability	○	○	○	○	○	○
We are well embedded in our local community	○	○	○	○	○	○

You have reached the end of the questionnaire. Thank you very much for taking the time to complete it.
We'll send you an in-depth anonymous report containing the results of all partaking companies free of charge in early 2010.

To submit this questionnaire simply click on "Submit" on the bottom of this page.

If you have previously saved the questionnaire there will be an error message.
In this case do as follows: Save the completed questionnaire as PDF document and email the file to: andreas.hinz@unisg.ch

Submit Reset

Questions for telephone interview

1. Current sustainability issues

- Which are the challenges in terms of sustainability you are keenest to solve?

2. Dimensions of sustainability and innovation

- Which initiatives do you think are needed to progress on the sustainability dimension?
- Which initiatives do you think are needed to progress on the innovation dimension?
- Have you started with these initiatives?
- What is an example of an incremental innovation in your firm?
- What is an example of a radical innovation in your firm?
- Why do you define it as radical innovation?
- What is its impact on sustainability?

3. Business case for sustainability

- How do you create your business case for sustainability and what does it look like (e.g. characteristics, motivation, processes, etc.)?
- What is the impact of the sustainability theme on your investment decisions?

4. Supply chain

- How do you manage sustainability performance of your 2nd tier suppliers and the ones further upstream (e.g. standards, certifications, processes, controls, etc.)?

5. Communication

- How do you communicate your sustainability initiatives internally and externally?
- Why?

6. Sustainability KPI

- Which sustainability KPI do you use?
- How do you validate your sustainability KPI?
- Which KPI are suitable for firms with heterogeneous product spectrums?

Questions for site visit

1. Sustainability management & strategy

- "(Hi)Story of adoption": when, why and how?
- Please briefly explain your sustainability strategy and why it is important.
- Why is your sustainability management integrated centrally / de-centrally into overall strategy?
- Why is it standardised / customised for all your subsidiaries?
- Do you clearly distinguish between process and product sustainability or do you consider all aspects "holistically"?
- Which capabilities for successful sustainability management are needed to...
  - identify the drivers of the sustainability challenge?
  - understand this new information?
  - implement the chosen sustainability strategy?
- What are the differences between capabilities to deal with internal and external issues?
- How do you ensure compatibility of capabilities needed to deal with internal and external sustainability?
- What are the differences between capabilities on lower / higher hierarchical levels?
- Which pre-conditions enable the creation of these capabilities?
- Do you work actively on building new capabilities?
- How do you know which ones to focus on?

2. Business case for sustainability

- Why have you chosen your business case for sustainability?
- Do you need to acquire missing capabilities externally (consultants, researchers) or do you succeed in educating employees internally? What are the challenges?
- Do you evaluate investments in sustainability initiatives? If yes, how?

3. Sustainability KPI

- Do you develop and operationalise your own sustainability KPI and / or do you adopt existing ones? To what extent are they separated from other KPI? Are there sustainability KPI that are integrated with financial KPI?
- Which are the most important sustainability KPI you use?
- How do you distinguish between sustainability KPI on firm, departmental, project and product level? How are these connected? Do you have a system for comparing your sustainability performance with that of competitors? How do you benchmark yourself with competitors on sustainability?
- How do you communicate your sustainability KPI to external parties? How do you use facts on sustainability performance in marketing?
- Why do you use these KPI?
- How do you select these KPI?
- How do you apply them (i.e. responsibilities, frequency, management buy-in)?
- What is the overall commitment for using sustainability KPI? Compared to conventional KPI, do you feel that employees attach similar attention and weight? Is there any resistance to using them? If yes, where?
- How do you learn from the resulting information?
- Which stages of the supply / value chain do they cover?
- Do you use shared KPI with suppliers and customers?

4. Supply chain

- What is needed to increase transparency of 2nd tier suppliers and the ones further upstream?

5. Dimensions of sustainability and innovation

- Which capabilities exist on these two dimensions today?
- Which capabilities are needed for progress along both dimensions and to enlarge competitive advantage?
- Which measures need to be taken in order to build these capabilities?

Questions for follow-up interview

1. Market context

- Please describe your market context regarding sustainability.
- How relevant is sustainability in your market?
- Which stakeholders ask for sustainability initiatives?
- How do you prioritise which activities to address?

2. Sustainability drivers / stakeholder pressures

- Which particular sustainability challenges did you encounter in the past which help you to address today's challenges?
- How do you detect opportunities to address the sustainability challenge? Which specific knowledge capabilities are needed?
- How do you build understanding of sustainability drivers? Which specific knowledge capabilities are needed?
- How do you select which capabilities to invest in?

- Which supporting and hindering factors exist to develop these knowledge capabilities?
- Why are NGO among the most important drivers? What are specific expectations? How do you react? How do you build the required knowledge? What is the impact on your sustainability strategy?
- Why are shareholders among the most important drivers? What are specific expectations? How do you react? How do you build the required knowledge? What is the impact on your sustainability strategy?
- Why are customers among the most important drivers? What are specific expectations? How do you react? How do you build the required knowledge? What is the impact on your sustainability strategy?

3. Need for knowledge

- How do you assess the need for knowledge to respond to these pressures?

4. Sustainability strategy

- What exactly does sustainability mean to you?
- Why is sustainability an important topic for you?
- More internally or externally driven?
- Do you have a formally written sustainability strategy?
- How often do you revise it?
- Is the sustainability strategy on the same level as other strategies (i.e. manufacturing, marketing, etc.)?
- Where is it embedded organisationally?
- Is your sustainability strategy primarily based on proactive long-term planning or ad-hoc reaction to pressures? Why?
- How do you implement your sustainability strategy?
- Do you understand your business case for sustainability as the business-minded execution of your sustainability strategy?

5. Types of knowledge for sustainability activities

- Which types of knowledge are needed to implement your sustainability strategy (i.e. technical)?
- Which are important examples for each type?
- Do these types of knowledge already exist or do you have to build them in order to address the sustainability challenge?
- Which are examples for the ability to…
  - build new sustainability knowledge from internal sources?
  - build new sustainability knowledge from external sources?
  - coordinate sustainability knowledge internally (i.e. access internal knowledge / knowledge sharing)?
  - coordinate sustainability knowledge externally (i.e. access external knowledge / knowledge sharing)?
  - use sustainability knowledge internally (i.e. develop solution / product)?
  - use sustainability knowledge externally (i.e. selling licensing agreements)?
- Which supporting and hindering factors exist to develop these types of knowledge?

6. Sustainability knowledge building

- Which of these knowledge capabilities are most important to build, retain and apply knowledge for sustainability initiatives?
  - Proactive behaviour in sustainability management
  - Motivation for sustainability
  - Longer-term horizon
  - Diversity and inter-disciplinarity among employees
  - Readiness to challenge the status quo

    - Building alliances
    - Sustainability training and education
    - Integration of sustainability into overall strategy
- Which of the discussed drivers influence you to build, retain and apply knowledge?
- Which other knowledge capabilities are important?
- How do you select in which capabilities to invest?
- Which supporting and hindering factors exist to develop these knowledge capabilities?
- Do you encourage organisational freedom for employees to challenge established thinking and if yes, how?
- Do you engage in benchmarking to measure and compare performance of internal teams?

7. Impact of sustainability initiatives

- Which are examples for the impact of your sustainability initiatives?
- To which of the discussed drivers did they react to?

Curriculum Vitae

Name: Andreas Hinz
Date of Birth: 13 May 1977

Education

2008-2011	**University of St Gallen (ITEM), Switzerland** PhD Student Focus on Sustainability and Knowledge Management
2003-2008	**UBS Global Asset Management, Zurich, Switzerland** Various Banking, Investment and Management Courses
1999-2000	**Université de Lausanne (HEC), Switzerland** European Scholarship
1998-2002	**University of Aberdeen, UK** Master of Arts in Economic Science Focus on International Trade and Macroeconomics

Work experience

2008-2011	**University of St Gallen (ITEM), Switzerland** Research Associate Focus on Sustainability and Technology Management
2004-2008	**UBS Global Asset Management, Zurich, Switzerland** Asset Allocation & Currency Analyst, Global Investment Solutions Member of the Global Asset Allocation Committee
2003-2004	**UBS Global Asset Management, Zurich, Switzerland** Junior Key People (JKP) Program
2002-2003	**Interactyx Ltd, Aberdeen, UK** Part-time research work, Economics & MBA Education
2001	**Transconnect Consulting Group, Munich, Germany** Internship, Management Consulting
2000-2002	**University of Aberdeen, UK** Part-time work, Alumni Fundraising
2000	**BMW of South Africa Ltd, Pretoria, South Africa** Internship, Technical Purchasing & Supplier Control
1999	**BMW Group, Munich, Germany** Internship, Sales & Customer Relations