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Management of Knowledge Integration in the Development of Self-Driving Cars

PELLE HÖGNELID | DEPARTMENT OF BUSINESS ADMINISTRATION

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Purposeful Combination

Management of Knowledge Integration in the Development of Self-Driving Cars

This book offers new insights into the process by which individuals in a firm combine their knowledge to create new products and services. Typically, previous research have attempted to explain the management of knowledge integration through the perspective of how various problem characteristics make a problem more or less difficult to solve. In contrast, this study explores the strategic dimension of knowledge integration as a process of a purposeful combination of knowledge.

The study was undertaken with a case study research design, in which the single case ("Omega") was a joint venture between two participants in the automotive industry. The purpose of Omega was to develop and commercialize active safety technology for advanced driver assistance systems ('ADAS') and autonomous driving ('AD'), colloquially referred to as 'self-driving cars.' Through the analysis of the empirical material, a new mode of explanation emerged in which a firm's objectives and the circumstances for achieving these objectives are at the core of the management of knowledge integration.

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Management of Knowledge Integration in the Development of Self-Driving Cars

Pelle Högnelid

LUND UNIVERSITY

DOCTORAL DISSERTATION

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Purposeful combination: Management of Knowledge Integration in the Development of Self-Driving Cars

Abstract
Knowledge integration theory frames outputs of firm activity as a combination of multiple individuals' knowledge. Previous research have greatly advanced our understanding of the management of knowledge integration by exploring the influence of various problem characteristics. This study attempts to contribute to an alternative, more strategic, approach in which knowledge integration is treated as a goal-oriented process and defined as the purposeful combination of knowledge. Accordingly, the purpose of this study is to contribute to the understanding of how knowledge integration is influenced by the objectives of a firm.

The study was undertaken with a case study research design, in which the single case ("Omega") was a joint venture between two participants in the automotive industry. The purpose of Omega was to develop and commercialize active safety technology for advanced driver assistance systems ("ADAS") and autonomous driving ("AD"), colloquially referred to as 'self-driving cars.' A central theme in the empirical material was that individuals appeared to synthesize three thematic kinds of knowledge (technological, organizational, and commercial) to solve problems in alignment with the objectives of Omega. Moreover, this kind of knowledge typically involved references to both firm-specific and industry-specific aspects of how to manage knowledge integration. This prompted the approach of applying additional theory regarding the business idea (including business models) and industry recipe in a knowledge integration framework. The resulting analysis produced several findings which are quite novel, relative to prior research on knowledge integration. First, the study explores the knowledge-foundation of the business idea and the industry recipe. Second, the study illustrates how this kind of knowledge was applied by individuals for the purpose of solving problems in alignment with the objectives of a firm. Third, the novel concepts of 'business idea evolution' and 'industry recipe evolution' were developed to capture how such knowledge was observed to continually evolve during the Omega-case. Fourth, the approach of applying literature on the business idea, business model, and industry recipe in a knowledge integration framework was found to have benefits in both directions.

The resulting picture is a more strategic perspective on the management of knowledge integration. A conclusion from this study, therefore, is that the conventional approach of studying the influence from various problem characteristics (the 'characteristic-driven mode') needs to be complemented by an alternative mode of explaining the management of knowledge integration: the 'objective-driven mode.' In this objective-driven mode, a firm's 'strategic context' (i.e., the objectives and the circumstances for achieving these objectives) is central to the question of how and how not to integrate knowledge effectively.

Key words Knowledge integration, Combination of knowledge, Business idea, Business model, Industry recipe, Bounded rationality, Management of knowledge integration, Self-driving cars, Technological problems, Organizational problems, Commercial problems

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To mom and dad.
Thank you!

Acknowledgments

This journey started with a spirited sales pitch by Thomas Kalling. Young and gullible as I was, I took the bait, drank the Kool-Aid, and prepared myself (or so I thought) for the impending rollercoaster ride. Other budding researchers have used similar metaphors to describe the journey to become a Ph.D., and for good reason. The highs are high, and the lows are low. Especially gutting was the passing of my dear mother, Lena, in 2018, who during her illness had expressed how sad she was that she would not be there to celebrate the completion of this project. Since she loved references to music, I feel compelled to describe the completion of this journey as a kind of bittersweet symphony.

Fortunately, after the rain comes the sunshine. I would like to take this opportunity to thank everyone who has helped and supported me in the completion of this project. First, I would like to express my gratitude to my supervisors, Thomas Kalling and Matts Kärreman. Thank you both for your unwavering support and many lessons about how to conduct research. I have tried to be a good listener and apprentice. Results may have varied, but never due to a lack of respect for your wisdom and leadership. Thank you!

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Pelle Högnelid
Yomitan, Okinawa
November 18th, 2022

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1 Introduction

1.1 Introducing Knowledge Integration

1.1.1 From the forest to the living room

If you think about it, all the products and services which we consume have been subject to integration of knowledge. Consider the process leading up to the decision by a customer to purchase new furniture, such as a comfortable sofa. Upstream in this process, factor inputs such as wood and textiles have been grown and harvested by individuals who have applied their specialized knowledge to solve various problems related to the handling of this raw material. As different skills are typically required for each respective raw material, division of labor often causes individuals as well as firms to specialize, e.g., in either wood or textiles.

Specialized knowledge can be exercised through individuals' minds but also through their hands, such as in the application of a tool or the operation of advanced machinery. Moreover, such tools and machinery, for example, in a sawmill, are themselves also a product of knowledge integration by individuals. A way to think about such physical objects is that they embody knowledge about how to solve a certain problem in a way that improves the quality or efficiency of manual labor. This is particularly apparent in the case of robotics, as such physical objects have the potential to replace manual labor altogether for specific tasks.

To produce such objects requires contributions by individuals which can be referred to as 'knowledge-work,' i.e., in contrast to 'manual labor.' For example, furniture designers apply knowledge about how to manipulate the raw materials as to create a product that satisfies several criteria. Such design criteria could be that the sofa is comfortable, durable, and possible to manufacture at a cost which a certain customer segment is willing to pay. Additionally, customers' awareness of the product, i.e., which is a pre-requisite for an individual to purchase it, hinges on efforts by other knowledge-workers to market the product, such as in brick-and-mortar stores or through various media.

Note that these kinds of 'white-collar' tasks (e.g., of the designer and marketer) also can be solved with better or worse precision and productivity, i.e., just as how the raw material can be manipulated with different levels of dexterity. For example, regarding marketing, there are typically alternative offerings in the market which the customer may consider and ultimately choose to buy instead. In summary, this vignette illustrates how the finished product, which a customer decides to buy, embodies a *combination* of knowledge about how to produce this product as well as what type of product to design and market to customers.

1.1.2 Organizing knowledge integration

The distinction between ‘manual labor’ and ‘knowledge-work’ in this fictional example is instructive since it highlights that knowledge integration can be organized differently depending on the problem to be solved. Coordination of knowledge integration to solve less difficult problems can typically be solved through standardization, i.e., in terms of output, process, and so forth. Consider the assembly line, in which skilled labor of different specializations is coordinated through a production process with distinct steps, each requiring its own specialized knowledge to produce a standardized output. This type of coordination minimizes the need for mutual adjustment, i.e., between the steps of an assembly line or another type of standardized process. For example, how wood is harvested, transported, and then handled in a sawmill.

Accordingly, the need for mutual adjustment becomes more pronounced as the problems to solve are less standardized. For example, the task of designing a product or a manufacturing process. In such instances, interdependences between various problems typically require more interplay between subjects, i.e., analogous to tennis doubles. Problems that require mutual adjustment may, however, still involve little or no *creation* of knowledge (apart from residual learning about how to improve mutual adjustment between subjects). Application of specialized (existing) knowledge may be sufficient to solve many tasks, and if an individual does not have that requisite knowledge her or himself, she or he can search for it within a firm or in external sources.[1]

Consequently, it is fair to consider efforts to create new knowledge as being an even more advanced form of knowledge integration. Such instances typically require more elaborate organizational responses, compared to instances where standardization and planning can be effective mechanisms. For example, in the opening illustration, to conceive and produce the machinery in a sawmill arguably requires a different organizational process than the operations in the mill itself. A principal difference is, for example, that the machine only needs to be conceived once for it to be reproduced multiple times. This motivates significant investments in the conception of the machine, as the gains from such efforts are reaped every

[1] In our current day, the internet is an abundant source of information. Substitutes have, however, existed in the past. For example, domain-specific literature and media, conference attendance, to hire industry consultants or experts, and reverse engineering of competitor’s products.

time the machine is reproduced, as well as every time an operation with the machine is performed in the sawmill.

1.1.3 Integrating knowledge across firm boundaries

Since division of labor leads to diverse specializations among firms, new combinations of knowledge may be achieved through organizational arrangements which span firms' boundaries. Joint ventures, alliances, mergers, and acquisitions have thus historically been methods of organizing knowledge integration to produce novel combinations. Apple's investments in and partnership with Corning is an illustrative example (Molina, 2021; Tibken, 2019). Instead of Apple itself cultivating the knowledge necessary to make the 'gorilla glass' for its iPhones, Apple works closely with a leading developer and producer of durable glass and other materials for its smartphones. This supplier-arrangement (cf. 'make-or-buy') allows Apple to decrease the scope of its internal knowledge integration efforts while still benefiting from externally developed knowledge.

A second illustrative example is the acquisition of Volvo Cars Corporation by Ford Motor Company in 1999 (Bradsher, 1999; Simison et al., 1999). Volvo Cars was recognized as having deep knowledge about how to design and produce cars that were safe but suffered from being a relatively small car manufacturer (cf. 'economies of scale'). The rationale for the acquisition was hence that the knowledge at Volvo Cars would become more valuable in a different setting, such as within the significantly larger Ford Motor Company. Such 'synergies' are a recurring theme in rationales to integrate knowledge across firms' boundaries.

As a third and last illustrative example, consider the partnership between Microsoft and Nokia in 2011 (Ando & Rigby, 2013; Deutsche Welle, 2016; Microsoft, 2013; Warren, 2016). The two firms possessed deep knowledge in their respective domain, i.e., as manifested in their respective products and services. In a nutshell, the rationale for the partnership was that Microsoft needed a smartphone manufacturer to propel their smartphone operating system into the mainstream to compete with iOS by Apple and Android by Google. Nokia, in turn, needed a unique selling point versus the likes of Apple and Samsung to boost its declining sales of hardware, i.e., which they had once been a market leader in designing and producing. The new product by Nokia and Microsoft thus represented a combination of knowledge which neither firm could have produced on its own.[2]

[2] Especially considering how intellectual property ('IP') would be an obstacle.

The Microsoft/Nokia-example is also fitting since the partnership did not work out as intended.[3] This is not a surprising outcome if you consult literature on inter-firm collaboration (e.g., Bruner, 2009; Das & Teng, 1998; Malmendier & Tate, 2008; Moeller et al., 2005). Knowledge integration is hence not just a matter of how to integrate technological knowledge into new products and services but also a matter of how to organize that process and (not least in the case of Microsoft and Nokia) a matter of understanding the market in which the new, combined offering is intended to be competitive.

1.1.4 A new theoretical perspective on an old problem

The field of knowledge integration theory offers strategy researchers and practitioners an opportunity to reconceptualize the process through which firms solve problems. In simplified terms, the field originates from the seminal 1996 special issue of *Strategic Management Journal* edited by J.C. Spender and Robert M. Grant, in which the notion of knowledge got re-introduced into strategic management (Spender & Grant, 1996b). In essence, knowledge integration theory treats *knowledge* as the key productive resource in firms and considers outputs from firm activity to represent an *integration* of knowledge.[4] In the same special issue, Grant (1996b) stated *"this paper identifies the primary role of the firm as integrating the specialist knowledge resident in individuals into goods and services"* (Grant, 1996b, p. 120). Simon (1973) had previously made the same ontological argument regarding knowledge and technology:

> But to view technology in terms of machines and tangible substances is to mistake the shell for the snail, or the web for the spider. Technology is not things; it is knowledge – knowledge that is stored in hundreds of millions of books, in hundreds of millions or billions of human heads, and, to an important extent, in the artifacts themselves. Technology is knowledge of how to do things, how to accomplish human goals. (Simon, 1973, p. 1110)

The maneuver by Grant (1996b, p. 120), however, enabled an expansion of this ontological assumption to encompass all domains of firm activity, i.e., to not limit the assumption of knowledge impregnation to technology (cf. Simon, 1973). From this perspective, any product, offering, technology, organizational arrangement, business model, or other output from firm activity can therefore be understood as an integration of knowledge (Grant, 1996b; Wikström & Normann, 1994).

[3] Microsoft acquired Nokia's smartphone division for $7,2 billion dollars in 2013, only to later write off almost the entire value of the asset in 2016 after selling the manufacturing assets for merely $350 million dollars (Deutsche Welle, 2016).

[4] Knowledge integration theory can thus be considered a bifurcation of the resource-based view (cf. Barney, 1991; Peteraf, 1993).

1.2 Defining the object of study

1.2.1 Integration of knowledge as the object of study

This study considers *integration of knowledge* to be the effect which warrants explanation. An important consequence of this demarcation is that the relationship between integrated knowledge (the output of a process) and various performance measures (such as financial performance) is *beyond the scope* of this study. However, the prospect of improved financial performance can be assumed to be the motivation for why firms ultimately engage in knowledge integration.

1.2.2 Orientation and definition of knowledge integration

There are other theoretical approaches that also use the concept of knowledge to understand productive activity which, to various degrees, overlap with the phenomenon of knowledge integration. To proceed with clarity, the orientation and definition of knowledge integration to be used in this study will be briefly explained.

Zahra et al. (2020) propose that knowledge integration has two fundamental orientations: knowledge integration as a *process* and knowledge integration as a *capability*. This study treats knowledge integration as a process, where the output is perceived as an integration of knowledge (Alavi & Leidner, 2001; Berggren, Bergek, Bengtsson, & Söderlund, 2011; Carlile, 2004; Szulanski, 1996; Wikström & Normann, 1994; Zahra et al., 2020).[5]

In terms of definition of knowledge integration, this study is grounded in the approach by Okhuysen and Eisenhardt (2002), which portrays knowledge integration as a process of combination and the suggestion by Berggren, Bergek, Bengtsson, and Söderlund (2011) that knowledge integration can be understood as a 'goal-oriented process.' Building on these two approaches, Tell et al. (2017a) defined knowledge integration as *"the purposeful combination of specialized and complementary knowledge to achieve specific tasks"* (Tell et al., 2017a, p. 5).

This definition notably raises a problem to be solved (cf. 'specific tasks') which is derived from an objective of a firm (cf. 'purposeful') into the core of knowledge integration. As will become apparent in the problematization of previous literature (see 1.4), the inclusion of 'purposeful' in this definition of knowledge integration is quite consequential (Berggren, Bergek, Bengtsson, & Söderlund, 2011; Tell et al., 2017a).

[5] This orientation will be explained further in Chapter 2. For example, although integration of knowledge will be treated as the output of a process, the mode of explanation will predominantly focus on the influence of various variables.

1.2.3 The scope of knowledge integration in this study

There are arguably three features which make knowledge integration distinct compared to other knowledge-based or resource-based theories:

- An explicit recognition of outputs from a firm's activity as an *integration of multiple individuals' knowledge* (Grant, 1996b; Okhuysen & Eisenhardt, 2002; Tell et al., 2017a; Wikström & Normann, 1994);
- An emphasis on *individual* knowledge, in contrast to theories which focus on *organizational* knowledge (Grant, 1996a, 1996b); and
- A *dynamic* view of knowledge, in contrast to theories which perceive knowledge as a *static* kind of asset, capital, or resource (Spender, 1996).

The first feature is noteworthy since it arguably makes knowledge integration theory distinct, i.e., relative similar theoretical concepts that also employ a knowledge-perspective. Also notable, the second feature positions individuals as both the main repository of existing knowledge and the creators of new knowledge (Grant, 1996a, 1996b). This feature hence answers the question of origin for organizational-level knowledge (Kogut & Zander, 1992).

However, to apply a too strict scope increases the risk of not including relevant research that uses other labels or terms to explain phenomena which essentially correspond to the three features of knowledge integration. A quite generous scope will thus be applied in this study.[6] Several established theoretical approaches to strategy and management will be treated as being outside the scope of knowledge integration.[7] The most difficult demarcation concerns contributions that appear to deal with knowledge integration, but which instead use the label of 'capabilities.'[8] Such contributions will be included or excluded from the scope of knowledge

[6] The following knowledge perspectives will be treated as within the scope of knowledge integration, if/when the meaning of the individual contribution sufficiently matches the outlined three features which make knowledge integration distinct: knowledge transformation (Carlile, 2004; Carlile & Rebentisch, 2003; Sanchez & Mahoney, 1996), knowledge transfer and sharing (Szulanski, 1996; von Hippel, 1990, 1994), knowledge conversion (Nonaka, 1994; Nonaka & von Krogh, 2009), knowledge utilization, application, or acquisition (Kalling, 2003b), knowledge creation (Nonaka, 1994; Nonaka et al., 2000; Nonaka & Toyama, 2003; von Krogh, 1998), knowledge partitioning (Takeishi, 2002; Zirpoli & Camuffo, 2009), problem-solving (Nickerson & Zenger, 2004; Postrel, 2017), knowledge management (Demarest, 1997; Kalling, 2003b; Postrel, 2002; Tsai & Ghoshal, 1998), and the firm as a knowledge system (Tsoukas, 1996; Wikström & Normann, 1994).

[7] For example, organizational learning (March, 1991; Huber, 1991), information processing (Galbraith, 1974), absorptive capacity (Cohen & Levinthal, 1990), knowledge absorption (Foss et al., 2005), organizational routines (Nelson & Winter, 1982), and dynamic capabilities (Teece et al., 1997; Eisenhardt & Martin, 2000). Noteworthy, the capabilities-concept is currently the most established rival explanation versus knowledge integration.

[8] For example, contributions on *integrative capabilities* (Henderson, 1994; Verona, 1999; Mitchell, 2006; Brusoni et al., 2005), *combinative capabilities* (Kogut & Zander, 1992; De Boer et al., 1999) and *organizational capability* (Grant, 1996a, 1996b).

integration on a case-by-case basis, depending on conformance with the three features which were outlined above. Therefore, contributions on capabilities or dynamic capabilities which do not conform with the features of knowledge integration will be treated as being out of scope, i.e., as part of the distinctly different literature on capabilities (e.g., Teece et al., 1997; Winter, 2003). While cumbersome, this case-by-case approach ensures that the meaning of knowledge integration remains intact.

1.3 Empirical problem

Naturally, other variables than knowledge integration also influence the financial performance of firms. However, the management of knowledge integration is arguably essential for the achievement of most conceivable objectives. 'Management' can be defined as the *"judicious use of means to accomplish an end"* (Merriam-Webster Dictionary, 2022a). In the context of knowledge integration, 'management' hence refers to responses (cf. 'means'), such as acts or interventions, with the intention of achieving that end.

An important assumption for the relevance of studying knowledge integration is that better or worse management of a process is likely to lead to different outcomes.[9] An often-unspoken feature of firm activity which reinforces this depiction is that it is not advantageous in a competitive context to expend more efforts to produce the same output as competitors, i.e., as that would lead to higher costs (*ceteris paribus*). However, less effortful mechanisms for integration of knowledge, while cheaper, are not automatically superior. To not invest sufficient efforts can result in a failure to integrate knowledge, i.e., to not accomplish the 'end' in question. For example, to *not* solve a technological problem or to *not* persuade a customer to buy a product.

Logically, the appropriateness of responses can be motivated based on the *efficiency*[10] of the process to integrate knowledge and the *effectiveness*[11] of outputs. The management of knowledge integration is therefore exposed to constraints, in terms of time and resources (M. T. Hansen, 1999; Mitchell, 2006; Szulanski, 1996).

[9] Contingency theory (e.g., Lawrence & Lorsch, 1967; Thompson, 1967; Woodward, 1958, 1965), which proposes that specific external and internal conditions make certain responses for how to organize internally more or less appropriate, is sometimes credited as the origin of this assumption within knowledge integration theory (De Luca & Atuahene-Gima, 2007; Enberg, 2007; M. T. Hansen, 1999; Tell, 2011).

[10] That is, the degree to which time and resources are not wasted (Grant, 1996b). The underlying logic is that it is superior to be able to produce the same good or service at a lower cost than competitors.

[11] That is, the degree to which the integrated knowledge solves a focal problem (Berggren, Bergek, Bengtsson, & Söderlund, 2011; Nickerson & Zenger, 2004). The underlying logic is that at the same cost, a better solution to a problem is superior to an inferior solution.

Moreover, the notion of *product-market fit* illuminates the symbiotic relationship between efficiency and effectiveness. The viability of a good or service in a market economy is not solely determined by its capacity to solve a problem (i.e., the effectiveness of the output) but is exposed to what it would be worth for a potential buyer to solve the problem. The cost of the good or service (i.e., which depends on the efficiency of the process), thus, simultaneously influences the viability of providing the good or service to the market (cf. *cost-benefit*).

In summary, there is an abundance of ways in which firms can fail to achieve its objectives. What can be learned about how firms can improve their practices for management of knowledge integration, hence, constitutes an empirical problem which warrants attention.

1.4 Theoretical problem

1.4.1 The established view: Problem characteristics

Most established contributions to knowledge integration take their departure in an approach which is inspired by, albeit different from, contingency theory. In short, this literature examines the degree of difficulty of problems and appropriateness of responses (cf. 'mechanisms' for integration) through the perspective of *characteristics* of the particular problem to be solved (Berggren et al., 2017; Carlile, 2002, 2004; Grandori, 2001; Okhuysen & Eisenhardt, 2002; Szulanski, 1996; Tell, 2011; Van de Ven & Zahra, 2017; Zahra et al., 2020; Zollo & Winter, 2002). At its core, this framework suggests that effective management of knowledge integration depends on the problem's characteristics that are in play (Grandori, 2001; Grant, 1996b; Nickerson & Zenger, 2004; Tell, 2011). Largely, there is a consensus regarding the prevalence of three major categories of characteristics:

- *Task characteristics*, such as complexity and uncertainty (Carlile & Rebentisch, 2003; Enberg, 2007; Grandori, 2001; Nickerson & Zenger, 2004; Perrow, 1970; Takeishi, 2002; Tell, 2011; Zollo & Winter, 2002);
- *Knowledge characteristics*, such as depth of knowledge and tacitness (Brusoni et al., 2005; Carlile, 2002; Grant, 1996b; Nonaka, 1994; Postrel, 2002; Spender, 1996, 1998; Szulanski, 1996; Tell, 2017); and
- *Relational characteristics*, such as trust between subjects and influence from history (Alavi & Tiwana, 2002; Berggren et al., 2017; Bhandar et al., 2007; Newell et al., 2004; Szulanski et al., 2004; Tsai & Ghoshal, 1998; Zahra et al., 2020).

Using these problem characteristics as a framework, it becomes possible to distinguish between simple and difficult knowledge integration. Clearly, there are many situations in which efforts to integrate knowledge are characterized by moderate challenges, where less intricate or effortful responses can be expected to be sufficient. For example, planning and sequencing are generally efficient responses to problems without considerable uncertainty (Grant, 1996b; Lindkvist et al., 1998). Similarly, routines are generally a cost-efficient mechanism for tasks that have high frequency and low heterogeneity (Enberg, 2007; Zollo & Winter, 2002). However, problems which are valuable for a firm to solve are rarely simple. Furthermore, efforts to solve difficult problems are unlikely to be managed effectively through knowledge integration mechanisms that are appropriate for less advanced tasks. Thus, as a general pattern, the *costs* of responses are expected to increase as the difficulty of a problem increases (Carlile, 2002; Grandori, 2001; Grant, 1996b; Okhuysen & Eisenhardt, 2002; Tell, 2011; Van de Ven & Zahra, 2017; Zahra et al., 2020).

Previous research have made significant progress in terms of our understanding of these dynamics, i.e., how effective management of knowledge integration depends on various problem characteristics. However, this literature can also be criticized for adopting a perspective which is too narrow, relative to the scope of the empirical problem (see 1.3). Specifically, can the effectiveness of responses really be determined *solely* based on such problem characteristics? Hence, are two problems identical if they have identical characteristics, such as if they share an identical degree of complexity, require an identical depth of knowledge, and so forth?

Arguably, such previous research have refrained from problematizing the extent to which the purpose of solving a problem influences how to manage that process. For any practitioner, this myopia violates an intuitive feature of business and management: *the objective matters.* Therefore, the circumstances for achieving this objective cannot be ignored. Arguably, there are differences between industries and between firms within those industries which are *not* captured through the framework of problem characteristics (i.e., task, knowledge, and relational). Rather, such differences depend on what different firms intend to accomplish. For example, the emphasis on technological development, product development, product manufacturing, service design, logistics, marketing, recruitment, and so forth, varies between industries and varies between firms in the same industry. This is not only logical but quite established in research outside the scope of knowledge integration theory, such as in theory on industrial organization and logics (e.g., Porter, 1980; Spender, 1989).

1.4.2 Toward a more strategic perspective on knowledge integration

1.4.2.1 Purposeful combination

That firms have different problems to solve depending on objectives and circumstances is at the heart of the notion of *strategy*. This is another way of framing the activity of problem-solving in firms, i.e., compared with the established view presented in 1.4.1. This framing is, for example, reflected in the notion of *strategic intent* by Hamel and Prahalad (1989), such as to be first at putting a man on the moon or to overthrow the dominant competitor in an industry.

Although this framing is not emphasized in mainstream knowledge integration theory, there is support in previous literature to adopt this kind of strategic perspective on knowledge integration. Consider the definition of knowledge integration as the *purposeful combination* of knowledge that was introduced in 1.2.2. This definition builds on the views of Berggren, Bergek, Bengtsson, & Söderlund (2011) of knowledge integration as a 'goal-oriented process.' Upon further reading, a similar suggestion was detected in other contributions to knowledge integration, which reference notions such as 'objectives' (e.g., De Luca & Atuahene-Gima, 2007; Grandori, 2001; Nickerson & Zenger, 2004; Nonaka, 1994; Spender, 1996; Tiwana, 2004) and 'goals' (e.g., Brusoni et al., 2021; Enberg, 2007; Johansson et al., 2011; Nonaka et al., 2000; Tsoukas & Vladimirou, 2001; Willem et al., 2008).

A second cue to explore the strategic dimension of knowledge integration is theoretical concepts that *implicitly* reference 'that' which a firm is attempting to achieve (i.e., versus explicit references to objectives or goals). For example, the concept of 'satisficing' (Demarest, 1997; Simon, 1947, 2018; Winter, 2000) begs the question: satisficing in relation to what? In Simon (1947, p. 6), satisficing is positioned in relation to the objectives which an organization is attempting to achieve. Similarly, Winter (2000) positioned satisficing in relation to the 'aspiration' of the organization (cf. Hamel & Prahalad, 1989).

A third argument for an interest in objectives is the *logical argument* that firms' problems to solve do not appear from thin air but are a product of whatever a firm is supposed to accomplish. Hence, problems are inherently relative to a kind of success criteria.[12] While this argument has not been stated outright in previous literature on knowledge integration, perhaps because it goes without saying, it is nonetheless worth spelling out in this instance. For example, this logic appears to permeate the 'problem-solving perspective' by Nickerson and Zenger (2004).

[12] Compare with the definition of 'management' in 1.3 as the *"judicious use of means to accomplish an end"* (Merriam-Webster Dictionary, 2022a).

1.4.2.2 Objectives which require knowledge integration

The approach to knowledge integration as a 'purposeful combination' of knowledge naturally positions the objectives and purposes of a firm as central. Regarding our understanding of objectives that require knowledge integration, there appears to be several generic objectives in the literature, which are common across different firms.

First, to deliver an *offering* to the market is a fundamental function of a firm, as the offering is both the basis for how revenue is generated as well as how costs are incurred (Wikström & Normann, 1994). For example, to produce and deliver an offering to the market may require knowledge integration to solve problems related to technological development, new product development ('NPD'), product manufacturing, service design, logistics, marketing, and so forth (Carlile, 2002; Eslami & Lakemond, 2016; Melander & Tell, 2014; Ordanini & Parasuraman, 2011; Salunke et al., 2019; Takeuchi & Nonaka, 1986).

To accomplish this within the constraints of *time* and *resources* is a second type of objective which firms simultaneously appear to consider. Temporal constraints (Brusoni & Prencipe, 2001; Dabhilkar & Bengtsson, 2011; Grant, 1996a; Mitchell, 2006) penetrate knowledge integration because most business opportunities are exposed to the involvement of other parties ('competitors'), who are also attempting to reap the economic benefits associated with the resolution of a focal problem.[13] Resource constraints (M. T. Hansen, 1999; Ravasi & Verona, 2001; Szulanski, 1996; Tiwana, 2004), which can also be derived from competition and markets, effectively means that a firm must manage the integration process within the boundaries of what its customers are willing to pay.[14]

A third type of generic objective is to capture *indirect* benefits of engaging in knowledge integration to solve problems. The most apparent such indirect benefit is *learning*, i.e., accumulation of knowledge (cf. Argyris & Schön, 1978; March, 1991). Although learning may not directly translate into benefits for the other two generic objectives, i.e., improvements in the offering-dimension or gains in the temporal and resource dimensions, learning may still be essential to ensure future competitiveness. For example, to accumulate knowledge about a novel technology may facilitate the transformation of a firm's offering.

1.4.2.3 Types of problems requiring combination of knowledge

A layer beneath objectives are the *problems* which need to be solved, i.e., for an objective to be achieved (see 1.4.2.1). It is hence relevant to consider what is currently known about different *types of problems* that can be subject to a 'purposeful combination' (Berggren, Bergek, Bengtsson, & Söderlund, 2011; Tell

[13] For example, due to competitive structures favoring *first mover advantages* (Dierickx & Cool, 1989; Lieberman & Montgomery, 1988) or *network externalities* (Katz & Shapiro, 1985).

[14] See, for example, the theory on *resource allocation* (Bower, 1970; Burgelman, 1983).

et al., 2017a). The review of knowledge integration literature revealed that there are three thematic categories:

- *Technological* problems (e.g., Brusoni & Prencipe, 2011; Sanchez & Mahoney, 1996; Tanriverdi & Venkatraman, 2005; Tiwana, 2004);
- *Organizational* problems (e.g., Ghoshal et al., 1994; Ravasi & Verona, 2001; Szulanski, 1996; Tsoukas & Vladimirou, 2001); and
- *Commercial* problems (e.g., Burgers et al., 2008; Ceci & Prencipe, 2017; Demarest, 1997; Eslami & Lakemond, 2016).

However, it should be made clear that these three types of problems have not previously been discussed in these terms, i.e., a categorization of types of problems which are derived from the objectives of a firm. Rather, it is fair to treat these contributions as individual pieces of a previously overlooked puzzle. In some of these contributions, one or multiple types of problems are directly discussed as part of the theoretical problem (e.g., Burgers et al., 2008; De Luca & Atuahene-Gima, 2007; Eslami & Lakemond, 2016; Tiwana, 2004). Often, however, these types of problems are merely part of a 'backdrop' against which the problem's characteristics are examined (see 1.4.1). For the purpose of this study, the former type of contribution is clearly more relevant.

A central pattern in this literature is that the resolution of each type of problem is expected to require the corresponding type of knowledge (Burgers et al., 2008; Eslami & Lakemond, 2016; Ravasi & Verona, 2001; Tanriverdi & Venkatraman, 2005; Tiwana, 2004). Conversely, a specific type of knowledge (such as technological knowledge), however deep, is not sufficient to solve other types of problems (i.e., organizational or commercial problems) in an effective way. This pattern is also a general assumption underpinning knowledge integration theory (Grant, 1996b; Tell et al., 2017a), such as references to division of labor and specialization (cf. Smith, 1776).

Another argument for imposing this categorization is that there are reasons to suspect there are differences between commercial and organizational problems, which deal with *social* phenomena, versus technological problems, which deal with *natural* phenomena. One such difference may be the requisite accuracy of the respective type of knowledge about how to solve a type of problem. Demarest (1997), for example, stated: *"The goal of commercial knowledge is not truth, but effective performance: not 'what is right' but 'what works' or even 'what works better' where better is defined in competitive and financial contexts"* (Demarest, 1997, p. 375).[15]

Another way of framing this difference is that social phenomena invariably depend on the peculiarities of human beings, such as bounded rationality (Simon, 1947,

[15] Cf. satisficing (Simon, 2018; Winter, 2000), i.e., in contrast to 'optimizing.'

1956; Tversky & Kahneman, 1974) and social construction (Alvesson & Sköldberg, 2009; Burrell & Morgan, 1979). In contrast, technological problems are not malleable to social construction but demand that solutions adhere to the laws which govern the natural world. Such differences and their potential implications for the management of knowledge integration are arguably not explained to a satisfying degree in the mainstream literature (Alavi & Leidner, 2001; Carlile, 2002; Grandori, 2001; Grant, 1996a, 1996b; J. C. Huang & Newell, 2003; Mitchell, 2006; Nonaka, 1994; Okhuysen & Eisenhardt, 2002; Pisano, 1994; Szulanski, 1996; Tell, 2011).

1.4.3 Problems in current literature

Following the perspective which was outlined in 1.4.2, literature on knowledge integration (see scope in 1.2.3) was reviewed to explore areas for problematization. Three main problems were identified that support the purpose of this study.

1.4.3.1 The commercial dimension of knowledge integration

The first and most pressing issue which the review uncovered is the relative lack of research on knowledge integration to solve *commercial* problems, i.e., versus technological and organizational problems. In the reviewed literature, commercial problems appear to often be trivialized as a given assumption of the process, for example, to capture 'market opportunities' (Kogut & Zander, 1992, p. 385). To treat the commercial dimension of knowledge integration so inconsequentially appears to be a fallacy, given how central the resolutions of commercial problems are for most conceivable objectives that a firm might have.

Several contributions were identified, which *mention* commercial problems and knowledge (Åkerman, 2015; Alavi & Leidner, 2001; Court, 1997; Frishammar et al., 2012; Melander & Tell, 2014; Nonaka, 1994; Ramesh & Tiwana, 1999; Tanriverdi & Venkatraman, 2005; Zhou & Li, 2012). This is, however, setting the bar very low. Looking more closely, only a few of these contributions appear to actually relate questions of commercial problems and knowledge to the problem of knowledge integration management (Burgers et al., 2008; De Luca & Atuahene-Gima, 2007; Demarest, 1997; Eslami, 2017; Eslami & Lakemond, 2016; Sanchez, 1999; Tiwana, 2004). For example, when/where in the business development or product development process can that combination of commercial knowledge with technological knowledge render better outputs (Burgers et al., 2008; De Luca & Atuahene-Gima, 2007; Eslami & Lakemond, 2016). Even among such contributions, the problematization of how firms' objectives influence knowledge integration (i.e., the point of departure for this study, see 1.4.2) is largely nonexistent. A clear symptom which demonstrates this point is that there are no literature reviews on the topic of commercial aspects and management of knowledge integration.[16]

A potential explanation for this weakness in our understanding of knowledge integration is that most previous contributions regarding knowledge integration tend to focus on the characteristics of problems to be solved, see 1.4.1 (e.g., De Luca & Atuahene-Gima, 2007; Grant, 1996a, 1996b; Nonaka, 1994; Tanriverdi & Venkatraman, 2005). This trajectory may be due to the roots of knowledge integration in the resource-based view (cf. Barney, 1991; Peteraf, 1993), which emphasizes *endogenous* sources of value creation. The flipside of this disposition is that previous research on knowledge integration have tended to not emphasize the influence of *exogenous* aspects and actors (such as customers and competitors) in the problem-solving process.[17]

Looking outside the scope of knowledge integration literature, there are several established theories which address such exogenous aspects, for example, the competitive forces-perspective (Porter, 1980, 1991), work on industry logics (Johansson, 2008; Prahalad & Bettis, 1986; Spender, 1989), and the business model-concept (Amit & Zott, 2001; Chesbrough & Rosenbloom, 2002; Hedman & Kalling, 2003; Johnson et al., 2008; Osterwalder et al., 2005). Thus, it was an interesting finding from the literature review that barely any references to these rather ubiquitous building blocks of strategy theory were found in previous research on knowledge integration.

To be fair, there may be good reasons which explain how and why the knowledge integration field has evolved along its current path. For one, previous research have arguably been tremendously productive in terms of expanding our understanding of how to manage knowledge integration (see 1.4.1). In any case, our present understanding of how the management of knowledge integration relates to the dynamics of commercial problems is quite incomplete and is thus a question which can and should be explored further.

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[16] Eslami (2017), who reviewed literature on ‘customer collaboration,’ is almost an exception. However, the scope of commercial problems is more comprehensive than this narrow inquiry, both in terms of the customer-dimension (e.g., knowledge about other aspects, such as sales and relationship management) and other commercial dimensions (e.g., knowledge about suppliers and the competition).

[17] There are, however, some researchers who have done interesting work on dynamics with suppliers (Brusoni et al., 2001; Ceci & Prencipe, 2017; Dabhilkar & Bengtsson, 2011; Melander & Tell, 2014; Takeishi, 2002). Unfortunately, such contributions tend to focus on the internal mechanics of the integration process (i.e., problem characteristics, see 1.4.1), rather than on knowledge about the commercial dynamics in play.

1.4.3.2 Interdependencies between categories of problems

A second weakness concerns our knowledge about *interdependencies* between the three types of problems (i.e., technological, organizational, and commercial) which require knowledge integration. The general relevance of interdependencies as a source of complexity is very established in the literature on knowledge integration (Carlile & Rebentisch, 2003; Enberg, 2007; Grandori, 2001; Grant, 1996b; Tell, 2011, 2017; Zollo & Winter, 2002). However, such previous research on various kinds of complexity do not typically apply the categorization of problems that was outlined in 1.4.2.3. There is, hence, an opportunity to apply the mentioned work on complexity within this less explored perspective on knowledge integration (cf. 1.4.2).

Within the reviewed literature which references the different types of problems, most of the contributions identified merely discuss *one* of the three types of problems or knowledge.[18] Due to this limitation in scope, these contributions do not deal with interdependencies *between* types of problems. Several contributions were identified which mention multiple categories of problems and knowledge.[19] However, the depth and relevance of these contributions for the inquiry in question (i.e., how the objectives of a firm may influence knowledge integration) vary significantly.

Within this body of work (cf. puzzle-metaphor in 1.4.2.3), there are however contributions which indicate that there might be more to the interrelationship between the three categories of problems and knowledge than what has previously been problematized. For example, Tanriverdi and Venkatraman (2005) examine potential synergies from the three types of knowledge in their work on multi-business firms.[20] Salunke et al. (2019) propose that synergies are more likely in instances with diverse knowledge inputs, such as technological and market knowledge. Burgers et al. (2008) explore the interplay between technological development and business development. De Luca and Atuahene-Gima (2007) explore the role of market knowledge in product innovation performance. Tiwana (2004) studies the effects of integrating 'business application domain knowledge' in the development process for software technology. Court (1997) and Ramesh and Tiwana (1999) both approach 'procedural knowledge' (cf. organizational

[18] (For example, Åkerman, 2015; Brusoni & Prencipe, 2011; De Luca & Atuahene-Gima, 2007; Demarest, 1997; Enberg, 2007; Eslami, 2017; Eslami & Lakemond, 2016; Jeong et al., 2017; Miles et al., 1997; Tsoukas & Vladimirou, 2001; Verona, 1999; L. Wang et al., 2020; Zhou & Li, 2012)

[19] Of which, some mention two out of three categories of problems and knowledge (e.g., Brusoni et al., 2001; Brusoni & Prencipe, 2011; Burgers et al., 2008; De Luca & Atuahene-Gima, 2007; Galbraith, 1990; Salunke et al., 2019; Sanchez, 1999; Sanchez & Mahoney, 1996; Tiwana, 2004) and some mention all three categories of problems and knowledge (e.g., Alavi & Leidner, 2001; Court, 1997; Frishammar et al., 2012; Melander & Tell, 2014; Ramesh & Tiwana, 1999; Rundquist, 2014; Tanriverdi & Venkatraman, 2005; Xi et al., 2020).

[20] Compare with complementarity of resources (Amit & Schoemaker, 1993; Barney et al., 2011; Harrison et al., 2001; Milgrom & Roberts, 1995; Song et al., 2005).

knowledge) as a combination of 'general knowledge' (cf. commercial knowledge) and 'domain-specific knowledge' (cf. technological knowledge). Furthermore, the interplay between a modular product architecture and organizational arrangements is discussed by several authors (Brusoni et al., 2001; Brusoni & Prencipe, 2011; Sanchez & Mahoney, 1996), and the interplay between product modularity and marketing is discussed by Sanchez (1999).

In addition to these theoretical contributions, there are empirical cues which reinforce the suspicion that the achievement of objectives may involve problems with interdependencies across multiple categories (i.e., technological, organizational, and commercial). Consider, for example, the notion of *cost-benefit* trade-offs (L. Bengtsson et al., 2017; Grandori, 2001), such as when the way to solve a technological problem depends on what the solution is worth for a potential customer (see 1.3).

Moreover, consideration of interdependencies across all three categories of problems is a feature in practical methodologies for product development, such as *agile* (Annosi et al., 2020; Beck et al., 2001; Bredin et al., 2017; Okhuysen & Eisenhardt, 2002; Takeuchi & Nonaka, 1986) and *stage-gate*[21] (Cooper, 1990, 2008; Cooper & Sommer, 2016). Specifically, it is common practice to consider all three types of problems when assessing the business case or strategic fit of a development effort. For example, the potential commercial impact (e.g., attracting new customers or increasing the spending by current customers), organizational constraints (e.g., bottlenecks such as the bandwidth of key individuals), and technological feasibility (e.g., dependence on efforts to solve other technological problems). More importantly, these dimensions are typically not analyzed standalone, but *relative* to the objectives which the focal effort is intended to achieve or contribute to (cf. 1.4.2). For example, does the current rate of technological development, which in part depends on the allocation of resources, enable the firm to capitalize on an identified opportunity in the market? This feature is arguably not sufficiently addressed in the knowledge integration literature on projects (Baxter et al., 2013; Bredin et al., 2017; Enberg, 2007; J. C. Huang & Newell, 2003; Klessova et al., 2020; Lindkvist et al., 1998; Mitchell, 2006; Newell et al., 2004).

Altogether, considering the reviewed literature and the mentioned empirical cues, this suggests that there might be a more *systemic* interplay between the three categories of problems and knowledge than described in previous research on knowledge integration. Such a dynamic would be of obvious relevance for the management of knowledge integration (cf. 1.4.2). Whether knowledge integration theory can contribute to an explanation of such systemic interplay or if further research would refute this proposition is an open question which is clearly worth pursuing.

[21] Colloquially referred to as 'waterfall' projects.

1.4.3.3 The foundation for the strategic perspective on knowledge integration

Last, it should be acknowledged that the move toward a more strategic perspective on knowledge integration and the foundation that was outlined in 1.4.2 are currently not acknowledged as an alternative approach within the domain of knowledge integration theory. There are thus several gaps which need to be addressed before such an approach can become a recognized alternative for how to understand knowledge integration.

To start with, there is no agreement on how to *define* the key building blocks of this approach. First, there are multiple terms that are used to convey ‘that’ which firms attempt to achieve. For example, *objectives* (M. T. Hansen, 1999; Kalling, 2003a; Nickerson & Zenger, 2004; Nonaka, 1994; Ramesh & Tiwana, 1999; Simon, 1947; Spender, 1996), *goals* (Becker & Zirpoli, 2003; Brusoni et al., 2021; Ceci & Prencipe, 2017; Grant, 1996b; Johansson et al., 2011; Okhuysen & Eisenhardt, 2002; Postrel, 2017; Tsai & Ghoshal, 1998; Tsoukas & Vladimirou, 2001; Van de Ven & Zahra, 2017; Werr & Runsten, 2013; Willem et al., 2008; Zahra et al., 2020), *purpose* (L. Bengtsson et al., 2011; Berggren, Bergek, Bengtsson, & Söderlund, 2011; Tell et al., 2017a), *mission* (Huber, 1991; Rauniar et al., 2019; Tsoukas, 1996), and *aspiration* (Winter, 2000). Moreover, these terms appear to vary in meaning, e.g., in terms of tangibility and scope. For example, goals can be interpreted to mean tangible results, i.e., they can be measured and articulated. A purpose or mission, on the other hand, appears to be less tangible and potentially broader in scope, for example, akin to a ‘vision’ of what could be accomplished. Furthermore, the term ‘purpose-driven’ is sometimes applied to emphasize sustainability and stakeholder value, i.e., implying a different and ‘higher’ purpose than mere shareholder value (Rey et al., 2019).

Secondly, multiple different labels are used in the categorization of different types of problem and knowledge (i.e., technological, organizational, and commercial). For example, technological knowledge is currently also discussed as technical knowledge (Baxter et al., 2013; Enberg, 2007; Tiwana, 2004; Verona, 1999), product knowledge (Alavi & Leidner, 2001; Tanriverdi & Venkatraman, 2005), and domain-specific knowledge (Court, 1997; Frishammar et al., 2012; Ramesh & Tiwana, 1999). There are also differences between proposed definitions within each category, for example, between the definition of commercial knowledge by Demarest (1997) and the definition of market knowledge by Burgers et al. (2008). Moreover, there is no ‘structural’ convergence *across* the three categories for how to define these building blocks in a knowledge integration context. For example, the definition of organizational knowledge in Tsoukas and Vladimirou (2001) is quite dissimilar from the definition of technological knowledge by Burgers et al. (2008) or the definition of customer knowledge by Tanriverdi and Venkatraman (2005). Clearly, a more strategic perspective on knowledge integration would become more workable if these problems regarding definitions could be resolved.

Another question that needs to be investigated is whether the approach outlined in 1.4.2 is in competition with or complementary to the established approach that was discussed in 1.4.1 regarding problem characteristics. Since both approaches attempt to explain effective management of knowledge integration, it is possible that they are mutually exclusive, i.e., cannot both be true. However, there are cues which indicate that these approaches are actually two sides of the same coin, i.e., that the two approaches are complementary. One such indication is that neither approach is collectively exhaustive, i.e., encompasses the 'independent variables' of the other approach. For example, the different types of problems (technological, organizational, and commercial) that are a product of a firm's objective are not explained by or fit within any of the categories of characteristics (task characteristics, knowledge characteristics, and relational characteristics). Despite such cues, this is arguably an open question, which remains to be examined further. Consequently, the preliminary framework (to be presented in Chapter 2) will be constructed using literature from both approaches.

A final problem concerns recommendations for how practitioners of management and strategy can improve their practices for knowledge integration. In comparison, the literature on problem characteristics (cf. 1.4.1) has contributed numerous normative implications for management of knowledge integration. For example, which mechanisms are appropriate given the influence of certain characteristics (e.g., uncertainty, complexity, tacitness, depth of specialization, and so forth). For the outlined strategic approach to knowledge integration to be relevant beyond the scope of academia, its value for practitioners of strategy and management should hence be articulated further than what has been the case in previous research. This issue will be considered in decisions regarding research design (see Chapter 3) as well as in Chapter 5 (Analysis) and Chapter 6 (Conclusion and further research).

1.5 Purpose of this study

The aim in 1.4 was to problematize previous research and to construct a 'mystery' that needs to be resolved (Alvesson & Kärreman, 2007; Alvesson & Sandberg, 2011). Important progress has arguably been accomplished in terms of our understanding of how various problem characteristics influence the knowledge integration process (Carlile & Rebentisch, 2003; Grandori, 2001; Grant, 1996b; Postrel, 2002; Szulanski, 1996; Tell, 2011). Implications for the management of knowledge integration from the 'purpose' (cf. objective) in a 'purposeful combination' of knowledge, however, has received less attention (see 1.4.2). This leads to questions about the strategic dimensions of knowledge integration which arguably need to be explored further (see 1.4.3).

In summary, the purpose of this study is *to contribute to the understanding of how knowledge integration is influenced by the objectives of a firm*. The definition of knowledge integration as a ‘purposeful combination’ of knowledge (Berggren, Bergek, Bengtsson, & Söderlund, 2011; Tell et al., 2017a) is central to the meaning of ‘objectives’ in this statement.

This purpose has some methodological implications, in that it calls for a qualitative approach (Edmondson & Mcmanus, 2007). Hence, a case study design will be employed (Eisenhardt, 1989b; Yin, 2009). In terms of case selection, it appears relevant to identify an empirical setting which allows for observations of the commercial dimension of knowledge integration (see 1.4.3.1) as well as exposes individuals to all three kinds of problems (see 1.4.3.2). Preferably, the setting should also be dynamic (cf. 1.4.1), e.g., expose individuals to new problems which have never been solved previously. The development and commercialization of advanced technology is thus a potential setting which satisfies all the mentioned criteria.

1.6 Disposition

Chapter 2 presents our best answer to the purpose of the study, based on a review of literature on knowledge integration. A preliminary theoretical framework, representing an expected pattern, is concluded from this review.

Chapter 3 explains the decisions regarding research design and methodological questions in the study. Furthermore, the chapter presents how the study was undertaken.

Chapter 4 presents the results of the study. The presentation is structured according to the theoretical modules in the preliminary framework (outlined in Chapter 2).

Chapter 5 compares the empirical material with the preliminary framework and presents findings from this analysis. A revised framework concludes the chapter, representing the new and improved understanding of the purpose of the study.

Chapter 6 presents conclusions from the study and discusses questions for further research.

2 Theoretical framework

A few themes can be clarified regarding how this preliminary theoretical framework was constructed. The point of departure for this study is the seminal 1996 special issue of *Strategic Management Journal* edited by J.C. Spender and Robert M. Grant (Spender & Grant, 1996b). This special issue included several contributions which later would become well-cited and influential in the field (e.g., Grant, 1996b; Sanchez & Mahoney, 1996; Szulanski, 1996; Tsoukas, 1996). Looking more closely at the antecedents of these contributions, the knowledge integration field clearly builds on the *Carnegie School* of understanding organizational behavior through the prism of individual decision-making (e.g., Cyert & March, 1963; March & Simon, 1958; Simon, 1947). Consequently, associated concepts such as bounded rationality (Simon, 1947, 1956; Tversky & Kahneman, 1974) and the duality of exploration and exploitation (Argyris & Schön, 1978; March, 1991) are ubiquitous in the knowledge integration literature.

Regarding the trajectory of the knowledge integration field after the 1996 special issue of *Strategic Management Journal* (Spender & Grant, 1996b), the preliminary framework predominantly builds on contributions that emphasize integration as an act of *combination* (Okhuysen & Eisenhardt, 2002) and which position knowledge integration as the 'dependent variable' to be investigated (Brusoni & Prencipe, 2011; Carlile & Rebentisch, 2003; Demarest, 1997; Postrel, 2017; Ravasi & Verona, 2001; Zahra et al., 2020).

Furthermore, the application of abductive reasoning (see 3.2) permitted ongoing refinement of the preliminary framework. Relative to the initial iterations of the preliminary framework, the most noticeable extension is the additional emphasis on the objective of firms (see 2.3 and 2.5.7).

2.1 Defining the object of study

2.1.1 Defining knowledge integration

There are multiple definitions of knowledge integration in previous literature, which are yet to converge into a consensus (Tell, 2011; Zahra et al., 2020). As stated in the introduction chapter, this study will employ the *combination* approach to knowledge integration (Okhuysen & Eisenhardt, 2002; Tell, 2011). Relative to other definitions (cf. Tell, 2011; Zahra et al., 2020), the combination approach arguably harmonizes more clearly with the feature of knowledge integration to perceive outputs from firm activity as an integration of several individuals' knowledge (Grant, 1996b).

While Okhuysen and Eisenhardt (2002) should be commended for helping to popularize this approach to knowledge integration, a weakness with their definition is that it does not sufficiently underscore the purpose of that combination process. This gap was addressed by Berggren, Bergek, Bengtsson, and Söderlund (2011), who approached knowledge integration as *"a goal-oriented process, or as part of a goal-oriented process"* (Berggren, Bergek, Bengtsson, & Söderlund, 2011, p. 7). Consequently, Berggren, Bergek, Bengtsson, & Söderlund (2011) introduced the notion of 'purposeful' when they described knowledge integration as *"a process of collaborative and purposeful combination of complementary knowledge"* (Berggren, Bergek, Bengtsson, & Söderlund, 2011, p. 7).

Building on Berggren, Bergek, Bengtsson, & Söderlund (2011), Tell et al. (2017a) proposed a definition which makes the achievement of that objective (cf. 'purposeful') even more tangible.[22] In this definition, which will be employed in this study to define knowledge integration (see 1.2.2), knowledge integration is defined as *"the purposeful combination of specialized and complementary knowledge to achieve specific tasks"* (Tell et al., 2017a, p. 5).

As was clarified in 1.2.1, the scope of knowledge integration in this study also includes contributions from other knowledge-based perspectives when they sufficiently match the three features which make knowledge integration distinct (see 1.2.3). Moreover, this scope involves both application of existing knowledge (Grant, 1996b; Kalling, 2003b) and creation of new knowledge (Nonaka, 1994; Nonaka et al., 2000; Nonaka & Toyama, 2003; von Krogh, 1998).

2.1.1.1 Antecedents in prior research

While the knowledge integration field arguably began with the 1996 special issue of *Strategic Management Journal* (Spender & Grant, 1996b), there are relevant antecedents in earlier research to what later became known as knowledge integration. The reference to Simon (1973) in the introduction chapter is an illustrative example of how previous work may illuminate our current understanding of knowledge integration (see 1.1.4). Another example is the classic work by Arrow (1962), which stated that:

> The central economic fact about the processes of invention and research is that they are devoted to the production of information. By the very definition of information,

[22] Note that Christian Berggren was a co-author of the chapter by Tell et al. (2017a) in *Managing Knowledge Integration Across Boundaries* (Tell et al., 2017b).

> invention must be a risky process, in that the output (information obtained) can never be predicted perfectly from the inputs. (Arrow, 1962, p. 616)

The features of knowledge integration, in particular the combination-approach, can also be detected in the previous work by Normann (1971), one of two main authors of Wikström and Normann (1994): *"A product is the outcome of the specialized competence of the various task subsystems of the organization"* (Normann, 1971, p. 203).

The point of these references to Simon, Arrow, and Normann is to illustrate how the ideas which underpin knowledge integration trace farther back than the main references in the field (e.g., Grant, 1996b). Moreover, this suggests that there may be further insights about knowledge integration in previous research which have not yet been applied in the context of knowledge integration theory.

2.1.2 Defining 'knowledge' – a pragmatic approach

The knowledge-concept is one of the most ubiquitous concepts in research but is very difficult to synthesize into a clear definition. Zahra et al. (2020) argued that the lack of precision about the meaning of knowledge, and by consequence knowledge integration, is one of the key obstacles to overcome to advance the knowledge integration field. This state of play presents two options for how to proceed. One option is to devote significant attention to resolving the problematic multiplicity of the meanings of 'knowledge.' This is effectively futile, given the lack of a consensus despite efforts by prominent contributors, i.e., throughout *centuries* of discourse. The other option is to accept that knowledge is a fuzzy and difficult phenomenon to capture precisely, i.e., contrary to the critique by Zahra et al. (2020). Several prominent authors on knowledge integration embrace this pragmatic approach, which will be adopted in this study as well (Carlile, 2002; Grant, 1996b; Spender, 1998). For example, Grant (1996b) stated:

> What is knowledge? Since this question has intrigued some of the world's greatest thinkers from Plato to Popper without the emergence of a clear consensus, this is not an arena in which I choose to compete. In terms of defining knowledge, all I offer beyond the simple tautology of 'that which is known' is the recognition that there are many types of knowledge relevant to the firm. (Grant, 1996b, p. 110)

In his perspective for understanding knowledge in firm activity, Spender (1998) argued for an epistemology that *"defines, or at least implies, a comprehensive knowledge-system, encompassing the knower, the known, the types of knowledge which relate the two, and the corresponding activities or processes of knowledge growth (learning), transfer (communication), and storage (remembering)"* (Spender, 1998, p. 237).

Furthermore, Spender (1998) also discussed the meaning of knowledge in relation to the purpose of studying organizations. The problems that organizational research is interested in, according to Spender, are *"in managing, in seeing how we can intervene in and change the world rather than simply know it"* (Spender, 1998, p. 237). Consequently, Spender argued that for researchers of management *"utility is key, which is why most managers claim to be pragmatists rather than seekers after universal truths"* (Spender, 1998, p. 237).

According to this pragmatic approach, rather than getting stuck on the ultimate meaning of 'knowledge,' attention should instead be directed toward understanding the different characteristics of knowledge, the practical implications of such characteristics for integration processes, and what individuals involved in the process can do about it for the benefit of the firm.

2.1.3 Defining 'integration'

The Cambridge Dictionary (2022) defines integration as *"the process of combining two or more things into one"*. While rudimentary, this is a useful point of departure when developing the meaning of integration in the context of firm activity.

The first question which requires a tentative answer is *why* integration is needed? Through the perspective of knowledge integration theory (Grant, 1996b; Wikström & Normann, 1994), a product or a service is effectively an embodiment of the knowledge needed to produce and deliver that product or service. While extremely *simple* products and services may not require the involvement and combination of multiple individuals' knowledge, more *advanced* products and services typically do. The need to involve multiple individuals is often explained as a consequence of the division of labor (cf. Smith, 1776), which over time leads to increasing specialization and differentiation of knowledge (Kogut & Zander, 1996; Sanchez & Mahoney, 1996; Tell et al., 2017a). Given that differentiated knowledge resides in multiple individuals, difficult integration processes, hence, typically require the involvement of multiple individuals (see also 2.4.1.1).

If this clarifies why integration is needed to solve problems, it can then be asked what the nature of an integration process is? An important assumption in knowledge integration theory is that the process leading to integration is not automatic nor friction-free, but typically requires substantial effort (Grandori, 2001; Grant, 1996b; Okhuysen & Eisenhardt, 2002; Tell, 2011; Thompson, 1967). This proposition can be juxtaposed with the 'invisible hand' metaphor by Adam Smith, which, according to Tell et al. (2017a), underestimates the costs of coordination and collaboration that are required in the general economy or the particular firm to achieve integration. Two types of problems for integration can thus be highlighted: coordination problems and collaboration problems.

2.1.3.1 Coordination problems

The dimension of coordination is present in almost every work on knowledge integration, due to the involvement of multiple individuals in firm activity to solve problems. Grant (1996b) was a prominent proponent of an emphasis on *coordination* and discussed its importance in achieving integration: *"the primary role of the firm as integrating the specialist knowledge resident in individuals into goods and services. The primary task of management is establishing the coordination necessary for this knowledge integration"* (Grant, 1996b, p. 120). Grant (1996b) argued that previous work in strategic management had placed too much focus on problems of 'cooperation' (cf. collaboration), and that this would lead to a *"neglect of the mechanisms through which individuals integrate their productive activities"* (Grant, 1996b, p. 113). Grant (1996b) hence argued that while:

> organization theory has tended to concentrate upon the problems of achieving cooperation, the complexities of knowledge integration, especially when tacit knowledge is involved, point to the fact that, even in the absence of goal conflict, coordination is not a trivial issue. (Grant, 1996b, p. 120)

This implies that coordination might be difficult even in instances where the involved subjects are pulling in the same direction.

2.1.3.2 Collaboration problems

Multiple scholars argue that collaboration problems are distinct from coordination problems in terms of both the nature of the problem and the type of mechanisms which are effective. Collaboration problems are typically grounded in the feature of knowledge integration theory to emphasize *individual* knowledge and agency (see 1.2.3). Postrel (2017) explained that there are:

> layers of loyalty, identity, common interest, social interaction, factual knowledge, interpretation, and so on, and each of these enforces a specific kind of separation between the people and groups on either side of the particular boundary. Differences in loyalty, identity, or interest may cause people to consciously act at cross purposes. (Postrel, 2017, p. 39)

Two main types of collaboration problems can be distinguished in the reviewed literature. First are conflicts of interest *within* the boundaries of a firm, often referred to as 'intra-firm' collaboration problems (Adler & Kwon, 2002; Andersson & Berggren, 2011; Bhandar et al., 2007; Lindkvist et al., 2011; Newell et al., 2004; Postrel, 2017; Runsten & Werr, 2020; Söderlund & Bredin, 2011; Söderlund & Tell, 2011; Willem et al., 2008). Secondly, there is research which focus on conflicts of interest *beyond* the boundaries of a specific firm, often referred to as 'inter-firm' collaboration problems (Bengtsson et al., 2011; Bergek et al., 2011; Dabhilkar & Bengtsson, 2011; Johansson et al., 2011; Swan & Scarbrough, 2005; Werr & Runsten, 2013).

2.1.4 Defining knowledge integration as a process influenced by variables

The process perspective is an established approach in the strategic management field (e.g., Mintzberg, 1978; Chakravarthy & Doz, 1992), which is fundamental to our understanding of knowledge integration theory. The grounding of knowledge integration in the *Carnegie School* is an important reason for adopting a process orientation. Specifically, to understand organizations through the prism of a decision-making process helps to reveal the knowledge-laden nature of individual agency. The main alternative to the process orientation is to instead view knowledge integration as a *capability* (e.g., Brusoni et al., 2005; De Boer et al., 1999; Grant, 1996a; Henderson, 1994; Kogut & Zander, 1992; Mitchell, 2006; Salunke et al., 2019; Verona, 1999; Zahra et al., 2020; Zollo & Winter, 2002). Literature on knowledge integration as a capability will be referenced on a case-by-case basis, in accordance with the scope and features of knowledge integration theory that were outlined in 1.2.3.

Multiple authors propose that an integration process has several distinct stages or phases (e.g., Alavi & Leidner, 2001; Carlile, 2004; Szulanski, 1996; Zahra et al., 2020). The forthcoming preliminary framework (see 2.7), however, will not depict one of these process models, e.g., emphasizing the different stages or phases of integration. Rather, the preliminary framework will be a summary of variables/factors which are expected to influence knowledge integration.

To discuss the process orientation is however relevant to clarify the meaning of the object of study (i.e., relative the capability orientation) and the meaning of various alternative knowledge concepts (e.g., 'transfer' and 'creation') in the context of knowledge integration. For example, Szulanski (1996) proposed that the knowledge transfer process has four stages, in which integration is the final stage: initiation, implementation, ramp-up, and integration. Alavi and Leidner (2001) described knowledge management processes in four stages: creation (e.g., Nonaka, 1994), storage/retrieval (e.g., Argyris & Schön, 1978; Darr et al., 1995), transfer (e.g., Cohen & Levinthal, 1990; Huber, 1991), and application (e.g., Grant, 1996b). Zahra et al. (2020) proposed five sequential stages: first, knowledge development and acquisition (e.g., Inkpen & Tsang, 2005); second, knowledge valuation (e.g., Cohen & Levinthal, 1990; Zahra & George, 2002); third, knowledge transfer, exchange, and sharing (e.g., Szulanski, 1996; Mitchell, 2006); fourth, making connections, such as between various types of knowledge (e.g., Mitchell, 2006); and fifth, knowledge deployment (e.g., Mitchell, 2006; Kalling, 2003b).

There are also several authors which build their models on the generic building blocks of a process, namely: 'Inputs,' 'Process,' 'Outputs' (Ahlskog et al., 2017; Berggren, Bergek, Bengtsson, & Söderlund, 2011; Malik et al., 2020; Wikström & Normann, 1994). A benefit of this approach is that it puts relatively more attention on the purpose of the process (i.e., the objective of the firm, as part of the 'input').

In comparison, the approaches by Szulanski (1996), Alavi and Leidner (2001), and Zahra et al. (2020) focus on the distinction between types of knowledge concepts (e.g., transfer, valuation, deployment, and so forth) and their typical sequence.

2.2 Outlining the framework structure

2.2.1 Scope and orientation

As was highlighted in Chapter 1, it is constructive to distinguish between integrated knowledge and various performance measures when constructing a framework (Tell, 2011). This study positions integration of knowledge as the effect, which warrants an explanation (see 1.2.1). There is clear precedent in the reviewed literature to adopt this orientation, i.e., to focus on integrated knowledge as the 'dependent variable.'[23] This empirical orientation can be contrasted with research which instead examines the effects that integration of knowledge may have on various performance measures.[24] To establish such relationships would be another type of inquiry which, importantly, requires another research design, e.g., deductive approaches and quantitative instruments (e.g., Bacon et al., 2019; Baxter et al., 2013; De Luca & Atuahene-Gima, 2007; Mitchell, 2006).

2.2.2 The framework structure and modules

Three conceptual modules were distinguished in the reviewed literature which appear to explain what influences knowledge integration (cf. the output which represents an integration of knowledge):

- An objective requiring integration of knowledge
- Subjects involved in the knowledge integration process
- Management of knowledge integration

[23] (For example, Bacon et al., 2019; Becker & Zirpoli, 2003; Brusoni & Prencipe, 2011; Carlile, 2004; Carlile & Rebentisch, 2003; Demarest, 1997; Enberg, 2007; Enberg et al., 2010; Enberg, 2012; Engstrand & Enberg, 2020; Grandori, 2001; M. T. Hansen, 1999; Kalling, 2003a; Malik et al., 2020; Nagle & Teodoridis, 2020; Nonaka, 1994; Okhuysen & Eisenhardt, 2002; Postrel, 2017; Ravasi & Verona, 2001; Szulanski, 1996, 2000; Zahra et al., 2020; Zollo & Winter, 2002).

[24] This includes, for example, studies of effects from knowledge integration on *firm performance* (Bierly & Chakrabarti, 1996; Appleyard, 1996; Bergek et al., 2008; Hagemeister & Rodríguez-Castellanos, 2019), *patent performance* ((Subramanian et al., 2017); Subramanian & Soh, 2017), *productivity* (Darr et al., 1995; Boone & Ganeshan, 2008), *production costs* (von Hippel & Tyre, 1995), *product innovation performance* (Tsai & Ghoshal, 1998; De Luca & Atuahene-Gima, 2007), and *innovation performance* (Baxter et al., 2013; Morone & Taylor, 2012; Pateli & Lioukas, 2019; Wang et al., 2018).

Based on these modules, a framework can be visualized according to Figure A. As discussed in 2.1.4, this model (Figure A) depicts how we can understand what influences if/how knowledge integration is achieved, rather than a process with stages or phases. Thus, Figure A does not include arrows in the opposite direction to capture the iterative nature of knowledge integration, i.e., how learnings from previous efforts are leveraged in later problem-solving (Berggren, Bergek, Bengtsson, & Söderlund, 2011, pp. 8–9).

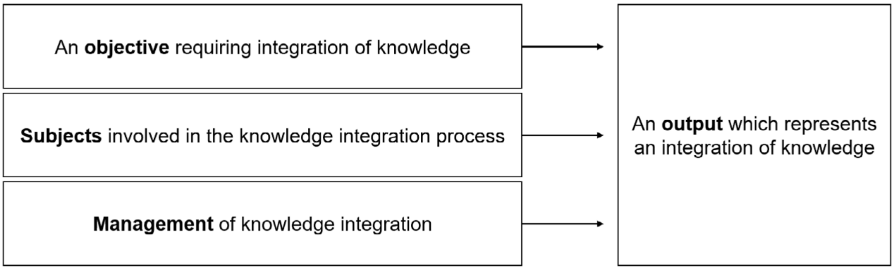


Figure A. A framework model for the purpose of this study.

The theoretical foundation of the three conceptual modules in Figure A will now be outlined, representing the expected pattern suggested by previous research (cf. Yin, 2009). Additionally, as a complement to the definition of the object of study (see 2.1), our pre-understanding of the output-module will be elaborated on in 2.6.

2.3 An objective requiring integration of knowledge

The purpose of this study (see 1.5) is to explore how the objectives of a firm may influence knowledge integration. This module will present how we can understand the notion of objectives in this context. Two dimensions will be explored. First, what we know about generic *objectives* which require knowledge integration, i.e., objectives that appear to be common across firms. Second, what we know about the different *types of problems* (i.e., technological, organizational, and commercial) which must be solved to achieve a firm's objectives (see 1.4.2). This second dimension also includes what is known about the corresponding *types of knowledge* that need to be integrated to solve each type of problem.

2.3.1 Objectives which require knowledge integration

The introduction to the theoretical problem in Chapter 1 (see 1.4.2) explained how knowledge integration can be perceived in relation to what a firm is setting out to achieve, i.e., its objective. An objective can be defined as *"something you are trying to do or achieve : a goal or purpose"* (Britannica Dictionary, 2022a).

Generally, the main purpose of firms is to generate wealth for its shareholders. Accordingly, Demarest (1997) argued that *"all knowledge management programs ought to be targeted directly at the firm's income statement: at revenue enhancement, cost reduction, or the management of risk associated with marketplace and financial performance"* (Demarest, 1997, p. 380). Ultimately, firms' performance can be financially measured in terms of profitability for a firm's shareholders, cf. return on equity ('ROE') or return on investment ('ROI'). Sometimes, both in research and in practice within firms, other metrics such as profit (cf. EBITDA), revenue, and costs are also employed to gauge performance. Clearly, other types of organizations than firms, such as NGOs or public/governmental functions, may have other objectives.

Although that shareholder returns are the main purpose of firms, the specific reasons to engage in knowledge integration will be assumed to vary between firms (Demarest, 1997). This can be deduced from the fact that firms rarely (if ever) find themselves in *identical* circumstances, e.g., due to differences in the resources at their disposal and/or their respective history. Thus, the reason for one firm to integrate knowledge can be assumed to not be a replica of the rationale of another firm. Yet, there might be similarities between the objectives of the firms. Three examples of generic objectives were identified in the reviewed literature and will now be presented.

2.3.1.1 To deliver an offering to the market

Regardless of its circumstances (e.g., which industry a firm is acting in, if the firm is a start-up or incumbent, or degree of vertical integration), part of why a firm must solve problems through knowledge integration is related to the objective of delivering an offering to the market (Wikström & Normann, 1994). There is a plethora of literature on technological development (Enberg, 2012; Johansson et al., 2011; Klessova et al., 2020; Nobelius, 2004; Pateli & Lioukas, 2019; Sydow, Windeler, Schubert, et al., 2012) and new product development (Becker & Zirpoli, 2003; Carlile, 2002; Court, 1997; Enberg, 2007; Eslami & Lakemond, 2016; Frishammar et al., 2012; Lindkvist et al., 1998; Magnusson & Lakemond, 2011; Ordanini & Parasuraman, 2011; Takeishi, 2002; Takeuchi & Nonaka, 1986), which substantiates this suggestion. In addition to what was stated in the introduction chapter (1.4.2.2), it may be constructive to clarify that the concept of an *offering* is not constrained to a traditional meaning of products as physical objects but also encompasses *services* (delivered by a human or through technology) and *customer experience (*such as the brand or other aspects which contribute to the attractiveness of an offering).

2.3.1.2 To complete the integration process within time and resource constraints

A second generic objective is to complete an integration process within time and resource constraints (Brusoni & Prencipe, 2001; Grant, 1996a, 1996b). On-time completion of projects is, for example, positioned as the dependent variable in Mitchell (2006). Resource constraints are also discussed in the literature, but often in quite vague and general terms, such as in relation to internal budgets (M. T. Hansen, 1999; Ravasi & Verona, 2001; Stringer, 2000; Szulanski, 1996; Tiwana, 2004).

Arguably, contributions on both types of constraints (time and resources) tend to neglect the real issue underpinning this generic objective. Logically, time and resource constraints originate in the dynamics of *competition*. However, only a few contributions (e.g., Argote & Ingram, 2000; De Luca & Atuahene-Gima, 2007; Grant, 1996a; Salunke et al., 2019) make explicit references to the influence from exogenous industry conditions, such as the ubiquitous five-forces framework by Porter (1980). This tendency in the literature is problematic for multiple reasons, not least for how to motivate why time and resource constraints are important in the context of knowledge integration.

2.3.1.3 To learn

While learning may not directly translate into improved performance in the short-term, learning is often considered strategically important because learning today may increase the likelihood of improved performance tomorrow (Hobday & Bergek, 2011). For example, path dependence can increase the risk of firms to become entrenched in knowledge domains, which are becoming increasingly obsolete (Berggren et al., 2017; Cestino & Matthews, 2016; Sydow, Windeler, Müller-Seitz, et al., 2012a). Accumulation of new knowledge and taking part in knowledge development outside the firm may thus be a strategic cost to break such vicious feedback-loops and enable the firm to compete in the new, emerging landscape (cf. Christensen, 1997). Furthermore, the tacit nature of certain knowledge (Nonaka et al., 2000; Spender, 1996; Szulanski, 1996) may force some learning activities to be undertaken hands on, cf. ‘learning-by-doing’ (von Hippel & Tyre, 1995). Learning as an objective can also be understood through seminal contributions on concepts that are outside the scope of knowledge integration, such as exploration and exploitation by (March, 1991), double-loop and single-loop learning by Argyris and Schön (1978), as well as absorptive capacity (Berggren et al., 2017; Cohen & Levinthal, 1989, 1990).

2.3.2 Types of problems to solve to achieve the objectives of a firm

The definition of knowledge integration as the ‘purposeful combination’ of knowledge to achieve certain tasks (cf. Tell et al., 2017a) prompted questions about the types of problems that this might entail (see 1.4.2). Since the literature on knowledge integration has not previously been reviewed from this perspective, the forthcoming review should be read as a bricolage of separate contributions which previously have not been discussed collectively (cf. puzzle-metaphor in 1.4.2.3). Despite this disclaimer, quite a lot appears to be known about each kind of problem and corresponding type of knowledge. Multiple phenomena are outlined in this review, which might be observed in an empirical setting.

2.3.2.1 Three categories of problems

In 1.4.2, it was proposed that the achievement of firms' objectives can be understood as contingent upon solving specific problems (Berggren, Bergek, Bengtsson, & Söderlund, 2011; Demarest, 1997; Nickerson & Zenger, 2004; Tell et al., 2017a). For example, to achieve its objectives, a firm may need to integrate knowledge to develop a technological product, to design and implement an organizational structure, or to reach an agreement with a customer to purchase part of the firm's offering. The literature review suggested that there are three thematic types of problems:

- Technological problems
- Organizational problems
- Commercial problems

'Technology' refers to *"the application of scientific knowledge to the practical aims of human life or, as it is sometimes phrased, to the change and manipulation of the human environment"* (Encyclopaedia Britannica, 2022). The 'practical aims' in question are sometimes clarified to concern application of scientific knowledge in industrial settings or engineering.[25]

'Organization' can be defined as *"a group of people who work together in an organized way for a shared purpose"* (Cambridge Dictionary, 2022c). Another relevant angle is to consider an organization to be *"an administrative and functional structure (such as a business or a political party)"* (Merriam-Webster Dictionary, 2022b).

'Commercial' can be defined as *"related to making money by buying and selling things […] used for selling goods or providing services for money, rather than for personal use"* (Cambridge Dictionary, 2022a).

Together, these three categories appear to be sufficiently exhaustive to encompass most types of problems which may be observed within firms. For example, the organizational category can swallow administrative tasks such as financial steering,

[25] For example, *"(the study and knowledge of) the practical, especially industrial, use of scientific discoveries"* (Cambridge Dictionary, 2022d), and *"the use of science in industry, engineering, etc., to invent useful things or to solve problems"* (Britannica Dictionary, 2022b).

financial reporting, and human resources. However, the three types of problems do not appear to be mutually exclusive in the sense that they cannot overlap. Rather, some problems which firms are facing appear to be a combination of multiple types, e.g., ‘new business development’ in Burgers et al. (2008). This ‘systemic’ potential was introduced in Chapter 1 (see 1.4.3.2) and will be reviewed in the upcoming 2.3.2.9.

2.3.2.2 Three categories of knowledge – to solve the corresponding type of problem

A categorization of problems is especially fitting within knowledge integration theory since it highlights how different kinds of *knowledge* are required to solve each type of problem. As was explained in the introduction-chapter, this is implied by division of labor and specialization of individuals, which are central assumptions that underpin knowledge integration theory (Grant, 1996b; Kogut & Zander, 1996; Tell et al., 2017a). This relationship is also very consequential for management of knowledge integration, which will be discussed further in 2.5.7.2. Consequently, this review will also discuss what is known about each corresponding type of knowledge, i.e., after discussing what is known about the type of problem in question.

2.3.2.3 Technological problems

Technological problems are perhaps the most obvious type of problem that requires knowledge integration. For example, technology was referenced in Chapter 1 (cf. Simon, 1973) to illustrate how the output of problem-solving represents an integration of human knowledge. This is also the type of problem which historically has generated the most attention among knowledge integration researchers (e.g., Becker & Zirpoli, 2003; Bergek et al., 2011; Brusoni et al., 2001, 2021; Brusoni & Prencipe, 2011; Burgers et al., 2008; Carlile, 2002; Enberg, 2007; Galbraith, 1990; Klessova et al., 2020; Sanchez & Mahoney, 1996; Takeishi, 2002; Takeuchi & Nonaka, 1986; Tiwana, 2004; Verona, 1999).

There are multiple ways of conceptualizing technological outputs (cf. Britannica Dictionary, 2022; Cambridge Dictionary, 2022). One such way is to distinguish between *material* technology, such as a car which solves the problem of how to transport a person from point A to point B, and *immaterial* technology, such as the software in that car which solves problems related to safety during that transport from point A to point B (Alavi & Leidner, 2001; Annosi et al., 2020; M. Bengtsson et al., 2020; Bergek et al., 2008; Hobday & Bergek, 2011; Tiwana, 2004). A second way of conceptualizing technological outputs is to consider different *applications* of technology, for example, in products, in services, in manufacturing methods, or in the development process of new products (such as computer-aided design, ‘CAD’), services, or manufacturing methods (Ahlskog et al., 2017; Annosi et al., 2020; Ordanini & Parasuraman, 2011; Pisano, 1994; Takeuchi & Nonaka, 1986).

2.3.2.4 Technological knowledge

To solve technological problems, there are plenty of contributions which explain how this involves a combination of *technological knowledge* (Burgers et al., 2008; Jeong et al., 2017; Salunke et al., 2019; L. Wang et al., 2020; Xi et al., 2020), *technical knowledge* (C. S. Galbraith, 1990; Tiwana, 2004; Verona, 1999), and *product knowledge* (Alavi & Leidner, 2001; Tanriverdi & Venkatraman, 2005). There is, however, no general definition of technological knowledge that is employed across these contributions. For example, Burgers et al. (2008) defined technological knowledge as *"knowledge associated with products, technologies and/or processes"* (Burgers et al., 2008, p. 56).

Technological knowledge is also reflected in knowledge integration research on technological phenomena such as *product architecture* (Brusoni & Prencipe, 2011; Sanchez & Mahoney, 1996), *new product development* (Becker & Zirpoli, 2003; Carlile, 2002; Enberg, 2007; Eslami & Lakemond, 2016; Y.-C. Huang & Chin, 2018; Lindkvist et al., 1998; Magnusson & Lakemond, 2011; Melander & Tell, 2014; Ramesh & Tiwana, 1999; Takeishi, 2002), *research and development* (Jeong et al., 2017; Klessova et al., 2020; Nagle & Teodoridis, 2020; Nobelius, 2004), and *creative accumulation* (Bergek et al., 2011). Finally, there are also contributions which deal with technological knowledge domains, such as *communities of practice* (J. S. Brown & Duguid, 1991), *epistemic communities* (Håkanson, 2010), *knowledge collectivities* (Lindkvist, 2005; Söderlund & Bredin, 2011), and *domain-specific knowledge* (Court, 1997; Frishammar et al., 2012; Ramesh & Tiwana, 1999; Rundquist, 2014).

2.3.2.5 Organizational problems

The literature on organizational problems can be divided into contributions on *intra-organizational arrangements* (Ghoshal et al., 1994; Grant, 1996b; Lindkvist et al., 1998; Ravasi & Verona, 2001; Szulanski, 1996) and *inter-organizational arrangements* (Appleyard, 1996; Johansson et al., 2011; Lane & Lubatkin, 1998; Liebeskind, 1996; Mowery et al., 1996; Weber & Weber, 2007). Mowery et al. (1996), for example, proposed that certain structural arrangements between firms are more effective in contexts characterized by complex knowledge, specifically favoring joint ventures ahead of contract-based alliances (such as licensing agreements). Other authors have explored the *risks* of inter-firm integration of knowledge, such as how a firm can install protective organizational arrangements (Liebeskind, 1996) to prevent external transfer to competitors (Argote & Ingram, 2000; Ceci & Prencipe, 2017). In addition to *how* inter-organizational arrangements are set up, there is also research which discuss how this issue is also a matter of *which* firms are involved in inter-organizational arrangements (Lane & Lubatkin, 1998; Mowery et al., 1996; Weber & Weber, 2007).

Another way of categorizing organizational problems is to distinguish between problems related to *structural* arrangements (cf. Mowery et al., 1996) and *procedural* arrangements. For example, Ravasi and Verona (2001) highlighted intra-organizational structural arrangements in their research on structural ambiguity as a potential design principle. Structural ambiguity has three distinct properties according to Ravasi and Verona (2001), which may be applied in isolation but are mutually reinforcing when applied together: multipolarity, fluidity, and interconnectedness. Especially relevant for this study is their argument that structural ambiguity is particularly suited for hypercompetitive environments, since high degrees of *flexibility* are expected to facilitate effective knowledge integration in such settings (Ravasi & Verona, 2001).

Moreover, there is also research on *informal structures* within firms (see also 2.5.4), i.e., which constitute its own kind of organizational problem (e.g., Runsten & Werr, 2020; Tsai & Ghoshal, 1998; Willem et al., 2008; Zhao & Anand, 2013). For example, Zhao and Anand (2013) critiqued previous research that treat *"interunit structures as unitary ties rather than a complex nexus of relationships"* (Zhao & Anand, 2013, p. 1514). To manage such aspects, Malik et al. (2020) made the distinction between 'ability-enhancing practices' (such as training, development and hiring) and 'motivation-enhancing practices' (see also forthcoming 2.4.1.1).

Last, there is research on the implications of various *procedural* arrangements (Alavi & Leidner, 2001; Annosi et al., 2020; Frishammar et al., 2012; Lindkvist et al., 1998). Outside the knowledge integration literature, such procedural arrangements are likewise the focus of literature on various development methodologies, such as *stage-gate* (Cooper, 1990, 2008; Cooper & Sommer, 2016) and *agile* (Beck et al., 2001; Bredin et al., 2017; Chan & Thong, 2009; Dingsøyr et al., 2012; Takeuchi & Nonaka, 1986).

2.3.2.6 Organizational knowledge

Similar to the lack of consensus regarding how to define technological knowledge, there was no agreed definition of organizational knowledge in the literature. As an example, Tsoukas and Vladimirou (2001) defined organizational knowledge as *"the set of collective understandings embedded in a firm, which enable it to put its resources to particular uses"* (Tsoukas & Vladimirou, 2001, p. 981). Thus, organizational knowledge should not be conflated with *everything* that an organization knows. Similar terms instead include *managerial knowledge* (Galbraith, 1990; Xi et al., 2020), *managerial know-how* (Miles et al., 1997), and *procedural knowledge* (Court, 1997; Frishammar et al., 2012; Ramesh & Tiwana, 1999; Rundquist, 2014). Frishammar et al. (2012), for example, proposed that procedural knowledge concerns the *"know-how of the NPD process per se […] As the NPD process typically is organized into different stages, procedural knowledge concerns "[t]he knowledge of what to do next" […] throughout the NPD process"* (Frishammar et al., 2012, p. 577).

2.3.2.7 *Commercial problems*

The two epic commercial problems that firms must confront are how to earn more money from customers and how to spend less money on inputs from suppliers. The financial implications of solving or not solving commercial problems should hence be quite obvious. A demarcation is that employees will not be treated as part of the commercial problem but will instead be sorted as part of the organizational-category, e.g., a problem related to how to allocate resources within the firm. Employees are however acquired in the factor markets through which the firm can find its inputs, which admittedly makes this approach imperfect.

In the instance of commercial agreements with suppliers, 'make-or-buy' decisions are the main kinds of problem (Becker & Zirpoli, 2003; L. Bengtsson et al., 2011; Brusoni et al., 2001; Castellucci & Carnabuci, 2017; Ceci & Prencipe, 2017; Dabhilkar & Bengtsson, 2011; Fine & Whitney, 1996; Mehta & Bharadwaj, 2015). Hence, questions related to if it is more beneficial to buy a good from the market or to produce that good within the boundaries of the firm.[26] In instances when it is deemed more beneficial to rely on the market, the next problem that firms are faced with is how to select between alternative suppliers (Beckman et al., 2004; Melander & Tell, 2014). Firms can be expected to attempt to apply a cost-benefit logic in such decisions (L. Bengtsson et al., 2017; Grandori, 2001; Werr & Runsten, 2013; Williamson, 1981). Note, however, that the implications of such cost-benefit judgments may transcend an agreement with a specific supplier. This is due to the domino-effects related to the ecosystem (cf. value chains), which a focal firm is embedded in (Beckman et al., 2004; Ceci & Prencipe, 2017; Sanchez, 1999; Swan & Scarbrough, 2005; Takeishi, 2002; Zirpoli & Camuffo, 2009). To reach a commercial agreement with a supplier is thus typically preceded by internal integration efforts as well as external integration efforts together with suppliers and other external parties (such as existing suppliers, alliance partners, brokers, consultants, and so forth).

In the instance of commercial agreements with customers, the firm is instead the 'supplier' in the equation. Knowledge integration is required to solve a number of problems before such an agreement can be reached between the firm and a potential customer. For example, how to configure the firm's offering, how to market and communicate the firm's offering, how to design the terms of payment, and so forth (De Luca & Atuahene-Gima, 2007; Sanchez, 1999; Wikström & Normann, 1994). As for commercial agreements with suppliers, this process can be expected to involve efforts by both internal and external subjects.

In both instances, the resulting agreement (between the firm and the customer or supplier) could be understood as a boundary object which embodies knowledge about what the parties are willing to provide and pay to mutually benefit from the

[26] Compare with transaction cost economics (e.g., Williamson, 1979, 1981). This perspective also supports why employees are not treated as part of the commercial problem, i.e., since employees are how the 'make'-option is exercised.

agreement (Carlile, 2002; Kravchenko & Swan, 2017; Star, 1989; Van de Ven & Zahra, 2017). On a word of caution, this is not a typical application of the literature on boundary objects, i.e., which rather tend to focus on boundary objects which embodies technological and organizational knowledge.

2.3.2.8 Commercial knowledge

Several different terms have been employed in previous research which describe various facets of commercial knowledge: *market knowledge* (Åkerman, 2015; Burgers et al., 2008; De Luca & Atuahene-Gima, 2007; Salunke et al., 2019; Zhou & Li, 2012), *customer knowledge* (Alavi & Leidner, 2001; Tanriverdi & Venkatraman, 2005), knowledge about *customers* (De Luca & Atuahene-Gima, 2007), knowledge about *competitors* (Alavi & Leidner, 2001; De Luca & Atuahene-Gima, 2007), *business application domain knowledge* (Tiwana, 2004), and *general knowledge* (Court, 1997; Frishammar et al., 2012; Ramesh & Tiwana, 1999).

Demarest (1997) was one of the most insightful contributions on commercial knowledge in the knowledge literature. According to Demarest (1997), commercial knowledge can be defined as *"an explicitly developed and managed network of imperatives, patterns, rules and scripts, embodied in some aspect of the firm, and distributed throughout the firm, that creates marketplace performances"* (Demarest, 1997, p. 375). Demarest (1997) positioned commercial knowledge as profoundly *practical*, arguing that commerce *"is about the provisional: about rules-of-thumb, swags, and truths that are highly productive and then become unproductive overnight"* (Demarest, 1997, p. 375).

Demarest (1997) therefore distinguished commercial knowledge from philosophical and scientific knowledge, i.e., knowledge which is more concerned with truth than *"what works better"* (Demarest, 1997, p. 375). This is similar to the notion of 'satisficing' by Simon (2018), which contrasted *"searching for the sharpest needle"* with *"searching for a needle sharp enough to sew with"* (Simon, 2018, p. 11934).[27] Furthermore, Demarest conceptualized commercial knowledge as profoundly *social*, in that it is *"produced and shared among a network of human and nonhuman actors within the firm (and increasingly across the firm's boundaries)"* (Demarest, 1997, p. 376). Consequently, Demarest (1997) connected commercial knowledge with the characteristics that moderate the interplay between subjects (see 2.5.4 Relational characteristics):

> commercial knowledge is traded, by knowledge workers, in knowledge economies that are today operating within every knowledge intensive firm in the world. What is traded for is either other different kinds of knowledge, or status within the knowledge worker guild within the firm. (Demarest, 1997, p. 376)

[27] See also Winter (2000, p. 984).

Burgers et al. (2008) is another noteworthy contributor, which focused on *market knowledge* in the process of new business development. Burgers et al. defined market knowledge as *"knowledge associated with targeting customer sets, entering markets, distribution channels, marketing approaches and business models"* (Burgers et al., 2008, p. 56). Moreover, Burgers et al. (2008) suggested that inter-firm collaboration can be a constructive mean of accessing market knowledge; they specifically argued that *"strategic alliances with partners possessing complementary market knowledge significantly shorten the time to acquire new market knowledge for NBD projects"* (Burgers et al., 2008, p. 57).

De Luca and Atuahene-Gima (2007) employed a similar approach in their study of implications of market knowledge on product innovation performance (cf. 2.2.1). Interestingly, this contribution includes quite an extensive instrument for how to measure the construct of 'market knowledge,' such as depth and breadth of knowledge about *customers* and *competitors* (De Luca & Atuahene-Gima, 2007; Zahra et al., 2000).

Åkerman (2015) and Zhou and Li (2012) both focused on the acquisition dimension of market knowledge. Åkerman (2015) outlined strategies for acquiring market knowledge from various knowledge sources (direct and indirect experience, external search and internal information). Zhou and Li (2012) paired integration mechanisms for market knowledge acquisition and internal knowledge sharing with the depth and breadth of the knowledge base in the firm, indicating that certain objectives (such as radical innovation) are facilitated by certain mechanisms.

Tanriverdi and Venkatraman (2005) applied the concept of *customer knowledge* in their work on knowledge complementarity. This work included one of the most specific definitions of customer knowledge, referring to *"the needs, preferences, and buying behaviors of customers—why they purchase specific products and services, which product/service attributes they value, what value they hope to get by using them, and what their businesses are about"* (Tanriverdi & Venkatraman, 2005, p. 102).

Eslami (2017) and Eslami and Lakemond (2016) focused on the integration of *customer's knowledge* in product development projects (cf. Burgers et al., 2008; De Luca & Atuahene-Gima, 2007). Note that what is being discussed in this work is actually customers' contribution of *technological* knowledge in the NPD process. This is made explicit by Eslami and Lakemond (2016), who even argue that customer's technological knowledge *"needs to be clearly distinguished from customer knowledge"* (Eslami & Lakemond, 2016, p. 891), i.e., which is more akin to the definition by Tanriverdi and Venkatraman (2005). I still consider the notion of 'customer's knowledge' in Eslami and Lakemond (2016) to be part of a body of knowledge about customers, such as their needs and problems to solve, even though the authors prefer to sort this kind of knowledge into the technological category (see 2.3.2.4). In terms of findings, Eslami (2017) argued that the value of integrating customer's knowledge is underestimated, and that firms thus should adopt their product development process to also enable customer's knowledge to be integrated. Notably, contributions on *design thinking* (e.g., Brown, 2008) express similar arguments and propose practical mechanisms for involving customers, albeit without reference to knowledge integration.

Tiwana (2004) applied the term *business application domain knowledge* to describe knowledge about the intended application of software (i.e., technology). Tiwana (2004) defined business application domain knowledge as *"knowledge about the customer's business processes, business rules, activities, stakeholder needs, and the customer's business objectives for the software"* (Tiwana, 2004, p. 900).

Last, several contributions employ the term *general knowledge* to describe a similar concept as commercial knowledge (Court, 1997; Frishammar et al., 2012; Ramesh & Tiwana, 1999; Rundquist, 2014). For example, Frishammar et al. (2012) employed the term *general knowledge* to argue that:

> Both internal and external technology exploitation efforts necessitate knowledge about what is happening outside the firm, which forces firms to engage in scanning activities […] Such knowledge searches are typically directed toward multiple domains, such as customers, competitors, future markets, and emerging technologies. (Frishammar et al., 2012, p. 578)

It is, however, questionable if and to what degree the notion of *general knowledge* encompasses the competitive dynamics, which a firm is exposed to in its dealing with commercial problems (see 2.3.2.7). For example, the subsequent contributions that used this term (Frishammar et al., 2012; Ramesh & Tiwana, 1999; Rundquist, 2014) referenced Court (1997), which in turn defined general knowledge as knowledge *"gained through everyday experiences and general education. The information used in updating this knowledge is that which most people know and apply without regard to the specific domain that they are working in"* (Court, 1997, p. 127).

2.3.2.9 Combinations of multiple categories

Some conceivable problems do not easily map into only one of the three categories but appear to be a combination of more than one type of problem. Although such interdependencies are very established on a general level (see forthcoming 2.5.2.1 on complexity), this specific potential is a sparsely researched aspect of knowledge integration. As was presented in 1.4.3.2, there are, however, both theoretical and empirical cues which suggest that there might be a kind of systemic interplay between the three categories of problems and knowledge.

Starting the conception of the firm as a *knowledge system* (Tsoukas, 1996; Wikström & Normann, 1994), this view emphasized the systemic character of firms. For example, it suggested that there are interdependencies between the problems that this knowledge is intended to resolve, i.e., in a general sense (cf. Grandori, 2001;

Grant, 1996b; Nickerson & Zenger, 2004). However, neither Wikström and Normann (1994) nor Tsoukas (1996) sufficiently referenced or discussed the three types of problems (see 2.3.2.1) nor how they might overlap, which is quite a severe limitation regarding the point in question (combination of multiple categories).

Burgers et al. (2008) is perhaps the most explicit contribution in terms of discussing the dependency between different types of problems and the subsequent importance of combining multiple types of knowledge. In their piece on *new business development*, Burgers et al. (2008) conceptualized successful business development as the resolution to problems which require both technological and market knowledge (i.e., two of the three categories in 2.3.2.1–2.3.2.2). Burgers et al. (2008) argued that each phase of the life cycle for new business development ('development,' 'commercialization,' and 'business') has a different emphasis, in terms of the type of knowledge needed, i.e., technological versus market knowledge, and the type of integration activity that the firm will be engaged in, i.e., exploration versus exploitation (cf. March, 1991).

Tiwana (2004) also invoked both technological ('technical') knowledge and commercial knowledge ('application domain knowledge') in their study of software development projects. Similar to Burgers et al. (2008), Tiwana (2004) suggested that software development performance (e.g., design effectiveness, development efficiency, and prevalence of defects) requires a combination of both types of knowledge. Tiwana (2004) specifically referenced several kinds of commercial problems that the knowledge embodied in the software must solve to achieve the objective with the software development effort. For example, related to end-user needs, the customer's business processes, and the customer's business objectives for the software. Importantly, Tiwana (2004) found that both the effectiveness of the software and efficiency of the development process benefited from integration of both types (i.e., technological and commercial) of knowledge.

Similarly, the combination of commercial and technological knowledge was a central question in the work by De Luca and Atuahene-Gima (2007) on the role of market knowledge in the product innovation process (cf. technological problems). Furthermore, there is research on product architecture which discussed the interplay between technology and organizational arrangements (Brusoni et al., 2001; Brusoni & Prencipe, 2001, 2011; Takeishi, 2002; Zirpoli & Camuffo, 2009) and technology and commercial aspects (Sanchez, 1999). Likewise, the need for both technological and commercial knowledge was discussed as an example of synergies from diverse (cf. complementary) resources in Salunke et al. (2019).

Invoking *all three* types of knowledge, Court, (1997) and Ramesh and Tiwana (1999) approached 'procedural knowledge' (cf. organizational knowledge) as a *combination* of 'general knowledge' (cf. commercial knowledge) with 'domain-specific knowledge' (cf. technological knowledge). This suggests that an organizational configuration (cf. procedural arrangements) can be a function of technological and commercial considerations. Using this categorization by Court (1997), Rundquist (2014) studied the relationship between different types of knowledge and practices for collaboration in distributed product development. Also building on Court, (1997), Frishammar et al. (2012) studied how the combination of ‘general knowledge’ with ‘domain-specific knowledge’ during a new product development-process can support the identification of commercialization opportunities (‘outward technology exploitation’). There are hence similarities between the work by Frishammar et al. (2012) and the pattern suggested in Burgers et al. (2008) and Tiwana (2004).

Tanriverdi and Venkatraman (2005) also invoked all three types of knowledge simultaneously, i.e., ‘customer knowledge’ (cf. commercial), ‘product knowledge’ (cf. technological), and ‘managerial knowledge’ (cf. organizational), in their work on knowledge relatedness as a source of complementarity. However, their thrust was primarily directed toward synergies in the context of multi-business firms. For example, Tanriverdi and Venkatraman (2005) quite narrowly defined knowledge complementarity as *“the extent to which a multibusiness firm uses a complementary set of common knowledge resources across its business units”* (Tanriverdi & Venkatraman, 2005, p. 103). Thus, this contribution is rather about re-usability of knowledge (cf. ‘economies of scope’) than about the combination of multiple types of knowledge to solve interdependent problems. As such, this work is not as applicable to the phenomenon in question as e.g., Burgers et al. (2008).

In light of this review of relevant contributions, the expected pattern, although nascent and not very corroborated, can be summarized as there appears to be problems which involve dependencies across *more than one* thematic category (cf. 2.3.2.1–2.3.2.2). For example, between technological and commercial aspects (Burgers et al., 2008; De Luca & Atuahene-Gima, 2007; Tiwana, 2004). Furthermore, and even less corroborated, there may also be problems which require a combination of *all three* categories of knowledge to be resolved effectively (cf. Court, 1997; Frishammar et al., 2012; Ramesh & Tiwana, 1999; Tanriverdi & Venkatraman, 2005; Wikström & Normann, 1994). How this issue may be consequential for the management of knowledge integration will be discussed in 2.5.7, in particular in 2.5.7.2.

Finally, as was discussed in the introduction-chapter (see 1.4.3.2), there are empirical cues outside knowledge integration research which support this expected pattern. Most notably, the consideration of all three types of problems appears to be a common feature in methodologies for product development, such as stage-gate (Cooper, 1990, 2008; Cooper & Sommer, 2016) and agile (Annosi et al., 2020; Beck et al., 2001; Bredin et al., 2017; Takeuchi & Nonaka, 1986). Literature on these project methodologies, however, does not use the categorization of problems and knowledge, which was introduced in 2.3.2.1. Nonetheless, these kinds of contributions arguably substantiate the expected pattern that was proposed in this section.

2.4 Subjects involved in the knowledge integration process

There appears to be two main kinds of subjects in the knowledge integration literature: *individuals* and *groups* of individuals (Grandori, 2001; Grant, 1996b; Johansson et al., 2011; Postrel, 2017; Tsai & Ghoshal, 1998; Zahra et al., 2020). Our pre-understanding of each kind will be reviewed separately (see 2.4.1 and 2.4.2), before discussing how to perceive their interplay (see 2.4.3).

2.4.1 Individual-level subjects

2.4.1.1 The nature of individuals

The emphasis on the individual as the key subject in the knowledge integration process (cf. Grandori, 2001; Grant, 1996b; Szulanski, 1996) leads to questions about the *nature* of individuals, i.e., which therefore can be assumed to influence the process. While there are numerous additional facets to individual behavior, such as the big five traits-model in the domain of psychology (Barrick & Mount, 1991; John & Srivastava, 1999), this review will focus on *bounded rationality* and *persuasion*.

For starters, there are plenty of contributions which incorporate cognitive limitations of individuals into the explanation of knowledge integration (Grant, 1996a, 1996b; Nickerson & Zenger, 2004; Spender, 1996; Tell, 2017; Zhao & Anand, 2013). The most noteworthy concept in such work is *bounded rationality* (Simon, 1947, 1956; Tversky & Kahneman, 1974). This feature of individuals explains why deep specialization is negatively correlated with broad differentiation for a specific individual, which, in turn, explains the need to involve multiple individuals to resolve problems requiring multiple specializations:

> Fundamental to Simon's principle of bounded rationality is recognition that the human brain has limited capacity to acquire, store and process knowledge. The result is that efficiency in knowledge production (by which I mean the creation of new knowledge, the acquisition of existing knowledge, and storage of knowledge) requires that individuals specialize in particular areas of knowledge. This implies that experts are (almost) invariably specialists, while jacks-of-all-trades are masters-of-none. (Grant, 1996b, p. 112)

Bounded rationality also implies that individuals can apply *judgment* when confronted with difficult decisions, i.e., juxtaposed with rational modes of computation or analysis (Spender, 2014a). Furthermore, the dexterity of individuals in applying their judgment can be assumed to vary among individuals, due to variation in, for example, IQ and previous experience. Consequently, Grandori

(2001) distinguished between *computational* complexity and *epistemic* complexity as different cognitive causes of failure for various integration mechanisms.

A second noteworthy aspect about the nature of individuals is their capacity for *persuasion*. Arguably, this is an inherent feature of the resolution of coordination and collaboration problems between individual subjects (Bhandar et al., 2007; Grant, 1996b; J. C. Huang & Newell, 2003; Postrel, 2017). Spender (2014d), for example, discussed how every individual is endowed both with the capacity to persuade others as well as to be persuaded themselves. Moreover, different facets of persuasion have been covered in previous research on knowledge integration, such as *negotiation* (Baxter et al., 2013; Hoffmann et al., 2017), *motivation* (Kalling, 2003a; Malik et al., 2020), *conflicts of interest* (Grant, 1996b; Melander & Tell, 2014), *conflict resolution* (Eisenhardt, 1989a), and *acceptance/resistance* (Chan & Thong, 2009). Moreover, the ubiquitous *rhetorical* framework by Aristotle can be included as part of our pre-understanding of persuasion (Rapp, 2022; Spender, 2014a). In terms of the contents of this framework, the three most known types of rhetoric appeals are *ethos*, *logos*, and *pathos* (Purdue Online Writing Lab, 2022; Rapp, 2022). Two additional, less known types of appeals are *kairos* and *telos*. *Kairos* refers to how the time and place (cf. timing) influences persuasion, and *telos* refers to the purpose of an appeal (Kinneavy & Eskin, 2000; Purdue Online Writing Lab, 2022).

2.4.1.2 Acting as a manager and an employee

In addition to the nature of individuals, it is also relevant to consider the role or capacity in which an individual is acting. The distinction between managers and employees is ubiquitous (Andersson & Berggren, 2011; Burgers et al., 2008; Grant, 1996b; Kalling, 2003a; Postrel, 2017; Söderlund & Bredin, 2011; Spender, 1996; Verona, 1999; Zahra et al., 2020). The most consequential difference between managers and employees is arguably their respective authority to make decisions (Colombo et al., 2021; J. R. Galbraith, 1974; Ravasi & Verona, 2001; Sanchez & Mahoney, 1996; Verona, 1999; Zahra et al., 2020). There are thus several ways in which managers can be expected to be more influential compared with 'regular' employees. For example, in terms of design and implementation of organizational arrangements. Even when an organization employs a structural arrangement in which mandates for decision-making are distributed among a larger number of employees (cf. Ravasi & Verona, 2001), such structures are themselves a product of decisions by managers. Another example is the responsibility of formulating the purpose and objectives of a firm. Typically, this responsibility is delegated by the firm's shareholders to individuals in senior leadership-positions within the firm.

To clarify, however, it does not mean that individual employees are expected to not be influential in the knowledge integration process, e.g., to merely function as cogs in a machine. On the contrary, a common theme in the literature is to also emphasize the importance of individual employees (Andersson & Berggren, 2011; Bredin et al., 2017; Burgers et al., 2008; Enberg, 2007; Enberg et al., 2006; Grant, 1996b; Håkanson, 2010; J. C. Huang & Newell, 2003; Lindkvist & Bengtsson, 2017; Ordanini & Parasuraman, 2011).

The distinction between employees and managers also has methodological implications, specifically in terms of interviewee selection (see data collection in 3.5). For example, it appears prudent to collect data from individuals in both types of roles, i.e., to obtain a more complete picture. Second, e.g., for the purpose of this study, it should be a priority to gain access to the senior management of a firm, i.e., since such individuals can be expected to be exposed to decisions which individuals at lower levels of an organization (e.g., middle-management, team leaders, and regular employees) are not privy to.

2.4.2 Group-level subjects

2.4.2.1 Definition of group-level subjects

While individuals are positioned as the key subjects who carry out the integration of knowledge, it is also the case that individuals can act on behalf of a group (Berggren et al., 2017; Zahra et al., 2020). Thus, there are *group-level subjects* who are involved in and can influence the process of knowledge integration (Berggren et al., 2017; Demarest, 1997; Johansson et al., 2011; Postrel, 2017; Zahra et al., 2020).

The most noteworthy group-level structure in the context of this study is, of course, the *firm*. For example, the firm is the entity that defines the objectives which a knowledge integration process is intended to contribute to, and the entity that employs and organizes the individuals who participate in the process. Other common types of groups include teams and organizational departments or functions. There is a plethora of contributions on the topics of the theory of the firm, organization theory, group dynamics, and so forth, which are significantly more ambitious in their descriptions of each type of structure (e.g., the firm, the team, the organizational department/function, and so on) than the purpose of this study permits (Enberg et al., 2006; Ghoshal et al., 1994; Håkanson, 2010; Jarvenpaa & Kim, 2017; Jeong et al., 2017; Lindkvist & Bengtsson, 2017; Newell et al., 2004; Okhuysen & Eisenhardt, 2002; Ramesh & Tiwana, 1999; Tsoukas, 1996; Zahra et al., 2020). In this study, the notion of group-level structures will be used to describe subjects which involve a legal entity and/or more than one individual.

2.4.2.2 Formal structures

Formal structures are relevant since integration problems of coordination and collaboration may have both structural origins and require structural solutions (cf. mechanisms). For example, collaboration issues may be related to individuals' sense of belonging to *groups* (Johansson et al., 2011; Postrel, 2017). Integration efforts are thus not exclusively inter-personal within an organization but are often inter-functional/inter-departmental (Ghoshal et al., 1994). For example, Boone and Ganeshan (2008) discussed how integration across intra-organizational boundaries appears to be more difficult than within an organizational unit. The firm can also be part of inter-firm structures (such as alliances, partnerships, and joint ventures) which can lead to further challenges. Melander and Tell (2014), for example, proposed that inter-firm conflicts of interest can have negative spillover effects on internal integration problems.

2.4.2.3 Informal structures

In addition to formal structures, such as the firm or a department, there are also *informal* structures in play (Adler & Kwon, 2002; Newell et al., 2004; Orton & Weick, 1990; Tsai & Ghoshal, 1998; Weick, 1976; Willem et al., 2008). These structures are not as easily observed, e.g., compared with a formal organizational chart, but can be equally influential for the integration process (see also forthcoming 2.5.4). An important disclaimer is that while individuals in the knowledge integration process may act on behalf of group structures (such as to represent your team in a department meeting), they are not necessarily acting according to the interests of their principals (e.g., their managers, all the way up to the shareholders of the firm). It is a well-known phenomenon that the interests and actions of individuals in firms (cf. 'agents' and 'stewards') may deviate from the interest of its owners (cf. 'principals') (Bartlett & Ghoshal, 1993; Grant, 2013; Jensen & Meckling, 1976; Nickerson & Zenger, 2004; Postrel, 2017). It is thus relevant to be vigilant about potential discrepancies between the objective of a firm (from the perspective of shareholders) and how individuals in the firm act. According to Spender (2014d), the previously discussed notion of *persuasion* (see 2.4.1.1) may be a relevant concept for interpreting how such interplay is governed.

2.4.2.1 Knowledge on the group-level

A clarification can be made regarding knowledge on the group-level. Consistent with the features of knowledge integration (see 1.2.3), in this study, individuals are considered to be the producers of new knowledge, the main repository of existing knowledge, and the subjects who ultimately undertake the integration activity. This depiction, however, does not exclude that knowledge can exist outside an individual, at the organizational level.[28]

For starters, knowledge can be transferred from individuals to information systems through codification (Alavi & Tiwana, 2002; Szulanski, 1996; Tell, 2011). For example, rules and procedures for recurring tasks contain knowledge on the organizational level, which remains in the firm even if the individual/-s who

[28] Not to be conflated with *organizational knowledge* in the sense of knowledge about how to solve organizational problems (see 2.3.2.6).

produced that knowledge leaves the firm (Grant, 1996b; J. C. Huang & Newell, 2003; Kogut & Zander, 1992; Zollo & Winter, 2002). Knowledge may also become embodied in boundary objects, for example, architectural drawings or products intended for sale to end-customers (Carlile, 2002; Kravchenko & Swan, 2017; Star, 1989; Van de Ven & Zahra, 2017).

Common for these and other examples of organizational-level knowledge is that it has gone through a conversion process (Kogut & Zander, 1992; Lindkvist & Bengtsson, 2017; Nonaka, 1994; Nonaka et al., 2000; Nonaka & von Krogh, 2009). More specifically, explicit knowledge, which ends up in group-level repositories, originates as knowledge at the *individual* level. As a heuristic, more advanced knowledge integration (e.g., for non-recurring tasks requiring deep specialization), thus, typically requires individual knowledge, i.e., cannot rely on organizational knowledge repositories. This is not only a matter of efficiency, i.e., as the conversion process is typically costly, but also a matter of effectiveness. For example, transactive memory systems (Enberg, 2012; Jarvenpaa & Kim, 2017) increasingly suffers from the black-box problem as the tacitness of knowledge increases (Postrel, 2002, 2017).

2.4.3 The interplay between individual agency and group-level structures

A recognized approach to the interplay between individual-level and group-level subjects is *structuration theory* (Giddens, 1984). Giddens (1984) distinguished agency (of individuals) from structures (such as the firm and sub-groups within the firm). In terms of their interplay, Giddens (1984) argued that individuals are influenced by structures when acting, and that their action, in turn, shapes and influences structures. Structures, such as a firm or a group, thus, are not static entities but are malleable to the agency of individuals (Giddens, 1984; Whittington, 2015). This perspective, hence, allows structural explanations to be incorporated without having to discard the role of individual agency. The structuration approach has been used previously in knowledge integration literature (Berggren et al., 2017; Nonaka & Toyama, 2003) but is considerably more established in other domains, such as literature on path dependence and organization theory (Garud et al., 2010; Sydow et al., 2009; Sydow, Windeler, Müller-Seitz, et al., 2012b; Sydow, Windeler, Schubert, et al., 2012; Whittington, 2015).

2.5 Management of knowledge integration

Our current understanding of how to manage knowledge integration is foremost grounded in prior research on how various problem characteristics influence knowledge integration (see 1.4.1). This is reflected in the disposition of this module of the preliminary framework. First, the approach of explaining problem difficulty through various problem 'characteristics' will be outlined (see 2.5.1). Second, literature on three types of problem characteristics will be presented, i.e., which explains differences in problem difficulty and suggests implications for integration costs (see 2.5.2-2.5.4). Third, a presentation of mechanisms for knowledge integration will follow (see 2.5.5). Fourth, a heuristic relationship between problem characteristics and mechanism cost will be outlined (see 2.5.6). Fifth, a summary of what is known about the influence of firms' objectives on the management of knowledge integration will be outlined, divided into three expected patterns (see 2.5.7).

2.5.1 Problem characteristics and problem difficulty

Previous studies have produced a significant body of knowledge about characteristics which make problems vary in difficulty (cf. 'factors' which influence integration in Tell (2011). There appears to be somewhat of a consensus regarding three categories of problem characteristics: task characteristics, knowledge characteristics, and relational characteristics (Brusoni et al., 2001; Carlile, 2002; Carlile & Rebentisch, 2003; Enberg, 2007; Grandori, 2001; Grant, 1996a, 1996b; Szulanski, 1996; Szulanski et al., 2004; Takeishi, 2002; Tell, 2011, 2017; Tsai & Ghoshal, 1998; Zahra et al., 2020; Zollo & Winter, 2002). These characteristics provide a language to describe the properties of the task (i.e., task characteristics), of the knowledge to be combined (i.e., knowledge characteristics), and of the interplay between subjects in the process (i.e., relational characteristics). As such, this literature describes why the knowledge integration process to solve a problem becomes more *simple or difficult* as certain characteristics increase or decrease. In line with Tell (2011), these problem characteristics can each be thought of as a continuum, from lowest possible to highest possible. For example, a task can be more or less complex, knowledge can be more or less specialized, and a group of individuals can have more or less trust in each other.

Importantly, different problem characteristics can be influential simultaneously. Hence, a problem can be both uncertain, involve tacit knowledge, and be undertaken by subjects without trust in one another. 'Problem difficulty' thus refers to the aggregate level of difficulty that is imposed by the categories of characteristics. Given the number of characteristics in each category, it would be quite overwhelming to elaborate in detail on potential inter-relationships between characteristics. A pragmatic approach will thus be employed, in which a premium is placed on what the literature says about how each characteristic influences knowledge integration and what individuals in firms can do to facilitate integration when the characteristic is present.

2.5.2 Task characteristics

Five task characteristics were identified in the literature:

- Complexity
- Uncertainty
- Novelty
- Frequency
- Heterogeneity

2.5.2.1 Complexity

Complexity is an established task characteristic in the knowledge integration literature (Carlile & Rebentisch, 2003; Grandori, 2001; Grant, 1996b; Nickerson & Zenger, 2004; Zollo & Winter, 2002). Three types of complexity could be distinguished in this literature: *analyzability* (Perrow, 1970), *decomposability* (Simon, 1962, 1973), and *interdependence* (Thompson, 1967). Simon (1962), focusing especially on *decomposability*, proposed a pragmatic meaning of complexity:

> Roughly, by a complex system I mean one made up of a large number of parts that interact in a nonsimple way. In such systems, the whole is more than the sum of the parts, not in an ultimate, metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole. In the face of complexity, an in-principle reductionist may be at the same time a pragmatic holist. (Simon, 1962, p. 468)

The general pattern to be expected is that more complexity makes a task more challenging, leading to more costly integration of knowledge (*ceteris paribus*).

2.5.2.2 Uncertainty

Together with complexity, *uncertainty* is arguably the task characteristic which has attracted the most attention in previous research (e.g., Enberg, 2007; Melander & Tell, 2014; Tell, 2011; Zollo & Winter, 2002). The overall pattern to be expected is that more uncertainty will lead to more costly integration of knowledge (*ceteris paribus*). An additional pattern to be expected is that the firm will attempt to reduce uncertainty. Compare with the ‘uncertainty-reduction hypothesis’ by Hogg and Mullin (1999), and that knowledge integration will be used for that purpose (Beckman et al., 2004; Hogg & Terry, 2000; Kamps & Pólos, 1999).

Three major types of uncertainty in the literature are *risk* (Knight, 1921), *ambiguity* (Zollo & Winter, 2002), and *uncertainty* (Casciaro, 2003; Milliken, 1987). Knight (1921) theorized that there is a fundamental difference between 'risk' and 'uncertainty,' which is grounded in whether the probability of an outcome is unmeasurable (cf. unknown). Elaborating on this further, Alvarez and Barney (2005) used the analogy of rolling a die to distinguish between the meaning of these three types of uncertainties. Starting with *risky* decisions, they explained that making *"risky investment decisions is analogous to rolling a die known to have six sides and known to be fair and balanced"* (Alvarez & Barney, 2005, p. 778), i.e., where the range and probabilities of outcomes are, thus, known *ex ante*. In the case of *uncertainty*, both the properties of the die and its probable distribution of outcomes are not known *ex ante*. *Ambiguity* can be conceptualized as being in between risk and uncertainty, where decision-makers *ex ante* know the possible outcomes but not the probabilities involved (Alvarez & Barney, 2005).

For simplicity, this study will sort all three meanings (risk, ambiguity, and uncertainty) under the same rubric of uncertainty. These nuances, however, are relevant to be able to interpret different observations correctly. In addition to these three meanings of uncertainty, there are other types of uncertainty which further explain implications for knowledge integration:

- *Environmental uncertainty*, in the internal and external environment (Beckman et al., 2004; Duncan, 1972; Jauch & Kraft, 1986);
- *Perceived and objective uncertainty*, e.g., Jauch and Kraft (1986), which differentiates between a) the objective environment, b) objective environmental uncertainty and c) perceived environmental uncertainty;
- *Primary and secondary uncertainty* (Milliken, 1987; Sutcliffe & Zaheer, 1998), which is similar to Jauch and Kraft (1986) but also references the notions of customers, competitors, and suppliers;
- *Firm-specific and market-specific uncertainty*, which explains the meaning of uncertainty that has its origin in the competitive context of firms and markets (Beckman et al., 2004; Castellucci & Carnabuci, 2017); and
- *Technological uncertainty*, *organizational uncertainty*, and *commercial uncertainty* (Hall et al., 2011; Melander & Tell, 2014), i.e., which mirrors the types of problems and knowledge which were identified and discussed in 2.3.2.

2.5.2.3 Novelty

Multiple authors propose that novelty is a task characteristic that may influence the knowledge integration process (Carlile, 2004; Carlile & Rebentisch, 2003; Takeishi, 2002). However, novelty is not completely discrete relative other task characteristics, such as uncertainty, frequency, and heterogeneity. As such, it may be problematic to pin down exactly how it influences knowledge integration. Arguably, novelty is, however, sufficiently distinct (e.g., has a natural opposite) and there is support in the literature to assert that it matters whether a task involves degrees of novelty or not. Summarizing the literature into an expected pattern, the literature indicates that a higher degree of novelty is expected to lead to more costly integration of knowledge (*ceteris paribus*).

2.5.2.4 Frequency

Thompson (1967) and Galbraith (1974) discussed frequency in terms of *exceptions* and Perrow (1970) discussed frequency in terms of *variability*. Galbraith (1974, p. 29) argued that the frequency of exceptions (i.e., in relation to *rules*) is an important factor, given *"goal setting, hierarchy, and rules"* as the main principles. Similarly, Enberg (2007) argued that exceptions are relevant because *"variability influenced the extent to which a task was predictable and thus the choice of integration mechanism"* (Enberg, 2007, p. 24).

Zollo and Winter (2002) suggested that task frequency, heterogeneity, and causal ambiguity require certain learning mechanisms. For tasks with a low frequency, Zollo and Winter (2002) suggested that knowledge articulation and codification are more effective integration mechanisms than a tacit accumulation of past experiences. Conversely, Zollo and Winter (2002) argued that the benefits of routines and tacit experience accumulation increase when task frequency is high. All things considered, the previous literature indicated that lower frequency leads to a need for more costly integration mechanisms (*ceteris paribus*).

2.5.2.5 Heterogeneity

Zollo and Winter (2002) discussed heterogeneity as *"variance in the characteristics of the task as it presents itself in different occurrences presents a different, albeit related, type of challenge with respect to the frequency problem"* (Zollo & Winter, 2002, p. 347). Moreover, Zollo and Winter (2002) suggested that there is a difference between heterogeneity and frequency:

> individuals have to make inferences as to the applicability of lessons learned in the context of past experiences to the task presently at hand. As task heterogeneity increases, inferences become more difficult to make and, when made, they are more likely to generate inappropriate generalizations and poorer performance. (Zollo & Winter, 2002, pp. 347–348)

Zollo and Winter (2002) consequently proposed that low task heterogeneity is likely facilitated by routines and tacit experience accumulation, and that high task heterogeneity is likely facilitated by knowledge articulation and codification. Overall, a higher degree of heterogeneity will be expected to lead to more costly integration of knowledge (*ceteris paribus*).

2.5.3 Knowledge characteristics

The following knowledge characteristics will be discussed in this section:

- Specialization (cf. knowledge 'depth')
- Differentiation (cf. knowledge 'breadth')
- Relatedness
- Complementarity
- Tacitness
- Locus (cf. 'internal'/'external')

2.5.3.1 Specialization

To produce something new arguably involves knowledge growth, either through deeper specialization or through new knowledge about how to combine existing knowledge. Consequently, to integrate *specialized* knowledge is considered central to the resolution of most conceivable problems (e.g., Carlile, 2002; Grant, 1996b; Kogut & Zander, 1996). The expected influence of specialization is straightforward: deeper specialization is (*ceteris paribus*) expected to lead to more costly integration of knowledge (Brusoni et al., 2005; Carlile, 2002; De Luca & Atuahene-Gima, 2007; Grant, 1996b; Nagle & Teodoridis, 2020; Postrel, 2002; Takeuchi & Nonaka, 1986; Tell, 2017; Zhou & Li, 2012).

2.5.3.2 Differentiation

Knowledge differentiation is often explained as a by-product of the division of labor (Huang & Newell, 2003). Various terms and concepts are used in the reviewed literature to describe this characteristic; for example, *knowledge breadth* (Brusoni et al., 2005), *domain-specific boundaries* (Engstrand & Enberg, 2020; Frishammar et al., 2012; Malik et al., 2020; Rundquist, 2014; Tell, 2017), *epistemic communities* (Håkanson, 2010), and *communities-of-practice* (Brown & Duguid, 1991). A high degree of knowledge differentiation can be juxtaposed with *shared* or *collective* knowledge, i.e., that an overlap of knowledge is the logical opposite of having different knowledge (Grant, 1996b; Postrel, 2002).

An implication of this characteristic is that it leads to decisions about how much of the differentiated knowledge needs to become collectively shared for a problem to be resolved. The general expectation is that more differentiation (*ceteris paribus*) will lead to more costly integration of knowledge (Grandori, 2001; Grant, 1996b). Note that this expectation stems from the previously outlined premise of bounded rationality (Simon, 1947, 1956; Tversky & Kahneman, 1974), which implies that problems that require multiple different specializations typically require the involvement of multiple individuals. The involvement of multiple individuals is, in turn, expected to lead to additional problems of coordination and collaboration (Johansson et al., 2011; Kogut & Zander, 1996; Postrel, 2017).

2.5.3.3 Relatedness

The relatedness of knowledge concerns the *distance* or *boundary* between different knowledge specializations, specifically describing *how different* the knowledge in question is. According to Breschi et al. (2003), there are three categories of knowledge relatedness: proximity, commonality, and complementarity. Breschi et al. (2003) use these categories to outline a knowledge-relatedness hypothesis that:

> firms follow a coherent pattern of technological diversification, which clusters around groups of technologies that share a common or complementary knowledge base, rely upon common scientific principles or have similar heuristics of search. (Breschi et al., 2003, p. 70)

The expected influence of this characteristic is that more relatedness of knowledge facilitates integration of knowledge and, conversely, that less knowledge relatedness leads to more costly integration of knowledge (*ceteris paribus*).

2.5.3.4 Complementarity

The idea of complementarity of knowledge originates from the concept of *asset complementarities* in the resource-based view (Amit & Schoemaker, 1993; Barney et al., 2011; Teece et al., 1994, 1997). Complementarity can be understood as another facet of knowledge differentiation, i.e., alongside relatedness (Breschi et al., 2003; Tanriverdi & Venkatraman, 2005). Tanriverdi and Venkatraman (2005) proposed that synergies (cf. 'complementarities') can come from different kinds of knowledge relatedness, namely the *"relatedness of product knowledge, relatedness of customer knowledge, and relatedness of managerial knowledge"* (Tanriverdi & Venkatraman, 2005, p. 103). Moreover, Tanriverdi and Venkatraman (2005) argued that the *"three types of knowledge relatedness are also complementary to each other,"* and that their *"coexistence can create additional, super-additive value synergies that are not captured by any one of them in isolation"* (Tanriverdi & Venkatraman, 2005, p. 103). The proposed relationship between boundary complexity and innovation novelty, by Van de Ven and Zahra (2017), also builds on a logic of complementarity:

> when knowledge boundaries are simple, that is there is little difference or dependence, and there is clear understanding among the parties involved, this similar knowledge is unlikely to promote radically novel recombinations. A moderate level of boundary complexity will result in novel and non-obvious recombinations because the parties involved are likely to recognize that their specialized knowledge is different, complementary, and interdependent, yet understandable. (Van de Ven & Zahra, 2017, p. 245)

Beyond a certain point of higher boundary complexity, Van de Ven and Zahra (2017) thus indicated that synergies begin to dissipate (cf. curvilinear relationship) due to the difficulties for individuals to understand each other and recognize potentially valuable recombinations. In summary, less complementarity does not lead to more costly integration in absolute terms. On the contrary, more similarity (i.e., higher relatedness) is expected to lead to less costly integration. However, the *relative* benefits of combining knowledge are expected to be higher when there is more complementarity (Enberg, 2007; Salunke et al., 2019). Consequently, because of such synergies, the expected net-effect is that less complementarity (*ceteris paribus*) leads to more costly integration when confronting difficult problems (Breschi et al., 2003; Burgers et al., 2008; Enberg, 2007; Nickerson & Zenger, 2004; Salunke et al., 2019; Tanriverdi & Venkatraman, 2005; Van de Ven & Zahra, 2017).

2.5.3.5 Tacitness

Grant (1996b) argued that a critical distinction lies between the *"transferability and the mechanisms for transfer across individuals, across space, and across time"* (Grant, 1996b, p. 111) of explicit knowledge (cf. *'knowing about'* facts and theories) and tacit knowledge (cf. *'knowing how'*). The most common reference on this phenomenon of tacitness of knowledge is Polanyi, who argued that *"we can know more than we can tell"* (Polanyi, 1966, p. 4). Following the same logic, Nonaka and von Krogh (2009) later defined tacit knowledge as *"knowledge that is unarticulated and tied to the senses, movement skills, physical experiences, intuition, or implicit rules of thumb"* (Nonaka & von Krogh, 2009, p. 635).

Tacit knowledge is thus distinct from information or knowledge which allows for ease of transfer to other individuals through *articulation* or *codification* (Szulanski, 1996; Van de Ven & Zahra, 2017; Zollo & Winter, 2002). Nonaka and von Krogh (2009) conceptualized tacitness as a continuum in which explicitness is the other extreme, and employed Nonaka's (1994) 'SECI-model' to explain how tacit knowledge can be converted into more explicit forms:

> Knowledge loses some of its "tacitness" through the process of externalization. As it moves along the continuum to become more explicit, knowledge becomes a basis for reflection and conscious action, and, as Grant (1996) remarks, it becomes less costly to share with others. (Nonaka & von Krogh, 2009, p. 642)

The overall pattern to be expected is that higher degrees of knowledge tacitness leads to more costly knowledge integration (*ceteris paribus*). This point is often made in reference to instances where information can easily be codified or articulated, which in turn enables mechanisms with considerably lower costs, e.g., through better economies of scale. (Grant, 1996b; Nonaka, 1994; Nonaka et al., 2000; Nonaka & von Krogh, 2009; Spender, 1996; Szulanski, 1996; Zollo & Winter, 2002).

2.5.3.6 Locus

A rudimentary requirement for integration of knowledge is that individuals have access to knowledge. Most literature discuss this location of knowledge in terms of being either internal or external to a firm (cf. Tell, 2011). Like other knowledge characteristics, the internal/external dimension can be understood as a spectrum, in which there are multiple levels of knowledge sources which are increasingly external, and thus distant for an individual to access. Evidently, knowledge residing in an individual or the team of individuals who is responsible for solving a problem is the most accessible source of knowledge. Knowledge is then decreasingly accessible when located in another team, department/organizational unit, firm, joint venture, and alliance or partnership (e.g., Bacon et al., 2020; Czakon et al., 2020; Enberg, 2012; Grant & Baden-Fuller, 2004). Fierce competitors are arguably the least accessible source of knowledge, since these subjects are unlikely to share knowledge without significant compensation (i.e., unless it is in their best interest). In summary, the literature indicated that it (*ceteris paribus*) is less costly to find and access knowledge in internal sources, i.e., in proximity to the subject responsible for a task, than it is to find, negotiate, and coordinate with more distant, potentially external sources (Becker & Zirpoli, 2003; L. Bengtsson et al., 2017; Dibiaggio, 2007; Mitchell, 2006; Takeishi, 2002; Tell, 2011).

Another way of conceptualizing the locus of knowledge is to instead consider the *absence* or *existence* of knowledge (Kraaijenbrink et al., 2010; Spender, 2008, 2014a). This view is inspired by the distinction between uncertainty and risk in the task-dimension (Alvarez & Barney, 2005; Knight, 1921). Risk implies that there is information on which to base an analysis (cf. the analogy in 2.5.2.2 regarding the range and probabilities of a die). Uncertainty, on the other hand, implies *absence* of data on which to base judgments. The expected implication of knowledge absence is the same as for a locus in the internal/external dimension, namely that it (*ceteris paribus*) is more costly to integrate knowledge when the problem is characterized by an absence of knowledge.

2.5.4 Relational characteristics

There were multiple alternative conceptions of this category of characteristics, for example, *relational characteristics* (Bacon et al., 2019, 2020; Tell, 2011), *individual-specific boundaries* (Tell, 2017), and *organization level factors* (Brusoni & Prencipe, 2011). The common feature is that they all describe how the process is influenced by the interplay between subjects who attempt to integrate knowledge. The following characteristics will be discussed:

- Trust and Social capital
- Coupling
- Collective identity and aspirations
- History and path dependence
- Proximity

2.5.4.1 Trust and Social capital

Several authors propose that *trust* between subjects is a characteristic, which may influence knowledge integration (Newell et al., 2004; Szulanski, 2000; Szulanski et al., 2004; Tsai & Ghoshal, 1998). One way in which trust has been researched is through the concept of *social capital* (Adler & Kwon, 2002; Bhandar et al., 2007; Inkpen & Tsang, 2005; Newell et al., 2004; Tsai & Ghoshal, 1998; Weber & Weber, 2007). A similar concept in Zahra et al. (2020) was *relational resources*, which *"denote the extent of the shared experiences among group members and the consequent trust and common understanding that exists among them"* (Zahra et al., 2020, p. 167). Newell et al. (2004) argued that when:

> team members have not worked together as a unit before, considerable effort and resource will need to be invested by both managers and team members in the development of such a community (Brown and Duguid, 1991) to enable members to engage in the 'generative dance' (Cook and Brown, 1999) that leads to knowledge integration. (Newell et al., 2004, p. 55)

Adler and Kwon (2002) proposed that three conditions need to be met in order for social capital to exist in a structure: opportunity, motivation, and ability. Bhandar et al. (2007) consequently define social capital as a *"naturally occurring resource"* which *"emerges in a structure due to the presence of OMA [i.e., opportunity, motivation, and ability] of participating members, and that facilitates action towards the goal of the structure"* (Bhandar et al., 2007, p. 265). Regarding the influence of social capital on knowledge integration, Connell & Voola (2013) referenced Fukuyama (1995), which argued that the *"the economic function of social capital is to reduce the transaction costs associated with formal coordination mechanisms like contracts, hierarchies, bureaucratic rules and the like"* (Fukuyama, 1995 cited in Connell & Voola, 2013, p. 220).

Similarly, Bhandar et al. (2007) argued that social capital *"can manifest itself in the form of trust, cooperation, obligations, power, collective identity, and so forth"* (Bhandar et al., 2007, p. 265) and that social capital thus *"can be leveraged for effective knowledge integration"* (Bhandar et al., 2007, p. 272). Newell et al. (2004) introduced an additional distinction between two types of social capital: 'external bridging social capital' and 'internal bonding social capital.' Newell et al. (2004) observed how these interact best in a sequence: strong internal bonding social capital is needed initially to create a *"cohesive social unit"* that is then able to *"effectively integrate knowledge that is acquired through members' bridging activity"* (Newell et al., 2004, p. 43).

In summary, the literature proposed that more social capital facilitates effective integration, i.e., which (*ceteris paribus*) leads to less costly integration of knowledge (Adler & Kwon, 2002; Alavi & Tiwana, 2002; Bhandar et al., 2007; Inkpen & Tsang, 2005; Newell et al., 2004; Robert et al., 2008; Willem et al., 2008; Zahra et al., 2020). Newell et al. (2004), however, also pointed out that there are potential drawbacks of social capital, such as conformity and groupthink (cf. Janis, 1972), which, in turn, can have adverse effects on knowledge integration.

2.5.4.2 Coupling

Fliaster and Golly (2014, p. 127) argued that too much of previous knowledge integration research have focused on *formal* mechanisms, such as reports, memos and formal meetings for information sharing, relative to the *informal* structures in play (cf. Zhao & Anand, 2013). A useful concept to make sense of the influence by informal social structures is the notion of *coupling* by Weick (1976). Orton and Weick (1990), for example, stated that the *"loose coupling concept may help theorists to understand is the fluidity, complexity, and social construction of organizational structure"* (Orton & Weick, 1990, p. 218). Broadly, Weick (1976) argued that *"loosely coupled system should be relatively inexpensive to run because it takes time and money to coordinate people"* (Weick, 1976, p. 8). An explanation for this was that loose coupling facilitates 'localized adoption' without effecting the whole system (Weick, 1976). Loosely coupled subsystems may thus be especially beneficial in more difficult knowledge integration efforts, since it enables the organization to *"retain a greater number of mutations and novel solutions than would be the case with a tightly coupled system"* (Weick, 1976, p. 7).

Within knowledge integration, this view is adopted in contributions on modularity of product or technical architecture (Brusoni et al., 2001; Brusoni & Prencipe, 2001, 2011; Ceci & Prencipe, 2017; Sanchez, 1999; Sanchez & Mahoney, 1996). In Sanchez and Mahoney (1996), it was, for example, proposed that modularity in the product dimension can enable organizational setups that are less interaction-intensive.[29] The extent of this effect is however nuanced in Brusoni and Prencipe (2001) and Ceci and Prencipe (2017). Brusoni et al. (2001), for example, argued that product modularity does not necessarily *"derive from, nor bring about, knowledge modularization"* (Brusoni & Prencipe, 2001, p. 202).

In summary, the effect of coupling as a relational characteristic can be expected to depend more on other problem characteristics than on having a uniform influence on knowledge integration on its own. In the resolution of difficult problems, such

[29] *"The information structure of a modular product architecture provides the 'glue' of embedded coordination"* (Sanchez & Mahoney, 1996, p. 66).

as involving task characteristics like high complexity and uncertainty, the literature indicated that loose coupling facilitates integration, i.e., leading to less costly knowledge integration (*ceteris paribus*). In contexts which favor standardization (e.g., high task frequency and low uncertainty), on the other hand, Weick (1976) proposes that a *"loosely coupled system might exhibit fewer of these presumed benefits"* (Weick, 1976, p. 7).

2.5.4.3 Collective identity and aspirations

Next, there can be a higher or lower degree of collective identity and aspiration (cf. 'objective') among subjects (Tell, 2011). Newell et al. (2004) proposed that this is relevant since efficient integration depends on the *"willingness on the part of project team members to subordinate their individual desires to project objectives"* and *"resilient trust based upon ongoing reciprocity norms"* (Newell et al., 2004, p. 56). Willem et al. (2008) agreed that this characteristic is of significance for knowledge integration, proposing that *"identification gave people a common goal, which resulted in very low rivalry and in high levels of trust and cooperation; a situation that is required for a high level of knowledge integration"* (Willem et al., 2008, p. 379).

The understanding of a 'common goal' can be discussed in terms of actors' mental *representation* of a task (Mohammed & Dumville, 2001; Rico et al., 2008; Runsten, 2017; Runsten & Werr, 2020; Werr & Runsten, 2013). Three variables for how to measure 'representation' were employed in Runsten and Werr (2020): 'clear' (i.e., how clear the *"understanding of purpose and direction"* is in a team), 'whole task' (i.e., how *"the task is being perceived as unified and meaningful"*), and 'expertise location' (i.e., the *"understanding of the organization of the transactive memory system"*) (Runsten & Werr, 2020, pp. 12–13). Regarding the influence of this characteristic on knowledge integration, Werr and Runsten (2013) argued that 'collectives' (i.e., groups of subjects) which coordinate effectively *"do so based on a shared understanding (representation) of how their tasks, knowledge and skills are interrelated with others in the system and act in accordance with this understanding"* (Werr & Runsten, 2013, p. 121).

Furthermore, on the topic of goal alignment in interorganizational knowledge integration, Werr and Runsten (2013) suggested that such:

> representations, rather than dividing and separating responsibilities should create broader and overlapping role representations encouraging the creation of integrative teams in which individuals interact towards a shared purpose, and where "invading" into others' areas of responsibility is regarded as helpful rather than inappropriate. (Werr & Runsten, 2013, p. 130)

A higher degree of collective identity and aspirations thus appear to facilitate coordination of subjects. While the costs of installing and maintaining this relational characteristic may vary, the general implication is (*ceteris paribus*) that higher degrees of collective identity and aspirations appear to lead to less costly knowledge integration (Bhandar et al., 2007; Newell et al., 2004; Tsai & Ghoshal, 1998; Werr & Runsten, 2013; Willem et al., 2008). In addition, there appears to be a connection between this characteristic and the characteristic of trust and social capital (see 2.5.4.1). For example, Bhandar et al. (2007) argued that social capital is important when *"developing cohesion within the structure, aligning stakeholders to the collective's goal and reducing the time and effort associated with developing an agreement in the network"* (Bhandar et al., 2007, p. 264).

2.5.4.4 History and path dependence

The historical context provides a scene for the interplay between subjects, in which path dependence of organizational processes influences the knowledge integration process (Berggren et al., 2017; Carlile & Rebentisch, 2003; Cestino & Matthews, 2016; Kogut & Zander, 1996; R. Singh et al., 2015; Sydow et al., 2009). The concept of path dependence has also been developed into the concepts of path creation (Garud et al., 2010; Garud & Karnøe, 2001) and path constitution (R. Singh et al., 2015; Sydow, Windeler, Schubert, et al., 2012; Sydow, Windeler, Müller-Seitz, et al., 2012b). Notably, the concept of path constitution explicitly builds on structuration theory (Giddens, 1984) and integrates two contrasting perspectives (cf. 2.4.3): 'path dependence' which *"focuses on historically embedded, contingent processes that are more or less beyond the control of actors"* (R. Singh et al., 2015, p. 643), and 'path creation' which *"emphasizes mindful contributions from powerful actors"* (R. Singh et al., 2015, p. 643).

Note, however, that the literature on path dependence is not constrained by the relational dimension, i.e., the interplay between subjects in the knowledge integration process. For example (outside the scope of knowledge integration theory), the contributions by Arthur (1989) and David (1985) deal with paths of technology, the contributions by Cohen and Levinthal (1990) and Zahra and George (2002) deal with paths of knowledge, and the contribution by Christensen (1997) deals with paths of businesses.

Within the scope of knowledge integration theory, Berggren et al. (2017) proposed a process of organizational path dependence in which three phases were identified: 'initial conditions,' 'self-reinforcement,' and 'lock-in.' These three phases were also reflected in the work by Garud et al. (2010), who argued that *"from this perspective, 'initial conditions' are not given, 'contingencies' are emergent contexts for action, 'self-reinforcing mechanisms' are strategically manipulated, and 'lock-in' is but a temporary stabilization of paths in-the-making"* (Garud et al., 2010, p. 760).

The expected influence of historical paths to knowledge integration was not possible to determine in general terms, as the literature foremost point out that this is a matter of the interplay between agency and structure in a specific context (Giddens, 1984; R. Singh et al., 2015). What can be deduced, however, is that if there are initial conditions at play (i.e., which creates self-reinforcing mechanisms) that are in *contradiction* with the objectives of a knowledge integration process (see 2.3), this characteristic (history and path dependence) logically appears to lead to more costly knowledge integration (i.e., due to subjects having to 'swim upstream').

2.5.4.5 Proximity

While spatial and temporal boundaries (cf. Tell, 2017) are in play across all three categories of characteristics, *proximity* (i.e., physical distance) between individuals can be discussed as a discrete relational characteristic (Boschma & Frenken, 2009; Crescenzi et al., 2007; Morgan, 2004; J. Singh, 2008). Geographical proximity refers to *"the physical distance between actors in absolute (e.g., miles) or relative (e.g., travel time) terms"* (Tell, 2017, p. 26). Proximity appears to facilitate knowledge integration, i.e., that lesser distance between individuals makes integration of knowledge less costly (*ceteris paribus*). For example, Boschma and Frenken (2009) argued that innovation typically benefits from geographical proximity, since face-to-face interactions between individuals become both easier and less costly under high proximity.

2.5.5 Mechanisms for integration of knowledge

The literature on integration mechanisms which individuals and firms can employ is quite extensive. The prevalence of these mechanisms is quite uncontroversial and will thus not be problematized. The main theoretical problem, instead, concerns *when* certain mechanisms should be employed and *why*. More on this in forthcoming 2.5.6, on a heuristic relationship between problem difficulty and mechanism costs.

In this section, various mechanisms to integrate knowledge that can be expected to be observed in a knowledge integration process will be presented. First, mechanisms that foremost are employed at the individual level and, second, group-level mechanisms which are deployed to organize efforts by multiple individuals. This division is far from waterproof but is still constructive since it infers the nature of the respective type of subject (see 2.4).

2.5.5.1 Individual-level mechanisms

On the most basic level, the least (directly) costly mechanism for firms to employ is for an individual to act alone to solve a focal problem. Individuals have a range of cognitive tools at their disposal which can be mobilized to solve a problem, such as computation, analysis, structured problem-solving, decomposition, search for existing knowledge, visualization, prototyping, and so forth (Grandori, 2001; March, 1991; Spender, 2014a; Tell, 2017).

There are also approaches which have mapped types of mechanisms to certain characteristics for knowledge integration, especially concerning the knowledge dimension (see 2.5.3). Tell (2017), for example, maps fifteen types of mechanisms (e.g., hypothesis, dialogue, socialization, and concept formation) as the combination of five types of *learning activities* (search, acquisition, assimilation, accumulation, and transformation) and three dimensions of knowledge articulability (tacit, articulated, and codified). Another attempt by Van de Ven and Zahra (2017) proposes nine types of mechanisms, as a combination of three linguistic barriers (cf. Carlile, 2004) and three degrees of knowledge complexity. Nickerson and Zenger (2004) similarly linked different levels of problem decomposability (cf. ‘complexity in 2.5.2.1) to the relative benefit of directional search (for fully decomposable problems) and heuristic search (for nondecomposable problems).

Van de Ven and Zahra (2017) also incorporate the use of *boundary objects* as an alternative mechanism (Carlile, 2002; Kravchenko & Swan, 2017; Star, 1989). Carlile (2002, p. 451) applies Star (1989) to categorize four types of boundary objects: repositories, standardized forms and methods, objects or models,[30] and maps of boundaries.[31]

However, since individuals are limited by bounded rationality (Simon, 1947; Tversky & Kahneman, 1974) and thus are not omniscient, there are limitations to the scope of problems that an individual can solve on her/his own. This is especially the case as problem difficulty increases, and more types of knowledge specializations are required. While coordination and collaboration costs are minimal for individual problem-solving, the allure of individual work is balanced by its lack of effectiveness in solving difficult problems. Competitive pressure arguably exacerbates this point, as time might be of the essence.

2.5.5.2 Group-level mechanisms

There are multiple concepts which describe the mechanism of involving multiple individuals (i.e., groups) to solve a focal problem, such as *group-problem solving* (Grant, 1996b), *problem-solving in communities of practice* (Grandori, 2001), *interdependent problem-solving* (von Hippel, 1990), 1990), *mutual adjustment* (Enberg, 2007; Perrow, 1970; Thompson, 1967), *problem-solving* (Nickerson & Zenger, 2004), and *joint problem-solving* (Postrel, 2017). Similarly, Ghoshal et al. (1994) use the concept of *lateral network mechanisms* to describe joint work in meetings, task forces, and teams.

The main benefit of mechanisms that involve multiple individuals is that they enable multiple, different specializations to be integrated. However, this benefit comes with the cost of managing coordination and collaboration problems arising from the involvement of multiple subjects. It is also known how some characteristics may

[30] Referring to *“sketches, assembly drawings, parts, prototype assemblies, mockups, and computer simulations”* (Carlile, 2002, p. 451).

[31] Referring to *“Gantt charts, process maps, workflow matrices, and computer simulations”* (Carlile, 2002, p. 451).

further increase the costs of employing group-level mechanisms, for example, a high degree of tacitness (see 2.5.3.5) or complexity (see 2.5.2.1).

Also, the involvement of multiple individuals leads to problems of organization, such as decisions about *resource allocation* (Bower, 1970, 2017; Burgelman, 1983) and *rules and directives* (Grant, 1996b). This leads us to mechanisms in the form of *structural* arrangements and *procedural* arrangements in organizations. Implications of different organizational structures (e.g., Boone & Ganeshan, 2008; Galbraith, 1974; Miles et al., 1997) have constructively been applied to explain integration of knowledge (Ghoshal et al., 1994; Ravasi & Verona, 2001). Examples of mechanisms which can be sorted as structural arrangements include *hierarchy* (e.g., Bhandari & Colomo-Palacios, 2019; Enberg, 2007), and multipolarity, fluidity, and interconnectedness (Ravasi & Verona, 2001). Additional established concepts about organizational structure which may be relevant for this study but are outside the scope of knowledge integration, include, for example, *adhocracy* (Mintzberg, 1979), *J-form* (Aoki, 1988; Nonaka & Takeuchi, 1995), *the innovative enterprise* (Lazonick & West, 1998), *organizational innovation* (Lam, 2006a), *external linkages* (Teece, 1998), and *the spaghetti organization* (Foss, 2003).

Procedural arrangements are also emphasized by several authors as a means of integrating knowledge more efficiently and effectively (Annosi et al., 2020; Frishammar et al., 2012; Lindkvist et al., 1998; Pisano, 1994; Szulanski, 2000; Takeuchi & Nonaka, 1986). In the procedural dimension, multiple types of mechanisms have been researched such as *sequencing* and *planning* (Enberg, 2007; Grant, 1996b; Lindkvist et al., 1998), and *agile* (Annosi et al., 2020; Dingsøyr et al., 2012; Takeuchi & Nonaka, 1986). Grant (1996b) is one of multiple authors who hence emphasized *sequencing* as a type of mechanism. Lindkvist et al. (1998) elaborate on this issue further in their work on *project* logics, grounded in the observation that traditional (sequential) models appear to become obsolete or even counterproductive in advanced knowledge integration efforts, e.g., due to uncertainty and complexity.

Although not related to knowledge integration *per se*, there is also a lot of literature on project methodologies (such as *stage-gate*), which go deeper into how work can be procedurally arranged (Cooper, 1990, 2008; Cooper & Sommer, 2016). This brings us to knowledge about *agile*, which is an iterative alternative to the more sequential stage-gate method (Annosi et al., 2020; Bredin et al., 2017; Chan & Thong, 2009; Dingsøyr et al., 2012). Takeuchi and Nonaka (1986) were pioneers in the study of SCRUM, which later evolved into what today is referred to as agile. They argued that to compete in increasingly difficult settings, firms need to adopt different ways of managing their product development processes that improve speed and flexibility. They also argued that firms need to embrace a management style that is suitable for the new type of process. This involves a recognition that *"product development seldom proceeds in a linear and static"* or *"totally rational and consistent manner"* but *"involves an iterative and dynamic process of trial and* *error"* (Takeuchi & Nonaka, 1986, p. 145). Notably, this procedural configuration prescribes a structural arrangement in which *adaptability* is an important feature (cf. Ravasi & Verona, 2001). In a piece which indicates differences between industries, Annosi et al. (2020) pointed out that applications of agile have increasingly been attempted *outside* the domain of software development, i.e., the domain for which agile (i.e., not to be confused with SCRUM) was first conceived.

Routines are another prominent type of mechanism for integration in the reviewed literature in which knowledge about past solutions is retained and re-used for frequent tasks, i.e., instead of individuals having to re-invent the wheel (Grant, 1996b; Salunke et al., 2019; Xi et al., 2020; Zollo & Winter, 2002). As was made clear in the section on task characteristics (2.5.2), the utility of routines clearly diminishes when frequency decreases, and novelty and uncertainty increase.

Lastly, it might be clarified that some 'boundary objects' (Carlile, 2002; Kravchenko & Swan, 2017; Star, 1989) might be better described as group-level mechanisms than as mechanisms on the individual-level. For example, modular product architectures (see 2.5.4.2) and organizational arrangements (see 2.3.2.5).

2.5.6 A heuristic relationship between problem difficulty and mechanism cost

2.5.6.1 A proposed heuristic

The literature on factors influencing knowledge integration is very fragmented and rarely converge into clear frameworks which cumulatively build on one another. A pattern regarding problem difficulty and mechanisms for integration, however, emerges from the review of previous research.[32] This relationship is neither very specific nor proposed to be universal. Instead, it should be interpreted as *heuristic*. This conception relies on two assumptions, namely that:

- Different problems are associated with different levels of aggregated difficulty, on a spectrum from 'simple' to 'difficult' and
- Different mechanisms for integration are associated with different costs, on a spectrum from 'less costly' to 'more costly.'

[32] (For example, Annosi et al., 2020; Argote & Ingram, 2000; Baxter et al., 2013; Berggren et al., 2017; Carlile, 2004; Carlile & Rebentisch, 2003; Enberg, 2007; Grandori, 2001; Okhuysen & Eisenhardt, 2002; Tell, 2011; Van de Ven & Zahra, 2017; Zahra et al., 2020; Zollo & Winter, 2002)

The heuristic relationship combines the two assumptions to propose that:

- *More difficult* problems can be expected to require *more costly* integration mechanisms and
- *Less difficult* problems can be expected to require *less costly* integration mechanisms.

As an example from the literature, Grandori (2001, p. 389) grounded her argument in the *comparative-cost framework* (Thompson, 1967; Williamson, 1981), in which the *"least costly mechanism for coordinating a certain type of interdependence"* should be employed. Grant (1996b) similarly argued that:

> The main contribution of the knowledge-based view to this discussion is recognition of the high costs of consensus decision making given the difficulties of communicating tacit knowledge. Hence, efficiency in organizations tends to be associated with maximizing the use of rules, routines and other integration mechanisms that economize on communication and knowledge transfer, and reserve problem solving and decision making by teams to unusual, complex, and important tasks. (Grant, 1996b, p. 115)

This proposition by Grant (1996b) is especially important for difficult problems, where the relative share of unusual, complex, and important tasks is larger than for simple problems.

2.5.6.2 On the feasibility of mechanisms

Grandori (2001) argued that the cognitive possibility varies between mechanisms, and consequently proposed that the *feasibility* of applying a mechanism should be accounted for before considering costs:

> A complete logic of mechanism assessment, I submit, should be two-tiered: the first tier should be made of 'possibility theorems' on the applicability domain of mechanisms, the second tier can be made by comparative propositions on the relative 'superiority' of different (feasible) mechanisms. (Grandori, 2001, p. 389)

This observation by Grandori (2001) is an important clarification but does not alter the heuristic relationship between characteristics and mechanism costs. Rather, it is an argument about hierarchy:

> Especially if we are concerned with knowledge growth, and recognize that economic action and organization is driven by knowledge problems and not only by cost issues, it is fruitful to distinguish between the two logics of assessment. Let me call them 'a cognitive failure logic' and a 'cost-benefit failure logic'. (Grandori, 2001, p. 389)

The heuristic relationship between factor difficulty and integration mechanism cost could thus be developed to take Grandori's (2001) feasibility argument into consideration. Accordingly, the best possible management of knowledge integration involves the least costly mechanisms possible, which the problem difficulty *permits*, while still producing an output that achieves the purpose of the integration process. This way of looking at the heuristic relationship would disqualify the use of mechanisms that are not feasible, which is a reasonable assumption to clarify.

2.5.6.3 On the varying costs of mechanisms

Multiple alternative expressions (such as 'costly,' 'elaborate,' 'time-consuming,' 'communication-intensive,' and 'effortful') are used to imply variable costs across mechanisms (Berggren, Bergek, Bengtsson, & Söderlund, 2011, p. 12; Grandori, 2001, p. 389; Grant, 1996b, p. 115; Lawrence & Lorsch, 1967b, p. 47; Nickerson & Zenger, 2004, p. 627; Tell, 2011, p. 29). However, it is not possible to *a priori* determine the costs of each mechanism described in 2.5.5, such as arranging them on a scale from low to high cost. This is because each mechanism can be undertaken with more and less effort, spending more or less time. For example, joint problem-solving can involve many or few individuals, who devote a large or a small share of their employment to this mechanism, during an extended or a very short period.

Also, the efficiency of various mechanisms is arguably subordinated by the actual solution to the problem (i.e., the effectiveness of an output). This view embraces the totality of costs that mechanisms may lead to, both direct and indirect. For example, to exert less effort to solve a problem may be less costly in direct terms but might lead to indirect effects which have significant costs, such as to not solve a problem effectively or to solve the problem too slowly, relative to competitors. Thus, what the management of knowledge integration is optimizing is how a problem can be solved a) effectively and b) with the highest possible efficiency.

2.5.6.4 The strategic relevance of the heuristic relationship between problem difficulty and costs of mechanisms

The proposed heuristic relationship between costs of mechanisms and problem difficulty does not answer *why* this relationship has strategic relevance for firms. Three arguments were identified which underpin why this feature of knowledge integration matters.

First, multiple authors point out an axiom that underpins the proposed heuristic, which is known as the *cost-benefit logic*. For example, regarding integration of external knowledge, L. Bengtsson et al. (2017, p. 96) stated: *"The crucial question, then, is when are the gains from crossing boundaries eaten up by the costs of the efforts required to integrate the external knowledge"* (L. Bengtsson et al., 2017, p. 96). Similarly, Grandori (2001) labeled the instance of using a too expensive mechanism a *"cost-benefit failure logic"* (Grandori, 2001, p. 389). A similar argument was presented by Werr and Runsten (2013), who concluded that *"the extra costs of coordination and potential double work following from overlapping* *role representations need to be offset by the extra value they bring to the joint problem solving process"* (Werr & Runsten, 2013, p. 130).

The second argument is grounded in the potential value ('if-then') of decisions regarding which mechanisms to employ. *If* mechanisms have different costs, *if* the effectiveness of mechanisms varies with problem difficulty and the specific characteristics in play, and *if* subjects make choices about which mechanisms to employ, *then* there are large gains, potentially even the difference between success and failure, which depends on the management of the integration process.

A third argument, which substantiates the second claim, can be deduced from the competitive context in which the integration process is embedded. Given an absence of monopolistic structures (i.e., which offset competition) and given an involvement of multiple firms (i.e., which compete to satisfy the same customer segments' needs), it is superior to produce *the same output at a lower cost* (i.e., as competitors). This could either translate into an equal offering at a lower price for the customer (likely leading to higher volumes sold), or into saved costs for the firm (likely leading to higher profitability). It is also superior to produce *a superior output at the same cost*, since this could enable the firm to command a higher price or lead to larger volumes at the same price as competitors. A firm which consistently exerts either too much or too little effort to solve its problems (i.e., bad management of knowledge integration) should thus expect its offering to become less competitive over time (*ceteris paribus*). As was discussed in 2.3.1, there are, however, few references to this type of influence in the reviewed literature.

2.5.7 The influence of firms' objectives on the management of knowledge integration

2.5.7.1 The role of objectives in the management of knowledge integration

It should not be a stretch to propose that effectiveness of the management of knowledge integration depends on how well it matches to the firm's objectives. Consider, for example, the definitions of 'objectives' (see 2.3.1) and 'management' (see 1.3). Yet, this logical relationship (cf. means-end reasoning) is typically not problematized or discussed explicitly in the reviewed literature. An expected pattern can, however, be pieced together by looking closer at work, which implies, directly or indirectly, how effectiveness of responses depends on the aims in question.

To begin with, there are grounds for this logical proposition in Simon's classic *Administrative Behaviour*, in which Simon (1947) explained that decision-making *"will depend both on the relative weight that is given to the different objectives and on judgment as to the extent to which any given plan will attain each objective"* (Simon, 1947, p. 6). The definition of knowledge integration as the 'purposeful combination' of knowledge (Berggren, Bergek, Bengtsson, & Söderlund, 2011; Tell et al., 2017a) and the reviewed contributions which reference ‘objectives’ or similar concepts (see 1.4.3.3) allude to this feature of management. For example, the means-end logic is implied in Salunke et al. (2019), which discussed a firm’s ‘knowledge integration capability’ as its capacity (i.e., ‘means’) to pursue business opportunities (i.e., ‘end’).

In addition, there is support for this view of effective management in the conceptual reasons to integrate knowledge which were outlined in 1.4.2.2 and 2.3.1. For example, a particular timeframe or specific resource constraints (see 2.3.1.2) arguably influence how a process of knowledge integration ought to be managed, i.e., as there might be multiple ways of approaching the problem to be solved which are not equal in terms of implications for these objectives. The same argument can be presented regarding the common objectives of bringing an offering to the market (see 2.3.1.1) and learning (see 2.3.1.3).

Lastly, there are studies on the relational characteristic of ‘collective identity and aspiration’ (see 2.5.4.3), which implies that the effectiveness of management depends on the achievement of an objective (Bhandar et al., 2007; Newell et al., 2004; Werr & Runsten, 2013; Willem et al., 2008). Specifically, an individual’s understanding of objectives (cf. their ‘representation’ of a task (Runsten, 2017; Runsten & Werr, 2020; Werr & Runsten, 2013)), may improve both coordination and collaboration (cf. 2.1.3). This clearly implies that effective management is relative to the objectives that such a ‘representation’ entails. Accordingly, Werr and Runsten (2013) argued that ‘managers’ (cf. 2.4.1.2) ought to pay more attention to how such ‘representation’ is shaped among subjects.

To summarize, an expected pattern that can be formulated is that the management of knowledge integration seems to be effective relative to the objective that a firm attempts to achieve. However, no established references explicitly proclaim this exact view, which is instead a product of bricolage from a variety of perspectives on objectives and their role in knowledge integration.

2.5.7.2 Integration of different types of knowledge to solve the corresponding type of problem

The review of literature on types of problems and knowledge (see 2.3.2) uncovered several expected patterns. First, the literature quite uniformly suggest that a type of problem requires the corresponding type of knowledge to be resolved (Burgers et al., 2008; Court, 1997; Frishammar et al., 2012; Malik et al., 2020; Ramesh & Tiwana, 1999; Ravasi & Verona, 2001; Tanriverdi & Venkatraman, 2005; Tiwana, 2004). For example, solutions to technological problems require a combination of technological knowledge. Moreover, depth of knowledge in one category does not automatically translate into an aptitude to solve other types of problems. For example, knowledge about how to solve technological problems does not inform how to structurally organize individuals within a firm or how to persuade customers to buy an offering, and vice versa. This is quite aligned with the general logic which underpins knowledge integration theory regarding the need for specialized knowledge to solve problems.

Secondly, there might be problems that have dependencies across more than one type of problem (see 2.3.2.9). For example, objectives may have interdependencies across multiple types of problems, as typically considered in practical methodologies, such as stage-gate (Cooper, 1990, 2008; Cooper & Sommer, 2016) and agile (Annosi et al., 2020; Beck et al., 2001; Bredin et al., 2017; Takeuchi & Nonaka, 1986). The expected pattern in this instance is that multiple categories of knowledge are required (Burgers et al., 2008; Court, 1997; De Luca & Atuahene-Gima, 2007; Frishammar et al., 2012; Ramesh & Tiwana, 1999; Tanriverdi & Venkatraman, 2005; Tiwana, 2004).

2.5.7.3 Social and natural phenomena

Lastly, a more subtle pattern to be expected concerns the differences between knowledge about *natural* (such as technological) versus *social* (such as organizational and commercial) phenomenon. Demarest (1997) pointed this out regarding the purpose of commercial knowledge vis-à-vis philosophical and scientific knowledge:

> This is the essential nature of knowledge, as we have to deal with it commercially: good commercial knowledge, valuable knowledge, is knowledge that works. […] Its truth value is incidental to its ability to generate desirable commercial performances, Commercial knowledge, I would argue, is different in kind, not degree, from philosophical and scientific knowledge. (Demarest, 1997, p. 375)

As such, an expected pattern is that commercial knowledge will adhere to the satisficing principle (Simon, 2018; Winter, 2000). Technological knowledge, on the other hand, will be expected to conform to the laws of nature, which are not susceptible to human intervention. While neither Demarest (1997) nor other reviewed contributions discuss the philosophical status of organizational knowledge, I would propose that the logic underpinning commercial knowledge at least provisionally can be extended to encompass organizational knowledge because organizational problems are profoundly social phenomena, i.e., which can be assumed to be governed largely by the nature of subjects involved in their resolution.

2.6 An output which represents an integration of knowledge

In addition to the definition of the object of study in 2.1, a few remarks can be added regarding how to perceive the output which represents an integration of knowledge (see the framework model for the purpose of this study in 2.2.2).

2.6.1 A dual perspective

Two perspectives will be applied for how to comprehend the output from the knowledge integration process. The first perspective is to position integrated knowledge as the effect which warrants explanation (see 1.2 and 2.2.1). The second perspective is that of integration of knowledge as the solution to problems that are derived from a firm's objectives (see 1.4.2 and 2.3).

2.6.2 Unintended outputs

A potential critique of the above conception is that neither perspective encompasses the phenomenon of *unintended* outputs, even though that this is a known phenomenon outside on literature knowledge integration. For example, the accidental discoveries of penicillin, Viagra, and Valium (Rudd, 2017). Hence, outputs which were *not* part of the objectives that required knowledge integration.

If generous, the ubiquitous feature of *learning* (March, 1991) can be a type of unintended output, in that acquired knowledge may have unintended applications that are not known *a priori* (cf. Arrow, 1962). To the extent that unintended outputs are explicitly discussed in the literature, the main focus has been on *risks* such as unintended knowledge leakages (Enberg, 2012), knowledge disclosure (Czakon et al., 2020), information sharing (Ceci & Prencipe, 2017), or transfer of knowledge to external parties (Argote & Ingram, 2000; Liebeskind, 1996).

2.6.3 Value judgments about the output and the management of knowledge integration

While the effect of integrated knowledge on various performance measures is beyond the scope of this study (see discussion in 2.2.1), it should arguably still be possible to make value judgments about the output from the knowledge integration process. The opposite, to pretend that all outputs are equal, would not only belittle the relevance of the management of knowledge integration but, more problematically, does not make sense.

The extent to which integrated knowledge solves a focal problem can arguably vary in *effectiveness*.[33] For example, a rocket that explodes on the launching pad versus a rocket which delivers its payload. Furthermore, the same output from knowledge integration can arguably be achieved through more or less costly integration mechanisms, i.e., vary in *efficiency*. Combined, this suggests that the worse possible management of a knowledge integration process would be to fail expensively. Conversely, the best possible management of a knowledge integration process would be to succeed inexpensively. This study is committed to advancing our understanding of how individuals and firms can improve how they integrate knowledge (cf. constructing better rockets at a lower cost).

When making value judgments about the output and the quality of the management of the process, it is however important to not become biased by the effects of the integrated knowledge, which may be observed simultaneously. Arguably, appearances can be deceiving, since there are other aspects than the management of knowledge integration which explain variation in performance measures, e.g., initial conditions (Berggren et al., 2017; Porter, 1991) and scarce resources (Barney, 1991; Peteraf, 1993). The point is that firms can be better or worse at taking on a focal problem, and that better management of the process of solving that problem should, at least to some degree, increase the likelihood of achieving a firm's objectives (*ceteris paribus*). If not, efforts to improve knowledge integration practices would be irrelevant. Note that this is not a claim about causality, but an argument that value judgments are relevant in a model in which the output from knowledge integration is the 'dependent variable' (see 2.2.1).

2.7 The preliminary framework

To summarize, the preliminary framework (see Figure B) is structured according to Figure A (see 2.2.2). Rather than a process-model in the sense of stages (such as those reviewed in 2.1.4), this framework represents our current best answer to how the process of knowledge integration can be understood and the purpose of this study can be explained. The literature review outlined the contents of each theoretical module in the model, which are also briefly summarized in Figure B. The role of the preliminary framework in the study will be elaborated in the forthcoming chapter on methodology.

[33] See also objectives which require knowledge integration in 2.3.1.

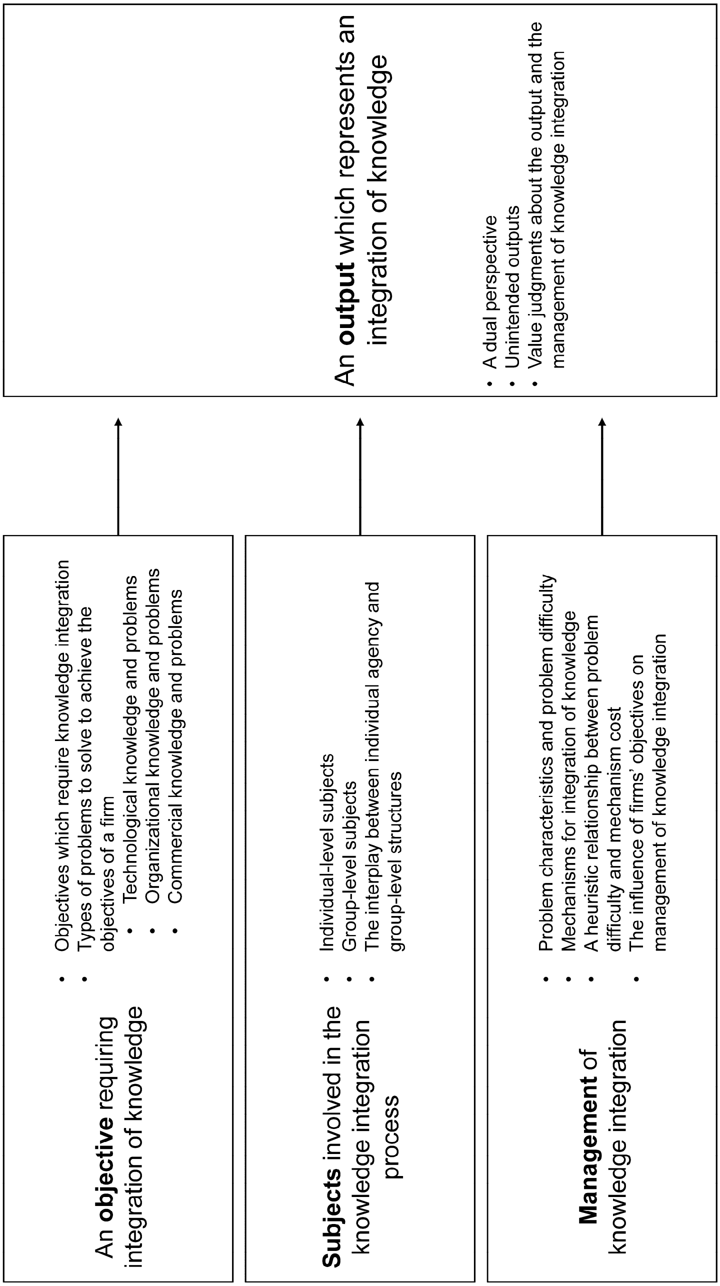


Figure B. The preliminary framework.

3 Methodology

3.1 A case study research design

A case study design was chosen in this research project, based on the nature of the object of study and the aim of developing theoretical propositions. Yin (2009) argued that the case study research design *"comprises an all-encompassing method - covering the logic of design, data collection techniques, and specific approaches to data analysis"* (Yin, 2009, p. 18).

Case studies have multiple benefits relative to other research designs, especially when studying questions of *how* and *why* (Yin, 2009). This is the situation in this study, of asking *how* knowledge integration is influenced by a firm's objectives (see 1.5). Furthermore, the case study research design is considered beneficial when it is difficult to distinguish between the phenomenon in question and the circumstances in which the phenomenon is observed. Typically, the case study facilitates that distinction by allowing for more depth and richness in the data collection, as well as analysis of observations (Eisenhardt, 1989b; Yin, 2009). This benefit is especially important given that this study will involve research on both the individual and the group level (cf. 'collective level' in Yin, 2009). The individual level, especially, benefits from this approach, as the case study-design helps to divide the organization being studied into its atomized yet interdependent parts. Given the purpose of this study, the case study design is hence a superior choice compared with other research methods, such as surveys, experiments, history, and archival analysis (Yin, 2009).

There are, however, significant drawbacks of case studies which ought to be considered. The primary drawback is the relatively limited *breadth* of case study designs (Eisenhardt & Graebner, 2007). This is a natural trade-off of enhancing the depth, i.e., given a somewhat fixed amount of time and attention for the researcher to 'spend.' Furthermore, the degree of generalization can be questioned in case studies, especially in the traditional (statistical) sense (see 3.7). Finally, the enterprise of diving deep into specific circumstances (i.e., the case) naturally impedes the *replicability* of case studies, i.e., as the data collected is a product of conditions at a certain point in time and place.

3.2 Abductive approach

The study is best characterized as abductive, as it involved a mixture of inductive and deductive elements (Alvesson & Sköldberg, 2009; Dubois & Gadde, 2002; Haig, 2008; Timmermans & Tavory, 2012). Alvesson and Sköldberg (2009) claimed that abductive reasoning can leverage the advantages of both inductive and deductive methods. To obtain the best of the two approaches, however, is contingent on taking measures to clarify how the study intends to balance elements from the two approaches. For both induction and deduction, risks are generally mitigated by directing sufficient effort toward reflexive analysis (such as about the researcher's pre-understanding and inclination) and transparency (e.g., in terms of how the study was undertaken).

A common critique of inductive methods is that no person nor researcher can be a 'blank slate' when observing reality, but that researchers are influenced by the pre-understanding which they carry into the process. For example, accumulated theoretical knowledge and previous experience may influence methodological choices, such as regarding research design (e.g., previous experience to work with case study methodology) and the unit of analysis (e.g., familiarity with a certain theoretical perspective). It can hence be questioned to what extent pure induction is even possible or, more moderately, if not most inductive research unintentionally applies a form of abductive reasoning (Alvesson & Sköldberg, 2009; Eisenhardt, 1989b). Thus, a compelling argument for abductive reasoning is that it accurately describes how a study involving induction was undertaken (Haig, 2008).

A second argument for the use of abductive reasoning is the utility of including and building on previous theory. For example, Timmermans and Tavory (2012) stated: *"Abductive analysis emphasizes that rather than setting all preconceived theoretical ideas aside during the research project, researchers should enter the field with the deepest and broadest theoretical base possible and develop their theoretical repertoires throughout the research process"* (Timmermans & Tavory, 2012, p. 180). It is for a good reason that the scientific enterprise is often described as a cumulative effort (cf. *"standing on the shoulders of giants"* (Newton, personal communication, 1675)). For example, there is an obvious risk that a researcher may spend unreasonable efforts to re-invent the wheel if previous studies are not considered.

For transparency, the research process in this study can be depicted schematically in the following way. The study began with a tentative research question, which prompted the construction of a first iteration of the preliminary framework. Equipped with this initial pre-understanding, empirical material was then collected (see 3.5). In accordance with pattern matching (Eisenhardt, 1989b; Yin, 2009), the 'observed pattern' from the fieldwork was then compared with the first iteration of the preliminary framework (i.e., the 'expected pattern'). Through this mode of analysis (see also 3.6.2), several observations in the empirical material were identified which were not explained by the first iteration of the preliminary framework. This prompted an additional reading of literature, in an effort to construct a credible explanation of these observations (see 3.7). Based on the new understanding which emerged through this process, the initial purpose of the study was then revised (see 1.5). The preliminary framework (see 2.7) was updated accordingly, to represent the pre-understanding of this revised purpose of the study within prior research on knowledge integration. The preliminary framework was then applied in Chapter 4 to structure the empirical presentation, as well as in Chapter 5 to analyze the empirical material (see 3.6). The revised framework which is presented in 5.4 is the end-product of this whole process.

Arguably, this schematic description of the research process illustrates how the abductive approach is a good fit with the case study research design, as it allows oscillation between empirical findings and literature studies as the process unfolds (Dubois & Gadde, 2002). Furthermore, it explains the introduction of additional theory in Chapter 5, i.e., as a response to observations in the empirical material, which could not be explained merely through the preliminary framework.

3.3 Case selection and unit of analysis

3.3.1 Single-case design

A holistic *single-case* design was chosen for this study for several reasons (Yin, 2009). Starting with the benefits of single-case designs, the purpose of the study made it relevant to identify a critical instance to examine. This was because the single-case design allows for deep exploration of that critical setting, which, in turn, may facilitate the development of a new theory. Knowledge integration theory has a rich history spanning more than two decades. However, to study the influence of firms' objectives is a nascent approach without much previous work to build on. To devote more attention to a single case hence makes sense, relative to dilute the attention across multiple cases (Edmondson & Mcmanus, 2007).

The main drawback of single-case designs relative to multiple-case designs lies in the lack of comparison between cases. This weakness can make the emerging theoretical propositions of single-case studies less robust if other measures (such as vigorous iteration between data and theory) are not applied (Edmondson & Mcmanus, 2007; Eisenhardt & Graebner, 2007). Whether a single-case or multiple-case study, points of comparisons do however still exist *a priori* which may inform value judgments about the single case. This can be compared with abductive reasoning, which asserts that previous experiences and understanding of theory are inferred into the research process (Alvesson & Sköldberg, 2009).

The single-case design can also be juxtaposed to quantitative methods, such as statistical analysis of data about a larger population. Such efforts have an important role in maturing a theory, such as moving it from analytical to statistical generalization (Edmondson & Mcmanus, 2007; Yin, 2009). For example, and which almost goes without saying, other inferences can be made when studying a larger population than when diving deep into a niched empirical setting. However, a theoretical concept must first be conceived before it can be adequately tested, and qualitative approaches, in particular the single-case design, are thus especially productive in the early stages of theory development (Gioia et al., 2013).

The feasibility of single-case studies is another, quite practical argument for the single-case design. In a critical setting for advanced knowledge integration, the data can be profoundly sensitive due to fierce competition between industry participants (such as between incumbents and entrants). Firms are, thus, typically reluctant to share information and insights which may benefit their competitors. Furthermore, the time-pressure in such settings makes participation in research projects somewhat of a 'nice-to-have,' i.e., as it would cause distraction from the actual problems that individuals in the firm are employed to solve.

Thus, once the opportunity presented itself to collect data from the specific case company in this study, the decision to design this study as a single case became quite appealing. Naturally, the relevance of the single-case design hinges on how interesting the chosen case is. The motivation underpinning the selection of the specific case ("Omega") will, hence, be outlined in forthcoming 3.3.3 (on Case selection).

3.3.2 Unit of analysis

Yin (2009) proposes that the unit of analysis should be derived from the research question (cf. purpose of this study, see 1.5). In this study, the unit of analysis (i.e., the case) is the *firm* which attempts to integrate knowledge. The behavior of individuals involved in knowledge integration is thus perceived in relation to the firm, rather than being units of analysis themselves.

The unit of analysis is delineated to a specific period: from April 2017 until June 2018. The decision about when to start this period coincided with access to data. The decision about when to end the study was a combination of saturation (Eisenhardt, 1989b; Glaser & Strauss, 1967) and a need to have sufficient time to finish the research project. The decision to limit the case to the specific period was not a demand by Omega.

3.3.3 Case selection

The selected case is "Omega," a joint venture between Alpha and Beta which started its operations in late April 2017.[34] Hence, the unit of analysis concerns the knowledge integration processes at Omega during its first year of operations (approximately).

There were multiple conditions which made the case sufficiently interesting to warrant selection. While the final iteration of the preliminary framework (as depicted in 2.7) was not conceived at the time of the case selection, a similar yardstick and rationale were used to motivate this decision. For starters, Omega was conceived to compete in a race for the technological development and commercialization of autonomous driving technology (cf. 'self-driving cars'). This meant that there was a potential to encounter technological as well as commercial and organizational problems.

The novelty and expected impact of the technology in question also meant that the Omega-case was not only an opportunity to study strategic problems but an instance of industrial transformation and renewal, such as the combination of different industry logics. For the autonomous driving technology in question, this primarily concerned how to combine the logic for industrial production (for example, running projects according to stage-gate and organizing both internal arrangements and commercial agreements thereafter) with a software production logic (for example, adopting agile practices for internal organization and commercial arrangements).

Furthermore, due to the presence of several well-funded competitors, this case involved significant time-pressure to deliver these breakthrough products (i.e., for autonomous driving) to the market. This 'need for speed' presented Omega with additional difficulties, such as those related to technological development (e.g., stage-gate versus agile), design of the commercial offering (e.g., customization versus standardization), and how to organize internally (e.g., a distributed versus centralized structure).

The critical nature of the Omega-case can also be motivated through consideration of the type of problem characteristics that appeared to be in play (see 2.5.1-2.5.4). For example, the high degree of novelty in the technological and commercial dimensions indicated that the Omega-case would be an instance with significant uncertainty and knowledge absences, as opposed to an instance of application of existing knowledge under certainty, which e.g., allows sequential planning to be an effective mechanism. The above description of multiple types of problems also

[34] During the study period, Beta created a spin-off called Gamma, which assumed Beta's role as owner and counterpart to Omega. Later instances of the case will hence both involve Gamma and Beta, while earlier instances of the case exclusively involved Beta.

indicated a high degree of complexity as well as a need for specialized knowledge of many different kinds.

The context of inter-firm collaboration is also known to be conducive for conflicts of interests, clashes of culture, and so forth. The joint venture-setup, hence, contributed to the difficulty level of the Omega-case by introducing additional relational characteristics to manage, such as trust and collective ambition (see 2.5.4.3). Additionally, the fact that Omega was a blend between a carve-out and a start-up indicated additional difficulties that could be interesting. The carve-out of personnel from Alpha and Beta (approx. 200 plus 50 employees, respectively), for example, meant that path dependent structures potentially would be imported into Omega from the owners of the joint venture (Alpha and Beta). Simultaneously, being a start-up meant that not even basic organizational resources (such as IT and workstations), processes (such as payroll), structures (such as locus of decision-making authority) and communication about what the objectives of Omega were (and, not least, *why*) existed at the outset. Furthermore, the intent was to recruit several hundred new employees during Omega's first year of operations. Thus, one can imagine that it is difficult enough to compete in a race to develop and commercialize technology without simultaneously having to manage the establishment of a completely new organization.

Finally, the feasibility of undertaking the case study should not be understated as a factor for why the choice fell on Omega. Other prospects were also contacted during the process of case selection. Unfortunately, however, most honeytraps with interesting data are not open for researchers to freely investigate and, ultimately, diffuse through publication. Thus, the selection of Omega was also a product of Omega being willing to enter into an agreement to undertake the study. This process, which was not inconsequential for subsequent data collection and analysis, will now be explained further in 3.3.4 Gaining access.

3.3.4 Gaining access

While Omega was selected as a case for the above stated reasons, it is equally true and important to disclose why Omega agreed to participate in this study. To gain access to data which could be used for this research project, Omega was offered something akin to free 'consulting services.' Omega deemed this offer sufficiently relevant to set up an internal project, which had the purpose of investigating future revenue and offering models, and to appoint an Omega-employee as the project lead.

More specifically, the arrangement was such that I was allowed to gather data through participation in this internal project (see 3.5.3), although within a scope that was decided by Omega. Upon completion of this internal project, I would then be allowed to collect additional data based on the scope of my own research project (see 3.5.4). Initially, the relationship with Omega was thus partly transactive.

A final note that is important to disclose is that Omega required an NDA to be signed, by yours truly as well as my supervisors for this dissertation-project (Thomas Kalling and Matts Kärreman). The NDA stipulated that I would not be permitted to disclose observations that I might be exposed to in this dissertation. For example, I had interactions with current and prospect customers which are not disclosed in this publication. Another example was a project report which I produced and presented to Omega that neither will be shared nor referenced in this study. However, the exposure to and handling of this sensitive data undoubtedly influenced my own understanding of the case, which, in turn, influenced subsequent data collection and analysis in the second phase (see 3.5.4). Thus, the limitations of working under an NDA still permitted interesting findings to permeate the final product which you are now reading, without disclosing data that would be damaging to Omega (Gioia et al., 2013; Vetenskapsrådet, 2017).

3.4 Operationalization of the preliminary framework

Multiple interview guides have been used during the study, as a product of ongoing refinement (cf. abduction). First, 3.4.1 discusses the operationalization of the preliminary framework into data collection needs and the conception of an interview guide, which was deployed during the second phase of the case study (see 3.5.4). The refinement of the initial interview guide for semi-structured interviews (see 3.4.1) is discussed in 3.4.2. To accurately convey how data were collected throughout the case study, three additional interview guides are included, which are not as tethered to the preliminary framework. These were used in the process of gaining access to the case and the first phase of the study (see 3.5.3). The interview guides in this section are hence *not* presented in a chronological order.

3.4.1 Main interview guide for semi-structured interviews

The preliminary framework was operationalized as an interview guide for the purpose of semi-structured interviews in the second phase of the study (see 3.5.2). The interview guide (see Appendix A) began with a presentation of the PhD project as well as questions to establish basic facts about the interviewee, such as the interviewee's previous experience and current role at Omega. These initial questions were not derived from the purpose of this study *per se*, but were deemed useful to better understand the interviewees' subsequent answers and reflections. For example, this revealed that multiple participants had been recruited from the same previous employer ('Sigma').

The main thrust of the interview guide was directed toward trying to understand *why* the knowledge integration challenges, which the interviewees were facing, were difficult and *what* mechanisms they had decided to employ in response. To identify suitable questions, the categories of characteristics which influence the management of knowledge integration were used (see 2.5.1–2.5.4). Although this tethered the inquiry to the pre-understanding in the literature, the approach was, in practice, quite exploratory during the interviews. For example, if an interviewee described that complexity made his/her task more difficult, further questions were typically asked to understand why a problem was complex or how that had implications for the process of solving this problem.

As a supplement to questions about the difficulty of managing knowledge integration, an appendix was attached to the interview guide with additional data collection needs that I considered to be relevant (see Appendix B). This appendix started as private notes but turned out to be useful to read before and during interviews. In hindsight, an updated interview guide would have been a better choice than adding an appendix to the main interview guide.

Regarding content, the supplement to the main interview guide (Appendix B) included questions about the *historical process*, which could help to put responses from interviewees into a more nuanced perspective. A second type of questions related to problems on *multiple levels*, i.e., the individual-level and various group-levels. A third type of question concerned data about both *coordination* and *collaboration* problems. A fourth type of question concerned data about features and components in the process, e.g., objectives, challenges/problems to solve, solutions (such as major decisions), and outcomes. This was deemed relevant to avoid the risk of getting stuck in a certain aspect of knowledge integration, e.g., to only ask about problems and completely forego solutions.

For transparency, as this is a product of the iterative process of abduction, I have included the appendix in its original, crude state (however, translated into English from Swedish). Note that neither the interview guide (appendix A) nor its appendix (appendix B) should be understood as operationalizations of the refined version of the preliminary framework, i.e., which is presented in 2.7 in this study, but rather as the *state of play* at the time of data collection during the second phase (see 3.5.4).

3.4.2 Refined interview guide for semi-structured interviews

In line with abductive reasoning, a second interview guide for semi-structured interviews (see Appendix C) was constructed based on the analysis of already collected data (cf. Alvesson & Sköldberg, 2009). The purpose of this refined interview guide was to probe deeper with individuals with whom I already had multiple interactions (including a semi-structured interview with the main interview guide). Hence, this interview guide was personalized to each of the four interviewees. An increasing degree of saturation had thus preceded the construction of the refined guide (cf. Eisenhardt, 1989; Glaser & Strauss, 1967). These interviews would turn out to be the last that were conducted during the study.

3.4.3 Interview guide for Omega's internal project

A third interview guide (see Appendix D) that was used in the study was constructed together with Alexander for the purpose of the internal project in the first phase of the data collection (see 3.5.2). Chronologically, this was hence the first interview guide which was used in the study.

Two major differences, relative to the instruments in 3.4.1 and 3.4.2, can be highlighted (see Appendix A, B, and C). First, this interview guide was not grounded in knowledge integration theory (i.e., or the purpose of this study) but was constructed solely for the purpose of investigating questions which were of importance for Omega. A second difference relative to 3.4.1 and 3.4.2, was the process for how the guide was conceived and applied in the interview setting. The guide in Appendix D was constructed *jointly* with Alexander, through structured problem-solving and subsequent interactions to refine the interview guide. A second difference was that Alexander was the lead interviewer during interviews with internal experts in this phase (see 3.5.2). My responsibility was primarily that of a note-taker, to ensure that it would be possible to analyze responses and to create a report that could be presented internally. However, my role was not passive during these interviews, as I both asked follow-up questions to interviewees and supported Alexander through time-management (e.g., by proposing to move on to the next question).

3.4.4 Interview guide for Omega's current and potential customers

A fourth interview guide (see Appendix E) was used to interview potential and current OEM customers.[35] This document was also co-created with Alexander, but it was decided that it was more useful to Omega if I conducted the interviews with OEMs alone, that is, without Alexander being present and steering the conversation according to his pre-understanding of the issues Omega was interested in investigating. One of the interviews, however, was held together with a representative from Beta. This was a pre-condition for setting up the interview since this OEM was in a sensitive stage of the process of becoming a customer to Beta.

[35] The term 'OEM' is short for 'original equipment manufacturer.' In this study, the term is foremost used in reference to the producers of vehicles for personal transport, i.e., 'cars.'

3.4.5 Initial data collection needs

A document with initial data collection needs (see Appendix F) was used in the correspondence with Omega, leading up to the agreement to undertake the research project. This interview guide was arguably the least consequential, as it was only used in an exploratory interview with David in April 2017. The purpose of this document was rather to portray to Omega the types of questions which I, at the time, thought I would be asking. Notably, the distinction between organizational, technological, and market-related (cf. commercial) aspects was already emerging (see Appendix F). This categorization may have been a consequence of observations and learning from a prior research project, which was terminated prematurely, due to a lack of access to relevant data.

3.5 Data collection

3.5.1 Principles for data collection

To make theory development from case studies more robust, Yin (2003) proposed three principles for data collection, which have been considered in this study. The first principle is to use 'multiple sources of evidence'. Thus, an objective in the data collection process was to establish *"converging lines of inquiry"* through triangulation of multiple data sources (Yin, 2003, p. 100). The primary mode of data collection in this study was semi-structured interviews (see 3.5.4). This mode was complemented by data from participant observations during the first phase of the case study, when I worked for Omega together with its employees (see 3.5.3). In addition, open-ended interactions (e.g., having lunch together or talking by the coffee machine), direct observation (e.g., observing employees in their job function), and document studies[36] (e.g., internal work material and external presentations in PowerPoint) were used as sources of data.

The second principle by Yin (2003) is to build and administrate a 'case study database'. The foundational building blocks in the database for this study are the audio recordings of interviews (ordered by the name of interviewee and date). Notes were also taken during each interview, which were subsequently archived according to the same format as the audio recordings. Two Excel-sheets were used to manage the database. Two Excel-sheets were used to manage the database. One Excel-sheet documented the date of every major interaction with a participant in the case (semi-structured interview or otherwise). A second Excel-sheet was used to catalogue interesting quotes from the fieldwork. To sort this data, each quote was categorized

[36] Documents which are presented in Chapter 4 have been adjusted to retain anonymity of Alpha, Beta, Gamma, and Omega.

by the type of characteristic (task, knowledge, and relational) that the quote was interpreted to foremost concern. To illustrate the level of detail, this second sheet contained more than 700 rows, where each row includes a quote of varying lengths. Documents (such as PowerPoint or PDF-files) were saved in folders describing their origin or nature. The empirical material was initially saved locally on a computer. To ensure redundancy, i.e., in the case of a serious malfunction of any single storing mechanism, the material was uploaded to cloud-storage (Google Drive) as well as to an external hard drive. The raw data can thus, if needed, be accessed by a third party. Beyond improving the reliability of the study, these practices also facilitated abduction by making it easier to iterate between theory and data, e.g., to look again at notes or to listen again to an original recording.

The third principle by Yin (2003) is to maintain a ‘chain of evidence’. This was facilitated by the administration of a case study database. The aim of this dissertation was that it should be possible for a reader:

> to follow the derivation of any evidence, ranging from initial research questions to ultimate case study conclusions […] Moreover, this external observer should be able to trace the steps in either direction (from conclusions back to initial research questions or from questions to conclusions). (Yin, 2003, p. 105)

Yin (2003) proposed that this principle can be achieved by providing a sufficient amount of quotes and, which goes without saying, that the database upon inspection should display the same data (i.e., evidence). Moreover, the data (such as the recordings) should be consistent with the procedures described in this chapter. Through adherence to this principle, the findings in this study can be substantiated all the way back to the questions that were asked and why.

3.5.2 Data collection process

Figure C displays the timeline for data collection in the study. Even though the case study is demarcated from the period between April 2017 and June 2018, data may have been collected unintentionally both before and after this period. For example, by reading news in media or posts on social media (such as LinkedIn). The main point of the timeline in Figure C is to illustrate how the study comprised two phases which employed different primary methods for data collection. Each phase will now be described in detail.

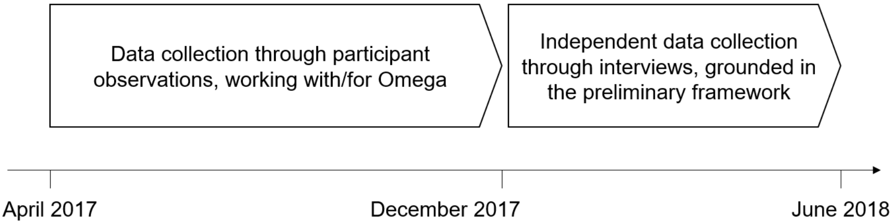


Figure C. Data collection process.

3.5.3 The first phase: Participant observations

The primary method in the first phase (from April 2017 until December 2017) was participant observations (Brannan & Oultram, 2012; Jorgensen, 1989; Schwartz & Schwartz, 1955). More specifically, I was an active participant in the knowledge integration process to accomplish a specific purpose which was decided by Omega, (cf. 'participant as observer') (Brannan & Oultram, 2012). The purpose was the development of the revenue model and offering for Omega, with a focus on products for autonomous driving.[37] This purpose was made explicit (articulated and codified in writing) when setting up the project as well as when presenting the project report.

Direct observation and experience were the primary forms of gathering data when participating as an observer. There is, however, room within this method to use multiple sources (Brannan & Oultram, 2012; Jorgensen, 1989). This was the case in this study, where semi-structured interviews (see interview guides in 3.4.3 and 3.4.4) as well as document studies were also part of the procedure to collect data. Notes were taken during all types of formal interactions, such as interviews, meetings, and workshops. During and after informal interactions, such as walking by someone's desk or meeting someone by the coffee machine, notes were only written sparsely, to avoid making participants feel like they were being monitored, i.e., which could disrupt the flow of the situation. Some insights from informal interactions were, however, put to the test in later formal interactions, which, in turn, were consistently documented.

A problem with my role as a participant observer was that it may have appeared quite opaque to individuals at Omega (Brannan & Oultram, 2012). This is a known drawback, i.e., some employees may have wondered if I was there to help them to solve a problem, or if I was there to observe them and their actions. The answer was *both*, which sometimes caused confusion, even after explicitly stating the purpose of my agreement and involvement with Omega. It was, for example, noticeable how

[37] That is, rather than products for advanced driver-assistance systems. More information about these two technologies will be provided throughout in Chapter 4.

this was less of an issue with key individuals who had been part of setting up our agreement and thus had accumulated a more nuanced understanding of my dual role.

Another issue was, of course, the process of assimilation (Brannan & Oultram, 2012; Jorgensen, 1989). The process of becoming an insider comes with benefits, such as access to data which otherwise would have been unobtainable or unintelligible. To become an insider, however, also comes with the risk of becoming biased. There is no simple protection against these negative effects from deep immersion in a setting. However, through the practice of 'reflexivity,'' it may be possible to interpret the construction of empirical material from other vantage points and thus, at least temporarily, become aware of and escape some biases (Alvesson & Kärreman, 2007; Alvesson & Sköldberg, 2009).

3.5.3.1 List of major interactions

Below is a list of all major interactions during the first phase of the case study. The type of interaction, as well as how many booked interactions I had with each participant, are stated in separate columns. Ad-hoc interactions, such as emails, brief telephone calls, text messages, or casual discussions in the hallway, are thus not included in the tally. Note that the total number is somewhat inflated, since I decided to not list each meeting, but the number of times I interacted with each participant through booked interactions. For example, a booked meeting with both Alexander and Bastian is counted twice. Hence, I have disclosed the total amount of booked interactions separately (i.e., 45) from the number of unique instances these were spread out across (i.e., 26).

Table A. List of major interactions (interviews and otherwise).

Pseudonym	Company affiliation	Position / Role	Type of interaction	No. of booked interactions
Alexander	Omega	Employeee	Full-day workshop, email, telephone, in-person conversations, informal meetings (e.g., lunches and casual discussion), attended the presentation of my project	16
Bastian	Omega	Senior management	Interview, telephone conversations, email, attended the presentation of my project	5
David	Omega	Senior management	Open-ended interview, semi-structured interview, in-person conversations, telephone conversations, email	3
Eton	Omega	Senior management	Semi-structured interview	1
Felix	Omega	Senior Management	Open-ended interview, semi-structured interview, informal meeting (lunch and casual discussion)	3
Robin	Omega	Employee	Attended the same workshop, attended the presentation of my project	2
Qasim	Omega	Intern	Work meeting, presentation of intern project, document studies	2
Peter	Omega	Senior management	Semi-structured interview	1
Stefan	Omega	Employee	Attended same workshop	1
Tim	Omega	Employee	Attended same workshop	1
Ulf	Omega	Middle-management	Attended same workshop	1
Oscar	Alpha	Middle-management	Semi-structured interview	1
Michael	Delta	Middle-management	Semi-structured interview	1
Mohammed	Epsilon	Middle-management	Semi-structured interview	1
Manuel	Zeta	Middle-management	Open-ended interview	1
Maximilian	Beta	Employee	Attended the interview with Zeta, email, telephone reflections after meeting with Zeta	2
Mauritz	Beta	Employee	Attended the same workshop	1
Markus	Beta	Middle-management	Attended the same workshop	1
Magnus	Beta	Middle-management	Attended the same workshop	1
		Total number of booked interactions		*45*
		Unique instances		*26*

3.5.4 The second phase: Semi-structured interviews

Semi-structured interviews were the primary means of collecting data in the second phase of the case study. The semi-structured approach was chosen in favor of more rigid interview-techniques due to the exploratory nature of this study. Hence, it seemed foolish to constrain the responses by interviewees to my own *a priori* ignorance. The semi-structured approach notably pairs well with abduction. For example, the preliminary framework provided a starting point from which an interview guide was crafted, and questions were asked. Depending on interviewees' responses, I chose to be more and less adamant about demanding answers to specific questions. Reflections about the empirical material and instantaneous analysis, thus, guided the data collection during semi-structured interviews. Rather than rushing to cover the whole interview guide with each interviewee, each interview was approached as part of a portfolio of interviews, which collectively had to satisfy the data collection needs.

Each semi-structured interview typically lasted 60 minutes. The first five minutes were typically a blend of small talk, a presentation of my research project, a statement about the purpose of the interview, as well as a description of the method I was going to use. Questions about the interviewee (e.g., current role, previous experience) then followed, before moving on to questions about the problems that the interviewee was dealing with. My aim was to let the conversation flow quite organically, especially when transitioning to other parts of the interview guide (see Appendix A and B). I noted that few, if any, interviewees were previously aware of or seemed to understand the meaning of *knowledge integration*, despite my brief presentation of this concept at the start of most interviews. Such semantic problems were, however, predominantly ignored in favor of speaking the interviewees' own language, and only later mapping the conversation back to the academic language and concepts used in the preliminary framework (cf. Gioia et al., 2013). The standard procedure was to conduct one interview per interviewee. More than one interview was, however, conducted with several individuals, of which some also featured in the first phase of the data collection process.

3.5.4.1 Interviewee selection

Interviewees were partly selected based on their function affiliation within Omega, i.e., to ensure representation from a diverse range of functions (such as software/product development, business development, and HR), but that is not the whole story. The most important criterion for interviewee selection was that the individual could be anticipated to contribute with insights about knowledge integration management and practices. First, this made it favorable to target individuals in the management group ('senior-management' in Table B), who were responsible for the definition of Omega's objectives as well as the process of achieving them. Secondly, to understand the nuances of how the process was managed, it was also important to involve leaders on lower levels ('middle-management' in Table B). Third, and crucially, it was important to identify and interview actual 'doers' without managerial responsibilities ('employees' in Table B). In practice, most of the interviewees were, however, identified through suggestions by their peers at Omega. Such suggestions came either spontaneously or as a response to a direct question about whom to talk to regarding a specific aspect of Omega's challenges or on a certain level of the organization (such as employee or middle-management). This process (involving peer judgment and recommendation) is, of course, far from random and may have caused the empirical material to become skewed (e.g., by exclusion of unpopular voices). However, case studies do not rely on random selection, which is why this process for interviewee selection should be somewhat acceptable, considering the selection criteria that simultaneously were considered.

3.5.4.2 List of respondents in the semi-structures interviews

Below is the list of semi-structured interviews during the second phase of the case study (Table B). Note that multiple interactions had already taken place with several of these individuals (e.g., Alexander, Bastian, David, Eton, Felix) during the first phase of the case study (see Table A in 3.5.3.1), i.e., in addition to the numbers stated below in Table B.

Table B. List of semi-structured interviews conducted at Omega.

Pseudonym	Position / Role at Omega	No. of semi-structured interviews	Dates	In-person / Remote
Alexander	Employee	2	20180315; 20180528	In-person; In-person
Bastian	Senior management	1	20180329	Remote
Carl	Employee	1	20180426	Remote
David	Senior management	2	20180315; 20180528	In-person; In-person
Eton	Senior management	1	20180411	In-person
Felix	Senior management	1	20180530	In-person
Gustav	Middle-management	1	20180411	In-person
Hugo	Employee	2	20180417; 20180530	In-person; In-person
Isak	Middle-management	2	20180417; 20180419	In-person; Remote
Joe	Employee	1	20180528	In-person
Kenneth	Employee	1	20180530	In-person
Leo	Middle-management	1	20180411	In-person
Martin	Senior management	1	20180530	In-person
Nicolas	Employee	1	20180315	In-person
Oscar	Middle-management	1	20180320	In-person
	Total number of semi-structured interviews	*19*		

3.6 Data analysis

This section will present three aspects of how the data were analyzed in this study. First, the ideas and procedures of grounded theory were influential on the iteration between data and analysis (Dubois & Gadde, 2002; Eisenhardt, 2021; Eisenhardt et al., 2016; Gioia et al., 2013; Glaser & Strauss, 1967; Suddaby, 2006; Timmermans & Tavory, 2012). Second, pattern matching was the main approach for the analysis of data (Yin, 2003). Third, on the meta-theoretical level, structuration theory (Giddens, 1984) and reflexive methodology (Alvesson & Kärreman, 2007; Alvesson & Sköldberg, 2009) were applied to make sense of the construction of empirical material.

3.6.1 An interplay between data collection and analysis

Eisenhardt et al. (2016) argue that inductive methods (and by extension, arguably, abductive methods) rely on a grounded theory-building process. This study was indeed inspired by grounded theory, even though it did not follow the rigorous procedures outlined by orthodox proponents (Eisenhardt et al., 2016; Suddaby, 2006). This study was rather inspired by the approach by Glaser (1978), who placed a premium on the ability of researchers to be creative and flexible (cf. *'theoretical sensitivity'*) in the interpretation process (Suddaby, 2006). According to Suddaby (2006), the work by Glaser and Strauss (1967) offers a *"compromise between extreme empiricism and complete relativism by articulating a middle ground in which systematic data collection could be used to develop theories that address the interpretive realities of actors in social settings"* (Suddaby, 2006, p. 634).

Two key concepts in Glaser and Strauss (1967), which have been applied in this study, are 'constant comparison' and 'theoretical sampling.' Applying the concept of constant comparison means that data are collected and analyzed simultaneously, which *"contradicts the myth of a clean separation between data collection and analysis"* (Suddaby, 2006, p. 634). Theoretical sampling infers a degree of analysis into the data collection process as *"the direction of new data collection is determined, not by a priori hypotheses, but by ongoing interpretation of data and emerging conceptual categories"* (Suddaby, 2006, p. 634).

These concepts thus help to explain how the act of analysis permeated the data collection process and the construction of empirical material in this study (Alvesson & Kärreman, 2007; Alvesson & Sköldberg, 2009). 'Sensitizing concepts' were used to support the iteration between theory and data (Alvesson & Sköldberg, 2009; Blumer, 1954; Bowen, 2006). Such concepts were subject to continuous refinement throughout the period of data collection, as well as in the writing of the empirical presentation and theoretical analysis.

Although the empirical presentation and analysis do not strictly apply the 'data structure' in Gioia et al. (2013), their approach to concept development influenced how these chapters were written. To enhance the rigor of concept development (cf. 'aggregate dimensions'), Gioia et al. (2013) argued that 'first-order concepts' should reflect the language and reality of participants in the study (cf. 'informant-centric terms and codes'). Based on such informant-centric terms and codes, 'second-order themes' can then be constructed using the language and knowledge of the researcher, (cf. 'researcher-centric concepts, themes, and dimensions') (Gioia et al., 2013). In practical terms, numerous quotes were included in Chapter 4 to introduce the reader to informant-centric terms and codes. A sense of how first-order concepts have been transposed into second order (i.e., research-centric) themes was then provided by a structure which employed theoretical concepts from the preliminary framework (see 2.7). Through this approach, it thus becomes possible to understand how the raw data were used to support the development of each new concept developed (cf. chain of evidence in Yin (2009)). To aid this understanding, frequent references were also made throughout the analysis-chapter to passages in the empirical presentation.

A final example of the interplay between the data collection and analysis was the application of 'category saturation,' which informed when to stop collecting data (Eisenhardt, 1989b; Glaser & Strauss, 1967; Suddaby, 2006). Saturation was starting to become noticeable during the second phase in the case study, after approximately 12 of the 19 semi-structured interviews. The impression at this point in time was that the degree of repetition was growing and the marginal benefit from each interview was decreasing. This manifested in the need to refine the interview guide before conducting further interviews (see 3.4.2), i.e., as an attempt to uncover data which previous interviews had not provided.

3.6.2 Pattern matching

The main method for writing the analysis was to use a pattern matching logic (Yin, 2009). The logic of pattern matching is to match the observations in the empirical material (i.e., the 'observed pattern') with the preliminary theoretical framework, which represents the pre-understanding that can be found in the literature (i.e., the 'expected pattern'). This logic is, hence, quite compatible with the abductive approach, i.e., in that it emphasizes the role of pre-understanding in the interpretation of empirical material (cf. Alvesson & Sköldberg, 2009).

One function of pattern matching is to confirm previously proposed relationships, i.e., instances of when the empirical material *matches* the expected pattern. While such instances contribute to internal validity, they do not, however, result in new theory. For that purpose, the other function of pattern matching is more relevant, namely, to point out *discrepancies* between the expected pattern in previous research and the observed pattern in the empirical material. Such instances, i.e., where previous theories do not sufficiently explain the observed pattern, are an opportunity to develop a new theory that may explain that which was observed. Eisenhardt (1989b) agrees that comparison with previous theory is central, stating that an:

> essential feature of theory building is comparison of the emergent concepts, theory, or hypotheses with the extant literature. This involves asking what is this similar to, what does it contradict, and why. A key to this process is to consider a broad range of literature. (Eisenhardt, 1989b, p. 544)

Furthermore, the pattern matching logic fits how Gioia et al. (2013) was applied in the development of new concepts. For example, there was no need to develop a new concept when the expected pattern adequately explained the observed pattern in the study (Yin, 2009).

3.6.3 Meta-theoretical considerations

Central meta-theoretical concepts which have been applied in this study should be made explicit to the reader, since these were quite consequential for the analysis of data. To begin with, knowledge is quite an elusive construct, which means that qualitative data about knowledge inherently involve a degree of interpretation. A useful concept to make sense of interpretations by the researcher is the work on reflexive methodology by Alvesson and Sköldberg (2009), which argue that researchers should carefully scrutinize their own interpretations in an *"open play of reflection across various levels of interpretation"* (Alvesson & Sköldberg, 2009, p. 281).

Reflexive interpretation has been applied throughout the research project regarding multiple topics, which have shaped the final writing of this text. For example, regarding my personal interest in the particular purpose of this study, my involvement as a participant in the fieldwork, my interaction with and 'construction' of the empirical material (Alvesson & Kärreman, 2007), and my interpretations of the underlying meaning in the material (Alvesson & Sköldberg, 2009). The main aspect which permeates how the analysis was written is arguably how the concerns of intersectionality were actively excluded in favor of an objectivist approach, emphasizing realism and positivism (Alvesson & Sköldberg, 2008; Burrell & Morgan, 1979). This emphasis was not accidental but the result of deliberate choices throughout the research project. For example, while there are negative effects from the organization of individuals to achieve the objectives of firms, as emphasized in critical perspectives on management (e.g., Alvesson & Sköldberg, 2009; Alvesson & Willmott, 2002), there are also important *positive* effects that ought to be equally considered. This is especially the case since, as Pinker (2018) argued, there often are vastly more ways for things to go wrong than there are ways to get things right.[38]

A first category of positive effects is the wealth generation for the shareholders of a firm, which is not trivial for economies to grow and living standards to improve. On the flip side, economic growth can also cause alarming externalities (such as in the case of climate change) and is not distributed equally among the individuals who contribute to the achievement of a firm's objectives. A second category of positive effects involves the ramifications for stakeholders of a firm (such as customers, employees, and society at large), i.e., which benefit from the productive activity that a firm undertakes. For example, autonomous driving technology has the potential to save thousands of lives every year by preventing accidents, and the potential to free up millions of hours, which today have to be spent on operating cars, semi-trailer trucks, and other means of transportation. On the flip side, jobs that undertake such tasks may become obsolete if autonomous driving technology is commercialized (cf. Schumpeter, 1939). Weighing these positive and negative effects against each other, I would argue that it makes more sense to perceive the impulse to solve a

[38] See the 'Law of Entropy,' inspired by the second law of thermodynamics (Pinker, 2018).

problem for millions of people as admirable, rather than problematic. Reflexive interpretation helps to point out how this perspective is not neutral but an expression of the political conviction of the researcher (yours truly). It is more than likely that this influenced how the study was undertaken, for example, which questions were and were *not* asked.

Lastly, this brings us to structuration theory (also discussed in 2.4.3). The work by Giddens (1984) provides an explanation of how agency and structure interact without engaging in sociology of radical change, i.e., how structures may lead to suppression or coercion of agency (Burrell & Morgan, 1979). Structuration theory is, thus, very constructive to operationalize the objectivist approach to the analysis of data by allowing consideration of both agency and structural influences. Exactly where this leaves important notions such as *power* in the context of knowledge integration is a relevant question. This study, however, does not aim to go further than to recognize and describe its mechanics in the case, when observed.

3.7 Validity and reliability

Numerous measures have been taken to enhance the robustness of the study. Construct validity has been established using multiple sources of evidence (Eisenhardt, 1989b; Yin, 2009) and constructing a chain of evidence (Yin, 2009), which enables the emerging theory to be grounded in the empirical material (Gioia et al., 2013; Timmermans & Tavory, 2012). Key participants in the study have also reviewed the manuscript and, in some instances, contributed with feedback.

Internal validity was established primarily through the practices of pattern matching (see 3.6.2) but also through consideration of rival explanations to knowledge integration theory, such as literature on capabilities (e.g., Eisenhardt & Martin, 2000; Teece et al., 1997; Winter, 2003), absorptive capacity (e.g., Berggren et al., 2017; Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Zahra & George, 2002), the resource-based view (e.g., Barney, 1991; Barney et al., 2011; Kraaijenbrink et al., 2010; Peteraf, 1993), the competitive forces-perspective (Porter, 1980, 1991), and the business model-concept (e.g., Amit & Zott, 2001; Hedman & Kalling, 2003; Johnson et al., 2008; Osterwalder et al., 2005). The influence of rival explanations in the proposed contributions from this study should become evident in Chapter 5, not least by the explicit suggestion to invoke additional literature to explain the observed pattern (see 5.2.1).

To establish a sufficient level of external validity can be problematic for single-case studies, since comparisons between multiple cases or the use of a replication logic are not possible (Eisenhardt, 2021). The main way to ensure analytical generalization was to iterate between theory and empirical data throughout the research process (Eisenhardt, 1989b; Yin, 2009).[39] Examples of such measures in this study included the grounding of the purpose of this study in a problematization of previous literature (Alvesson & Kärreman, 2007; Alvesson & Sandberg, 2011), the abductive refinement of the preliminary framework (Dubois & Gadde, 2002; Timmermans & Tavory, 2012), the use of pattern matching to develop concepts (Gioia et al., 2013; Yin, 2009), and the consideration of rival theories (Eisenhardt, 1989b; Yin, 2009).

Measures taken to establish reliability were outlined in 3.5, regarding the data collection process. Specifically, the case study database is an essential artefact to assure the reader that the contribution from this study is grounded in data, and that the original data, i.e., which claims are based on, can be accessed and scrutinized if needed. However, the NDA, which was signed (see 3.3.4), does, to some degree, weaken the reliability of this study, since it prohibits diffusion of the raw data to third parties without explicit consent from the individual who signed the NDA on behalf of Omega. This obstacle is, however, a legal matter rather than a problem associated with the case study database itself, i.e., since third-party access to the case study database could be negotiated.

3.8 Ethical considerations

The study was undertaken with a continuous consideration of the trade-off between truth seeking and potential ramifications for participants in the study (Vetenskapsrådet, 2017). Several research practices which protect subjects were applied in the case study (Yin, 2009). First, interviewees were made aware that I was conducting a research project, in which what they said could potentially be published. While this may have been less clear in the first phase of the case study (see 3.5.3) than when conducting semi-structured interviews during the second phase of the case study, the subjects I interacted with were still informed about my purpose and gave their consent. Furthermore, all individuals who feature in Chapter 4 have given written consent to use their quotes.

Second, measures were taken to minimize the risk of subjects becoming exposed to harm through their participation in the study. The name of the case company (Omega) and the name of participants have been pseudonymized to ensure privacy and confidentiality after the publication of this study. Formal titles and role descriptions for individual subjects have been kept at a minimum for the same reason.

[39] A similar concept is the quality criteria of ‘transferability,’ i.e., of findings between the cases (Guba, 1981).

Third, a continuous dialogue with key individuals at Omega (especially Alexander, David, and Bastian) during the study helped to set the boundaries of what could be published without harm to Omega. This was not an easy trade-off, given the extremely sensitive nature of the data which Omega agreed to let me take part of. As was made clear in 3.3.4, the study was undertaken under an NDA. Data which the NDA explicitly stated that I cannot publish have consequently been omitted from the text. Beyond such black and white areas, I have tried to be pragmatic and make compromises. On the one hand, attempting to find ways of including interesting data but, on the other hand, doing so in a way which is as anonymous as possible and without damage to the subjects who featured in the study. To have a rigorous ethical standard, hence, partly comes at the cost of transparency for the reader (cf. reliability).

4 Empirical results

4.1 Chapter structure

An introduction of the Omega-case will set the scene (4.2). The chapter will then be structured according to the modules in the preliminary framework.

The first part of the chapter (4.3) will present empirical findings related to the objectives-module in the preliminary framework (see 2.3).

The second part of the chapter (4.4) will present empirical findings related to the subjects involved in the knowledge integration process (see 2.4).

The third part of the chapter (4.5–4.8) will then present empirical findings about the management of knowledge integration (see 2.5). Specifically, 4.5 presents results regarding the influence of objectives (see 2.5.7) and 4.6–4.8 present results regarding the influence of various problem characteristics (see 2.5.1–2.5.6).

A brief epilogue (4.9) will then conclude the empirical presentation, presenting major events that happened after the case study which are pertinent to the interpretation of the empirical material.

Naturally, less space will be devoted to observations that largely confirmed the expected pattern in the preliminary framework. For example, the task characteristics of complexity and uncertainty were observed to be immensely influential in the empirical material. However, this was in line with the expected pattern. More attention will in turn be directed toward surprising findings, i.e., observations that the preliminary framework does not appear to explain. Lastly, it may be clarified that the object of study (see 2.1 and 2.6) will be treated as the effect which each part of the chapter aims to explain (see 2.7).

4.2 Introduction: Omega

4.2.1 The purpose of Omega

Omega was a joint venture that was created to consolidate the efforts by Alpha and Beta to develop and commercialize active safety technology in transport applications. Specifically, technological products for advanced driver assistance systems ("ADAS") and autonomous driving ("AD"). The purpose of the joint venture, in simplified terms, was to generate a return on investment to its owners, both directly (through the development and commercialization of self-driving technology) and indirectly (through the appreciation of assets owned by Alpha and Beta). The potential indirect effects were idiosyncratic for each owner of the joint venture. Thus, an understanding of Omega's objectives requires an understanding of the purpose of Omega for Alpha and Beta, respectively.

4.2.2 The purpose of Omega for Alpha

The purpose of Omega for Alpha (an OEM, producing cars) was to accelerate the rate of development of software for active safety applications. This was a priority for Alpha since features for ADAS and AD were deemed to become increasingly important within the industry, and Alpha's ambition was to deliver a superior customer value proposition to the market. Notably, Alpha also had a long-standing history of being an industry leader in the passive safety technology and was at the time emerging as a pioneer within active safety technology. According to Oscar at Alpha, Omega was one of three strategic initiatives that Alpha was undertaking related to this purpose.

4.2.3 The purpose of Omega for Beta[40]

Beta's business was to develop and manufacture hardware components for passive and active safety, to be sold to OEMs which integrate these components into their own products (see Figure E in 4.2.5). By teaming up with Omega, Beta would be able to offer an integrated product suite of hardware and software specifically developed for that hardware. When Omega started its operations in April 2017, the CEO of Beta, for example, framed the potential combination of the experiences of a tier 1 supplier (Beta) and a premium OEM (Alpha) as an advantage that would enable Beta to deliver competitive solutions to the market.

4.2.4 Inputs to the joint venture from Alpha and Beta

The exact terms of the joint venture were not disclosed publicly nor in the data collection process of this study. However, what can be pieced together from public communication by Alpha and Beta is that each firm contributed different inputs to the joint venture in exchange for equal ownership, i.e., each holding 50% of the shares in

[40] During the case period, Beta created a spin-off ("Gamma") that replaced Beta's participation in the joint venture. This was announced in December 2017 but not finalized until June 2018. Thus, this part of the joint venture will often be referred to as Beta/Gamma. Some interviewees (in excerpts from interviews toward the end of the case study period) will even explicitly refer to Gamma.

Omega. As part of this arrangement, both Alpha and Beta agreed to license and transfer intellectual property rights regarding ADAS systems to the joint venture (Omega).

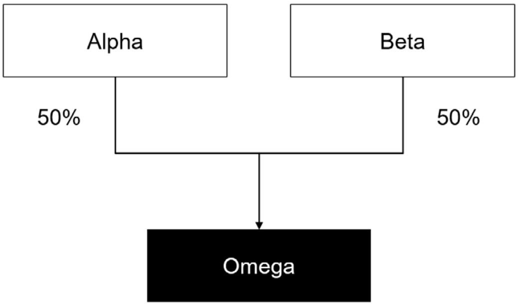


Figure D. Joint venture ownership structure.

Alpha's main contribution, apart from the intellectual property, was the transfer of approximately 200 employees to the new joint venture (i.e., a 'carve-out'). The main contribution from Beta was an investment of approximately US$120 million, of which the largest part appeared to be an initial cash contribution to fund the operations of Omega. Beta also contributed approximately 50 employees, i.e., significantly fewer than Alpha. A notable individual among the ex-Beta was Bastian, who had been part of the process of creating Omega together with David (ex-Alpha) and was also appointed to the Omega management team.

4.2.5 Starting the joint venture

The joint venture started its operations in April 2017 as the result of a process between Alpha and Beta. According to David, who was part of conceiving the joint venture, the idea for something akin to Omega was the result of two converging developments. One development was an increasingly close collaboration between Beta and Alpha, and the other development was the emergence of more advanced active safety technology. The latter had ignited a vision of autonomous driving in a not-too-distant future. To reconcile the respective rationale of Beta and Alpha to create the joint venture, participants from both firms worked together to write a business plan that would be considered in the decision to start the joint venture.

> Pelle: Perhaps we can maybe compare where you started to where we are today. Do you remember how the first version was conceived, e.g., on a paper napkin or in a workshop? What was the gameplan? Was it the same as when we met in May [2017] when you told me about the decisions regarding reference architecture and so on? What was the first iteration of this like?

David: There were perhaps two versions in the first iteration, when we were starting discussions, at the paper napkin stage. We talked both about a joint development-agreement and about building a company. And the company-idea came in two flavors: first, a minimal company with perhaps 40–50 employees which would have a specific development task, or second, a company which would be very large, kind of like what we are doing now. And we went back and forth between the small and the large version, but we have now decided on the large version, which was up for discussion quite early. I remember a workshop in spring 2016, where Bastian, [name of colleague], Eton, Peter, and I sketched our ideas on a whiteboard.

Pelle: When you were sketching, what was it that you sketched? Was it an organization structure with boxes and arrows, or was it a vision and mission statement?

David: No, not a mission statement. It was the organization. There was a draft for a business plan. What we would sell. So it was the scope. It was not the mission, more like what the scope would be and what we would develop, and 'this' is how it would look like. If we were to enter a process, then we would want to understand what a business plan would look like, which Bastian sketched, what could we sell and what was important to develop. And from that we did an estimate: if we were to deliver 'this,' then how many employees would we need to have? To get an additional feel for how many we needed to have, we also sketched a traditional organization, where we estimated how many employees are in each 'box,' That is how we landed on 650. […] and we are in that ballpark [today] which we estimated then, even though the organization is completely different, and the scope has changed to some degree. But it was not wrong.

Although most aspects of the management of the joint venture were delegated to the management team of Omega, the customer delivery model was carefully negotiated by the owners and written into the joint venture agreement (see Figure E). This model provided a scope within which the objectives of Omega had to conform, to ensure that the joint venture would become equitable for both of its owners.

In a sense, the customer delivery model outlined the process for how knowledge integrated within Omega would make its way into technological products which could be bought and used by end-customers. There were two channels to end-customers for Omega's products in this model: one channel through Alpha and a second channel through Beta (a so called 'Tier 1' supplier). Starting with Alpha, Omega (as a 'Tier 2' supplier) would deliver software products to Alpha, which were based on a hardware reference architecture that a) was decided by Omega's board of directors and b) was built on Beta's hardware. Alpha would then be responsible for the integration of this technology into the final product (i.e., the car) to be sold to end-customers, either through third-party dealerships or through Alpha's direct-to-consumer channel. The model for how Alpha would pay for Omega's products and how much its own products would be allowed to cost for end-customers was not entirely decided at the start the joint venture, which would lead to some interesting challenges down the line (see 4.3.3.2 and 4.5.4.1).

Beta was the other counterparty to whom Omega could deliver products in the agreed setup. In this part of the delivery model, Beta (with support from Omega) would sell a combined software and hardware offering to OEM customers, that (like Alpha) were then responsible for the integration of this technology into its own vehicles (with different levels of support from Beta and Omega). The flow of hardware from Beta to Alpha in the model was a central component in making the joint venture equitable for both parties.

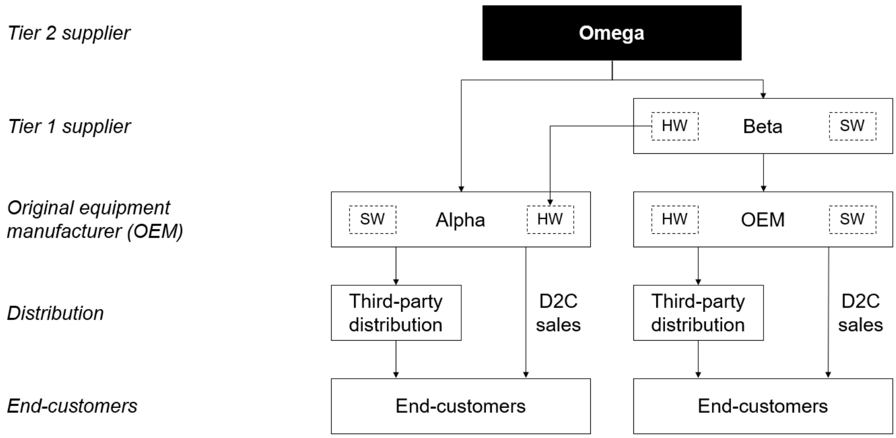


Figure E. Delivery model of products from Omega to end-customers.

4.3 An objective requiring integration of knowledge

The preliminary framework defined knowledge integration as *"the purposeful combination of specialized and complementary knowledge to achieve specific tasks"* (Tell et al., 2017a, p. 5). Three thematic types of problems were identified in the reviewed literature: technological, organizational, and commercial problems (see 2.3.2). In summary, the observations in the study confirmed the expected pattern that a particular type of knowledge was needed to solve the corresponding type of problem. For example, technological knowledge to solve technological problems.

More surprising, however, was the observation that additional types of knowledge were frequently inferred to improve the solution to a problem. For example, the application of organizational knowledge when solving a technological problem, in addition to technological knowledge. This pattern was indicated by the preliminary framework, albeit not to the degree that was observed in the study. Another surprising finding was the many references to how problems usually or typically are solved in a particular industry, such as in the automotive industry.

4.3.1 Observations of technological problems and knowledge

In summary, numerous technological problems were observed in the study, which required specialized technological knowledge, i.e., in line with the expected pattern. The frequent application and importance of non-technological knowledge in the resolution of technological problems, however, was a more surprising observation.

4.3.1.1 Different types of technological problems

The technological products which Omega was developing required multiple types of technological knowledge, including both software, hardware, integration of software and hardware, architecture, and methods for validation (i.e., that the technology met safety requirements). Multiple interviewees pointed out aspects related to AD (i.e., rather than ADAS) as the most challenging technological problems to solve.

> Something we know approximately, not precisely but approximately, is how safe a self-driving car needs to be. And it needs to be super-safe. Not safe like the average driver, but considerably safer, maybe by a factor of a thousand. And then the question is how you develop a system which does that, and how do you *prove* that you have achieved that? That is super difficult, and that is why there are no self-driving cars, because no one has fully cracked it all the way. (David)

Another way of establishing the importance of technological knowledge was the problems caused by the *absence* of technological knowledge (see also forthcoming 4.7.6.2). For example, Eton described that it was unclear which factor inputs (such as sensors) Omega should buy from suppliers in the market:

> Should we wait for a technology which does not exist [today] or should we apply bricolage on fifty [sensors] which exists today? Depends on whether we must have a product ready by a certain date…it may be better to wait a year. (Eton)

Furthermore, since AD was a novel technological problem, David described that it entailed many ‘unknown unknowns.’ For example, that it was not clear at the outset when the problem would be considered solved:

> And when it comes to testing, is it enough with a million kilometers? More than that is probably needed, but is it ten million? Well, in that case, it would be very challenging and expensive. A hundred million? Well, if that is needed, then it is not possible; that is just too much. (David)

Similarly, Eton described that the main challenge was not to make a car drive by itself but to make a system that *never* fails and to devise methods that can prove that:

> Normally, there are standards, for example, how an indicator should blink. In this case, it is a kind of research. How do we validate? We do it our way, Tesla its own way, Google its own way. (Eton)

4.3.1.2 *The need for non-technological knowledge*

A more puzzling observation was that the resolution to technological problems often involved the integration of *non-technological* knowledge. For example, David described a trade-off between the feasibility of solving technological problems and commercial aspects, such as the price that end-customers would pay:

> So, this aspect is enormously difficult since it influences everything. Because you can always argue that we should add a couple more sensors to the car, 'then' we would have a good chance. Yes, but if we keep adding sensors, then it becomes even more expensive, and can we really sell that? And if we don't have enough data, we don't even have a product, and that is also a problem. (David)

Interestingly, technological problems were seldom discussed by engineers as instances which exclusively concerned technological aspects. For example, Hugo described how architectural problems occurred at the intersection between technological, commercial, and organizational aspects:

> You need someone to clear the road for the common challenges. For example, a simple thing such as which OS you should choose for a certain hardware platform, driven by business/commercial targets. We want to sell to 'these' and to 'these' customers; they are our target segment. […] These are decisions that each developer team cannot take, and which the product owner cannot take, but what I would call classic architectural problems. Or, how you make sure that a certain feature…some mechanisms need to be in place for a certain feature to not steal resources in the [control] unit. This is about fundamental architectural principles. (Hugo)

Hence, as an example of implications in the organizational dimension, if multiple feature teams rely on the same control unit, then the technological constraints (e.g., processing power, memory) of that control unit must be considered in how each team solves their respective part of the technological problem.

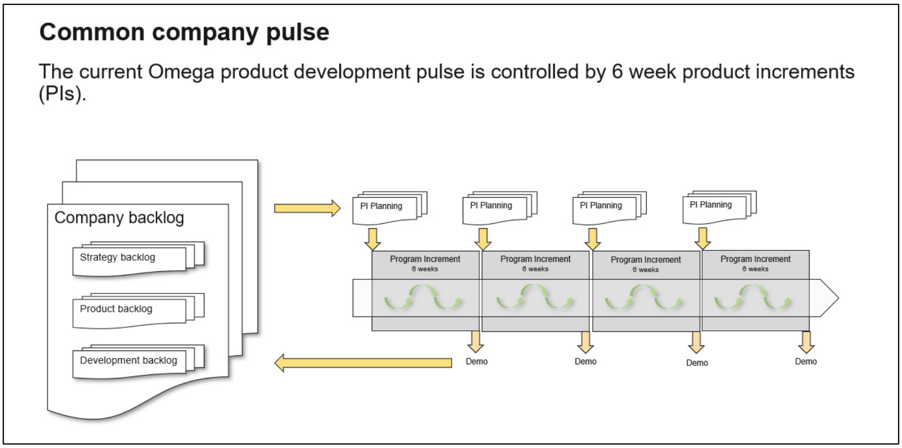
4.3.2 Observations of organizational problems and knowledge

In summary, multiple interviewees, both in managerial roles and regular employees, emphasized *organizational knowledge* as important to the resolution of the organizational type of problem (see 2.3.2.5–2.3.2.6). This was in line with the expected pattern of a dependence on the corresponding type of knowledge to solve a certain type of problem. However, the data also revealed several additional themes, such as industry-specificity of knowledge and the need for simultaneous applications of multiple types of knowledge (cf. 4.3.1.2). These themes will be explored at length later in this chapter (see 4.5.4.2 and 4.5.1, respectively).

4.3.2.1 Organizational process

Product development will be in focus in this section since this was the main activity in Omega (i.e., engaging most of the employees and which various functions had to relate to). The procedural arrangements for product development at Omega were explicitly influenced by agile practices for software development. In a document depicting the 'Common company pulse' (see Document A), the interplay between backlogs, iterative prioritization, and 'product increments' (cf. short projects) was visualized.

Every six weeks, a new decision (commonly referred to as 'prioritization') was made for which problems ('backlog items') to work on during the upcoming product increment. The recurring process leading up to this decision was referred to as 'PI planning' (i.e., product increment planning).

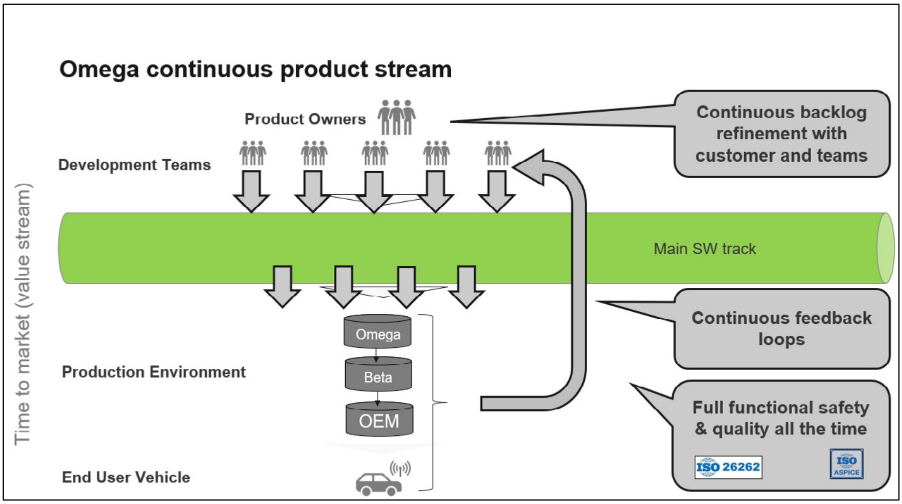


Document A. Common company pulse.

There were several noticeable features in the procedural arrangements for product development at Omega. First, an important feature was to improve the time to market drastically, i.e., from prototype within Omega to deployment in production environments (for Omega, Beta, and the OEM customer) and (ultimately) end-users' vehicles. Omega worked in product increments of 6 weeks during the study, but the intention was significantly more ambitious:

> The goal is two weeks from prototype to release. (Felix)

A second feature was to enable *continuous integration* and *continuous deployment* ('CI' and 'CD') of software, ultimately in the vehicle itself through over-the-air ('OTA') updates. A third feature was to have *one* main software track. The second and third feature are visualized in Document B below.



Document B. Omega's continuous product stream to OEM customers' end-user vehicles.

Interestingly, the resolution of this organizational problem was also influenced by the intra-organizational arrangements of OEM customers to whom Omega (through Beta) delivered its offering. Beyond an example of complexity (see 2.5.2.1), this was also relevant as it was described how the traditional approach to product development in the automotive industry revolved around OEM's car projects, which typically lasted years. In such multi-year ventures, suppliers (such as Omega) receive a purchase order from an OEM and then usually set up an internal project to deliver an agreed scope within a stipulated timeframe. While the project-logic for procedural arrangements had made sense previously in the hardware-centric automotive industry, Felix and other interviewees explained how such lead times (i.e., *years*) were a problem for the development of advanced software technology. The logic for how to solve organizational problems thus appeared to be partly industry-specific.

Further complicating the resolution of this type of organizational problem, the gap between the current state in the industry and Omega's preferred approach (e.g., to enable CI/CD) meant that OEM customers would have to make quite radical (and costly) changes of their own internal organizational arrangements (structural and procedural) to accommodate Omega's preferred approach to product development. Since the OEM was the potential customer in this constellation, it was not possible for Omega to coerce OEMs into making the desired changes. Instead, significant attention and effort went into persuading potential customers about the benefits of enabling a new approach to product development. However, Bastian, who had a background in the automotive industry was discernibly skeptical about the feasibility of persuading OEMs to change their ways of doing business and working with suppliers (such as Omega):

> Using continuous deployment, Felix is coming from a consumer market and is trying to adapt it to the automotive industry. Is there enough traction out there? Among OEMs, among clients. What would attract them? What actions would we need to take to approach the market? (Bastian)

Another interesting finding was that this interplay between market actors also illustrated how the resolution of interdependent organizational problems (such as between supplier and customer) simultaneously depended on solving *commercial* problems. For example, Bastian explained how contractual arrangements with OEM customers had to change to accommodate the above-mentioned procedural arrangements which, notably, in turn had technological antecedents (i.e., development of software versus hardware).

> This is why we attempt to get into agile contracts with customers, where we can say 'yes, we strive for that use-case' and 'yes, we will go after that,' but it is not a deterministic development any longer. It is a very complex development. And in complex developments you might end up in a dead-end. We might hit a certain problem here which from a technology point of view we cannot resolve. It does not matter if we put in 500 man-years more work. And that is an uncertainty and a development issue that you previously did not have. (Bastian)

4.3.2.2 Organizational structure

Continuing with structural arrangements, interviewees described the organization structure at Omega as a 'molecule structure' and juxtaposed this arrangement to a traditional, hierarchical bureaucracy.[41] In a PowerPoint-document for internal use, it was explained that Omega was *"an evolving organism of purpose driven empowered teams and roles,"* and that the *"organism continuously adapts depending on business, market trends, bottlenecks and customers."* Furthermore, the document stated that Omega *"shall be built around the value generating development teams in order to maximize their performance"* and that *"administrative/supporting functions in the company shall be kept at a minimum to minimize overhead and to maximize speed and flexibility."* Felix explained that the logic underpinning the decision to employ these organizational arrangements was grounded in the question 'what is Omega supposed to be good at?' Felix described

[41] This juxtaposition was not arbitrary but partially made in reference to Omega's initial organization structure before a major re-organization at the beginning of 2018.

Omega as an R&D organization without its own sales function, i.e., since the relationship with OEMs went through Beta (see Figure E in 4.2.5). Felix's experience was that firms typically organize in a way which maximizes efficiency at the top of the organization 'pyramid' (i.e., its management team). According to Felix, arrangements that enable the individuals at the top of the pyramid to make all decisions, however, cause problems:

> It requires information to be fed upwards in the hierarchy, and you build a system around that which is self-generating but not very productive. I, thus, questioned: if we are an R&D company, shouldn't we attempt to maximize efficiency down here among the teams, where we have almost all employees? (Felix)

To empower employees, Felix described how it was important that individuals at Omega instead felt that the structural arrangement was intended to make *their* job easier, not to make it easier for the group at the top of the pyramid. To employ this structure, however, depended on persuading other individuals at Omega (many of whom had spent their careers in quite hierarchical bureaucracies) that this was the most effective approach:

> When you challenge, like I do sometimes, and ask 'where do we want maximum efficiency, in the teams or for a few people at the top of the pyramid?' then the answer is quite simple. (Felix)

A practical manifestation of this approach was the mandate structure for backlogs within the product development process. As input to each PI planning, there were several backlogs, which contained items on different levels of abstraction (see Document X). There was a hierarchy between the backlogs, in which the lower levels were expected to mirror the prioritization of the higher-level backlogs. On the lowest and most practical level, within the 'Development backlog,' were 'Stories' (i.e., items that can be finalized within one product increment) and 'Epics' (i.e., items that can span across more than one product increments). The next level of Omega's backlog structure, the 'product backlog' contained features *("significant product initiatives or major enablers")*, sub-features (sub-sets of features that *"span over more than one product iteration")*, and 'capabilities' (*"Breakdown of features into a size that each can be finished in one product increment"*). Highest in the backlog hierarchy was the 'Strategy backlog.' The items in this backlog were referred to as 'Strategic themes,' which represented *"High level strategic directions of the company going forward, that drive innovation and differentiation"* (see Document C).

In terms of organizational structure, the mandates for the creation of items and decisions regarding prioritization were distributed across the organization. The 'Strategy backlog,' for example, was created by the 'Strategy team' (Omega's *de facto* management group) and ultimately prioritized by the CEO. The 'Product backlog' and 'Development backlog,' however, were both created and prioritized by lower levels of the organization. Thus, this structure involved everyone down to the members of development teams in the creation of the backlogs within Omega. A very tangible implication of this structural arrangement was consequently that many employees were involved in the decision-making at Omega, i.e., compared with a more centralized and hierarchical structure.

The company backlog(s)

The company backlog – a view of all the backlogs in Omega

Backlog	*Backlog items*	*Contains*	*Created by*	*Prioritized by*
Strategy backlog	Strategic themes	High level strategic directions of the company going forward, that drive innovation and differentiation	Strategy team	CEO
Product backlog	Features	Significant product initiatives or major enablers. Not necessarily mapping to a end user feature improvement	Chief product owner	Chief product owner
Product backlog	Sub-features	Subsets of backlog items of the type "features", that can span over more than one product iteration	Chief product owner	Chief product owner
Product backlog	Capabilities	Breakdown of features into a **size that each can be finished in one product increment** to control the continuous added value. Capabilities are typically implemented by multiple teams	Product owner	Chief product owner
Development backlog	Epics	Breakdown of each capability into suitable development team work packages. Epics can span over more than one team iteration/sprint.	Product owner	Product owner
Development backlog	Stories	Breakdown of each epic into work items that can be **finalized within one iteration/sprint**	Team	Product owner

Note: All company backlog items should be expressed as value bringing stories with a clear definition of done (DoD)

Document C. The company backlog – a view of all the backlogs in Omega.

Furthermore, an intentional coherence between the structural and procedural arrangements was observed. Multiple interviewees referenced the 'BAPO' principle to describe the logic which had been employed to find that coherence.[42] 'BAPO' is an acronym for Business, Architecture, Process, Organization. In essence, the principle stipulates a hierarchy between these four aspects, in which business has the highest priority. Through this perspective, an organizational design should be a result of the process you have chosen, which, in turn, depends on the (product) architecture that you have chosen, which, in turn, is the result of the customer needs that you have chosen to solve (i.e., the 'business'). David explained that it is common that businesses unintentionally approach these aspects in the reverse order. Accordingly, that which individuals in a firm know and are structured to undertake (cf. 'Organization') sets the agenda for which processes the firm excels at undertaking, which, in turn, demands a certain architecture to be developed over time, which only enables a certain type of business. This phenomenon ('OPAB') is sometimes referred to in software development as *Conway's law*, which predicts the

[42] See Bosch and Bosch-Sijtsema (2014).

influence of the organization structure in the product that a firm delivers.[43] The consideration of the BAPO-principle was consequently influential for the design of organizational arrangements within Omega, specifically in terms of how to balance needs in the procedural (cf. 'Process') and structural (cf. 'Organization') dimensions.

4.3.3 Observations of commercial problems and knowledge

The observations in the study confirmed the expected pattern that the resolution of commercial problems required integration of commercial knowledge. However, and which was not in line with the expected pattern, the empirical material exhibited that the commercial dimension of knowledge integration is significantly more important than as emphasized in previous research. Two examples of commercial problems will be highlighted in this section to demonstrate this point. Moreover, additional observations will be provided throughout this chapter (see 4.5 in particular), which also underscore this point.

4.3.3.1 Customer relationships

A clear example of a commercial problem during the study was the management of customer relationships. Two principal kinds of relationship management were observed: management of existing relationships and customer acquisition (i.e., forming new relationships). Commercial knowledge appeared to be central to the resolution of both kinds of problems to solve. The description below of how Carl navigated the 'game of cat and mouse' between OEM and supplier is arguably a clear example of this fundamental pattern:

> The project [for the supplier] does not begin before the purchase order etcetera is completed. This is not a textbook example, but in reality, it often fails in multiple steps of the process. [For example] you don't receive a correct specification, and you can probably never get it completely correct. With a large OEM, there are a thousand attachments, from different organizational units which contribute different requirements. […] And when we deliver our reply, that gets split up among the internal organizational units. [It is good] to be ready in the starting blocks, in the best case to even have a [development] team ready, to send out the offer as soon as possible. Perhaps you have already agreed on a deadline which must be kept. These are car-projects, which means that there often are no delays. As a supplier, you might feel inclined to take risks, such as to start early with development efforts to meet the deadline. It is tough. I have been around for a long time. Everything between not reaching an agreement and accepting that you may not be able to deliver. You may start working on the delivery but then threaten to slow down if the OEM does not send the purchase order. That can be a game of cat and mouse, to receive the purchase order. My experience, after having been burned a couple of times, is that the best

[43] Compare with the 'mirroring hypothesis' (Colfer & Baldwin, 2016; MacCormack et al., 2012).

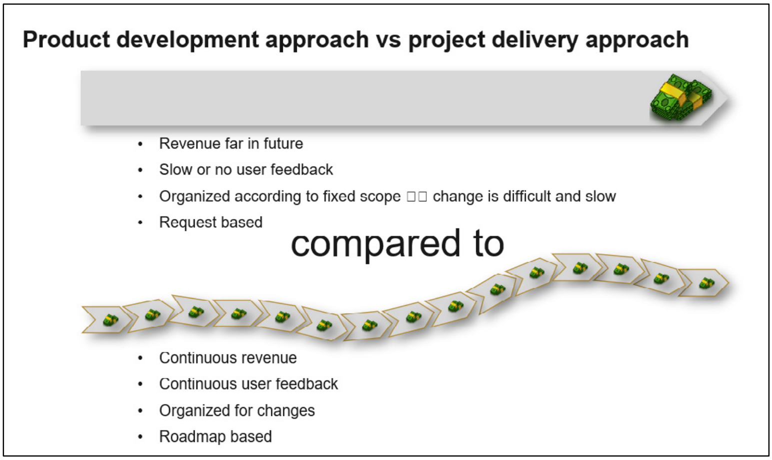
> course of action is to stay cool and hold out. If the purchase order does not arrive, we don't start working. Perhaps you state in the offer to the OEM that you have a relative time plan, which depends on when the purchase order arrives. The same game is played on the other side [by the OEM], between procurement, management, etcetera. There is hence a lot of psychology involved. (Carl)

Note also, similar to the observation in 4.3.2.1, that this depiction included multiple references to aspects which are specific to the automotive industry (see also forthcoming 4.5.4.2).

4.3.3.2 Revenue model

The observation that commercial knowledge could be industry-specific was also apparent in Omega's aspiration to establish a revenue model which challenged the norms in the automotive industry. Interestingly, the change of revenue model was entangled with additional aspects of what Felix referred to as the 'product development approach.' Four major shifts, i.e., between the current state and the desired state, were highlighted (see Document D). First, a shift from a coupling of revenue and project completion to a *subscription* model, in which the OEM would pay for access to a product that would be continuously improved and updated (cf. 'Continuous revenue' in Document D).[44] Second, a shift from slow or no user feedback to continuous user feedback. Third, a shift from being organized according to a fixed scope (where any changes in organizational arrangements are difficult and slow) to being organized to swiftly react if the business landscape changes (see BAPO principle in 4.3.2.2). Fourth, a shift from being (OEM) request-based to becoming roadmap-based in the priority of internal bandwidth.

[44] For background, the traditional project model for how to organize product development in the automotive industry was typically paired with a commercial agreement between the OEM and the supplier, which stipulated payment upon project completion.



Document D. Product development approach vs project delivery approach.

This observation was interesting in multiple ways. First, the articulation of the two approaches in Document B juxtaposed the ‘project delivery approach’ and the ‘product development approach’ as two competing *logics* for how to solve this commercial problem. Each logic, in turn, appeared to be supported by its own set of knowledge, i.e., which informs how and when each approach is an effective response to a commercial problem. Secondly, this observation showcased how the logic underpinning the proposed revenue model had dependencies (cf. complexity) with both organizational aspects (e.g., fluidity of structural arrangements) and technological aspects (e.g., feedback loops and rate of technological development). Consequently, several interviewees argued explicitly that the internal product development process would be either enabled or obstructed, depending on how this commercial problem (i.e., how OEMs would pay for Omega’s offering) was solved. Furthermore, this was another example of a simultaneous application of all three types of knowledge, i.e., as was also highlighted regarding the resolution of technological problems (see 4.3.1) and organizational problems (4.3.2). This recurring theme in the empirical material will be discussed in depth in the upcoming 4.5.

Third, the two approaches were described as distinctive for two different industries: the ‘project delivery approach’ in the automotive industry, and the ‘product development approach’ in the software industry. In the new industry of autonomous driving technology, Omega clearly argued for an increased emphasis on the logic which typically was employed in the software industry. This issue will be discussed in depth in the upcoming 4.5.4.2.

4.4 Subjects involved in the knowledge integration process

4.4.1 Individual-level

4.4.1.1 Judgment, difficult problems, and satisficing

The high degree of problem difficulty which was observed in the case (see forthcoming 4.6–4.8) appeared to make the cognitive limitations (cf. bounded rationality) of individuals more pronounced, in line with the expected pattern. To exercise judgment appeared to be a primary mechanism for individuals when confronting problems with difficult characteristics. An example of this was the decision to apply trust (i.e., versus control) as the prevailing mechanism to administrate internal organizational arrangements:

> We have tried to push down the responsibility to the team-level. To not work actively with follow-up and control. To trust what the teams say that they can accomplish in 6 weeks. (Eton)

Rather than based on 'facts' (i.e., which were not available), this decision appeared to be based on the experience of individuals in the management team and their interpretation of the circumstances in which Omega was acting. The application of judgment appeared to be especially prevalent in two types of instances. First, when it would be very time-consuming and effortful to produce an only marginally better decision through alternative mechanisms (e.g., search for information and rational analysis). Second, when substitutes to judgment were naturally constrained, for example, due to absence of knowledge or lack of access to knowledge (see 4.7.6). It was also common that individuals had to distribute their time and attention across multiple problems, which appeared to further lower the bar for when judgment was a preferred response. During the study, it was hence frequently implied that it was *good enough* for many decisions to be approximately right (cf. 'satisficing') if this meant that significant effort could be avoided.

Despite these benefits of individual judgment, in terms of speed (i.e., fast) and effort (i.e., low), there were also observations which demonstrated the drawbacks of frequently relying on judgment. Individual's judgment could, of course, turn out to be *wrong*. For example, Peter shared a situation where the top management made an important decision regarding a technological supplier, which Peter did not think was sufficiently grounded in his or his colleagues' technological expertise. A deeper investigation, which could have led to a better decision, would, however, have required more time and effort to be invested by multiple individuals, not least by the management team.

4.4.1.2 A persuasion-driven interplay between subjects

The results showed that the interplay between subjects was often characterized by persuasion, i.e., where a subject attempted to persuade another subject to make a certain decision. This is another way of interpreting the friction between subjects which is related to problems of collaboration, conflicts of interest, and so on (see 2.1.3.2). Specifically, the data showed that knowledge integration can often be described as a *tug-of-war*, where one side ends up victorious. Consider the cat-and-mouse metaphor by Carl in 4.3.3.1. Rather than merely a question of coordination, e.g., across respective internal departments, Carl described how it was also a problem of convincing internal and external subjects to take specific actions that would move the process forward in a specific direction. This type of interplay also manifested itself in the organizational dimension. In addition to conceiving procedural and structural arrangements, both Felix and David described how the implementation of these arrangements was not a given but involved efforts to convince individuals to let go of old ways of working. For example, after a major re-organization in January 2018, there were multiple individuals who previously had occupied 'managerial' positions that had to accept a new role without the same label or authority.

Consequently, it was surprisingly easy (i.e., relative previous literature) to apply the three central concepts in the rhetorical framework (*logos*, *ethos,* and *pathos*) to make sense of observations regarding the interplay between subjects. *Logos* was a useful concept to interpret observations of persuasion since both sides of the interplay typically invoked knowledge as a leverage for why a certain decision was superior. For example, the efforts to persuade OEMs to accept a subscription model (see 4.3.3.2) and continuous integration/deployment (see 4.3.2.1) appealed to a logic about how to solve the specific technological and organizational problems effectively.

Ethos was useful in interpreting how the credibility of subjects influenced persuasion. For example, Alexander described how the mechanism of utilizing colleagues as trans-specialists (cf. Postrel, 2017) endowed Alexander and his colleagues with additional credibility. This made it easier to get an audience with decision-makers who otherwise, i.e., without the involvement of the trans-specialist, would have been less inclined to consider their appeal:

> Such as when my colleague Robin works together with the product development-organization, then he always brings [name of colleague], since his experience is that he gets more of an audience when [name of colleague] joins him. (Alexander)

As an example of the influence of *pathos*, Alexander pointed out that persuasion was more challenging in instances where there was a tension or animosity between group-level constructs, such as between the different departments within Omega.[45] Interestingly, Alexander described how a proposed decision had to be *sold* to (and in extension: bought by) individuals in another department:

> If you want to push something into the backlog which the product owners do not think is a good idea, then it becomes very difficult unless you manage to sell the idea to them. Perhaps you can sell it to some product managers [who work for product owners], since it is easier to get them onboard. (Alexander)

Hence, it was indicated that there is a degree of 'performance' associated with the process of persuasion, i.e., beyond the reasoning of the arguments (*logos*) and how credible the subject is (*ethos*). *Kairos* was useful in interpreting the influence from historical paths (see 4.6.4) and from proximity (see 4.6.5). For example, the data showed that the process in Omega was spatially and temporally embedded in the history of its owners, the industry, the technology, the city, and the country, in which Omega was founded. As an example of the influence of *telos*, it was observed that the degree of collective identity and aspiration had implications for coordination and motivation (discussed in depth in 4.6.3). In summary, the extent to which the rhetorical framework could be applied to make sense of observations was surprising, relative to previous research. Moreover, this has implications for how to interpret the influence of relational characteristics, which will be discussed further in 4.6.6.

4.4.1.3 The roles and influence of managers and employees at Omega

In line with the expected pattern, there were many instances in which it became clear how managers had more influence than regular employees. See, for example, the hierarchy of backlogs and their respective scope in 4.3.2.2, in which the strategy team, i.e., the management team, had responsibility for strategic themes. Furthermore, the decision to design and implement the organizational arrangements discussed in 4.3.2.1 and 4.3.2.2 were far from democratic but a product of decisions by the same management team.

However, this depiction of managerial authority should be balanced with the importance of regular employees (i.e., individuals not acting in a managerial capacity) in the fluid and distributed organizational approach that was employed at Omega. To discuss decision-making as a wholly owned enterprise of managers, as often is the case in strategy literature, is simply wrong in this instance. Rather, the ambition to become an *"evolving organism of purpose driven empowered teams and roles"* (see 4.3.2.2) meant the opposite, in terms of what it meant to be a regular employee at Omega.

[45] Similar to Melander and Tell (2014), who discuss internal spillover from inter-firm conflicts.

4.4.2 Group-level

The observed pattern regarding group-level subjects largely confirmed what was outlined in the preliminary framework. For example, observations of how individuals were integrating knowledge in groups such as teams (with varying stability of group members), cross-team constellations, formal organizational units, ad-hoc task forces, the Omega-management team, and (on the highest level) firms (such as Omega, Alpha, Beta, Gamma, and potential customers and suppliers) and inter-firm constellations (such as the board of directors for Omega). It was also observed that individuals could both represent themselves and act on behalf of said types of groups.

The expected pattern regarding group-level knowledge was also reflected in the empirical material. For example, there were efforts to convert individual knowledge to explicit knowledge which were deemed worthwhile despite their added costs. 'Jira,' a popular information management platform for agile software development, for example, was used at Omega to distribute information about what each team was working on and the estimated status of each item. Regarding the influence of formal and informal structures within groups, this will be discussed at length in 4.6 Relational characteristics. What can be highlighted, however, which the preliminary framework does not emphasize, is that the degree to which the rhetorical framework can be used to explain group-level influence between subjects (i.e., as discussed in 4.4.1.2 regarding the individual level). For example, the cat-and-mouse metaphor used by Carl to describe the interplay between the OEM and supplier was illustrative of how individual-level interplay is influenced by the power of the group which an individual represents (see 4.3.3.1).

4.5 Knowledge about the firm and the industry as a mechanism for effective knowledge integration

The empirical material provided a new and surprising perspective on how knowledge integration is managed: by application of knowledge about how to achieve a firm's objectives. This observation is quite different from the emphasis in the preliminary framework on management according to problem characteristics. Furthermore, this finding goes much deeper into the influence of objectives than was outlined in 2.5.7. In this section (4.5), observations which led to and support this interpretation will be presented.

4.5.1 Mobilizing multiple types of knowledge simultaneously

While a particular type of problem (such as a technological problem) appeared to require integration of the corresponding type of knowledge mainly (i.e., technological knowledge), the accounts in 4.3 also illustrated how the resolution to multiple central challenges for Omega required integration of multiple types of knowledge. This potential was discussed in the preliminary framework (see 2.3.2.9). However, and more importantly, previous contributions appear to have overlooked the reason to mobilize all three types of knowledge simultaneously, i.e., the root cause for this pattern (cf. 2.5.7.2).

4.5.1.1 Technological problems

Starting with technological problems, the resolution of such problems at Omega repeatedly demonstrated interdependencies with commercial or organizational aspects. For example, how to solve a technological problem could be exposed to cost-benefit trade-offs (see the example about using more expensive hardware by David in 4.3.1.2) or be entangled with organizational aspects (see the example about architecture by Hugo in 4.3.1.2).

Another illustration of this observed pattern (i.e., the combination of multiple types of knowledge) was the explanation by Felix about how to enable faster feedback-loops. Felix explained that it is important for software companies to enable as fast feedback loops since this is conducive for iterative problem-solving, which, in turn, can increase the rate of technological progress. However, to establish a faster feedback-loop ('end-to-end') would in this instance involve the vehicles of end-customers. This was a major novelty compared to the current rationale in the automotive industry. Felix and other interviewees described how OEMs currently worked on projects that typically lasted 3–4 years to develop a new car model. In the current state, the lead time for feedback from end-customers was thus several *years* rather than several weeks, which was Omega's ambition (see 4.3.2.1).

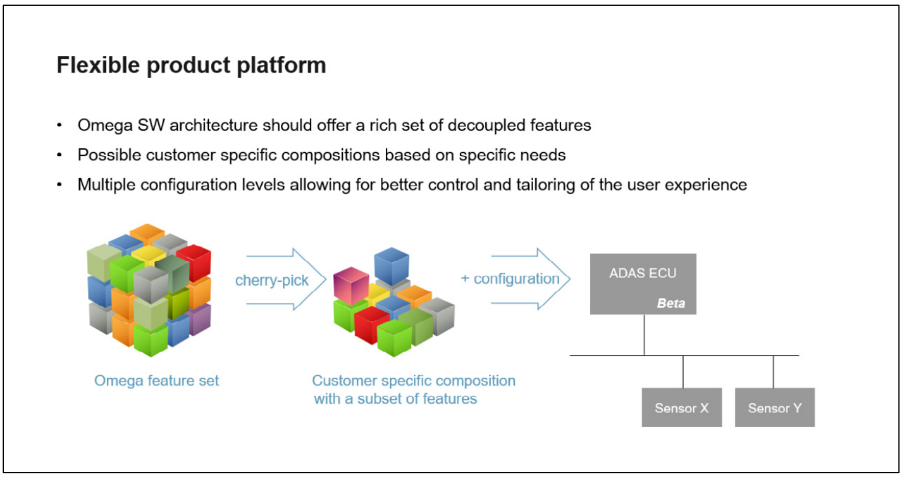
> If we deliver software which does not reach the car and end-user until 4 years later, at that point it is not even certain that we exist as a company or that the teams still exist to get feedback on what they developed. That is how a traditional procurement with an OEM works today. You write a contract with three thousand requirements and specify that it shall be delivered in 2023 on August 6th [as an arbitrary example]. Please swallow. (Felix)

Thus, the organizational arrangements (e.g., long projects) and commercial arrangements (i.e., with suppliers such as Beta and Omega), which typically were employed in the automotive industry, were obstacles for faster feedback-loops. Consequently, Felix argued that the business model in the automotive industry was the most challenging obstacle that Omega was facing, to enable superior technological development:

> And that is absolutely the most difficult thing to attack, because you cannot come all the way out to the car in the feedback-loop if you cannot change that business model. (Felix)

Multiple participants in the study, thus, praised the changes that were beginning to occur within Alpha, which previously had been quite entrenched in the automotive logic for product development. During the study, it was described that they were starting to appreciate the benefits of working differently with software development than with traditional hardware projects.

Another example of mobilization of multiple types of knowledge to solve a technological problem was the decision to employ a modular product architecture. An internal document (see Document E) explained that the *“Omega SW architecture should offer a rich set of decoupled features”* where it is *“Possible customer specific compositions based on specific needs”* and *“Multiple configuration levels allowing for better control and tailoring of the user experience”* (see Document E). In terms of cost implications, it was indicated (although not decidedly so) that this kind of modular architecture may be more costly to develop and maintain than its extreme opposite (i.e., a rigid, standardized architecture). However, it outweighed these added costs, and a modular architecture had benefits in the commercial and organizational dimensions (Brusoni & Prencipe, 2001, 2011; Sanchez, 1999; Sanchez & Mahoney, 1996). For example, in terms of which customers Omega could serve and how much customization Omega could offer to customers without having to make multiple incarnations of the same products. More on the latter will be discussed in the forthcoming 4.5.1.3.



Document E. Flexible product platform.

4.5.1.2 Organizational problems

The problem of how many individuals to hire was an illuminating example of dependencies between organizational and technological problems at Omega, with quite obvious financial repercussions. This problem was relevant since both the cost and time that it would take for Omega to solve technological problems would likely be a function of the amount of individuals that were hired to solve technological problems. However, the actual relationship between the time it would take to solve the technological problems in question (related to ADAS and AD) and the number of employees was not known *a priori* to the individuals that had the responsibility of making this decision at Omega.

> Currently, we are working a bit like 'how much can we afford to invest in machine learning?' Maybe we estimate that we need thirty individuals. OK, that sounds reasonable; let's do that. Let's find 30 people. To start somewhere! Fifty? Ten? A hundred? What is reasonable? That is a difficult judgment to make. (Eton)

Decisions about how many employees to hire (i.e., an organizational problem) thus required knowledge about how the lead time and effort required to solve the technological problems in question would vary depending on the number of employees with a certain specialization.[46] Eton, who was one of the key individuals regarding decisions about how many and which types of employees to recruit, for example, reflected on the quantity versus the quality of employees. Due to the opaque nature of individual abilities, Eton also described that it was difficult to know in advance if an individual would become a productive employee or not:

> Who are the individuals that contribute the most to a firm, really? Those who know everything but are not necessarily good at conveying it? Or is it the individuals who roll up their sleeves and just go? They may fail sometimes, but they keep going and produce results. What is competence, really? You can have a group of very intelligent individuals who do not produce shit. It [intelligence] is not a proof or a success factor that you will get a result. That requires a lot more. (Eton)

Moreover, there were observations during the study of organizational problems which required commercial knowledge to be resolved effectively. For example, potential tolerance for a longer lead time to solve certain technological problems was not arbitrary but depended on the progress of competitors who, essentially, were attempting to solve the same technological problems. Thus, if Omega would hire fewer employees, the certain technological problems may not have been solved within a viable timeframe (i.e., determined by the market). Since this would have been detrimental for the prospect of achieving any commercial objectives for Omega, there was a pressure to hire many employees rather than to be frugal. It was

[46] This was also an illustrative example of how judgment was applied in instances with significant uncertainty and complexity, i.e., which rendered other mechanisms unfeasible (see 4.4.1.1).

thus evident in the empirical material that knowledge about competition and the market which Omega participated in had to be leveraged in decisions about this organizational conundrum.

4.5.1.3 Commercial problems

In terms of interdependence between commercial problems and other categories of problems, a fitting example from the study was the challenge of deciding the scope and customizability of Omega's offering. Because the fixed costs represented a proportionally large share of the total costs to produce Omega's offering, the (software) products which Omega was developing had potential economies of scale. This potential, however, would only be realized if the product delivery could be standardized (i.e., delivering the same offering to multiple customers), since Omega's fixed costs for product development then could be shared by multiple customers.

However, the problem, according to multiple individuals at Omega, was that OEMs were more inclined to buy a customized product. This was because a customized delivery from Omega could enable the OEM to avoid internal costs related to technology integration. Interviews with Oscar at Alpha (as a customer of Omega) and representatives at other OEMs (during the first phase of the study) confirmed this internal assumption. Hence, there was a tension in the scope of Omega's offering between standardization (i.e., which was optimal for scale benefits but was less appealing to OEM customers) and customization (i.e., which was detrimental for scale benefits but was often a demand by OEM customers). When designing Omega's offering, it was hence essential to understand the properties of the specific technology (such as how costs of development are incurred) to strike a balance between the two modes of value creation. Notably, there were different opinions within Omega about how to resolve this tension:

> There are those who think we should just accept all proposed adaptations from customers, but then you have to know the consequences. (Felix)

Optimally, Omega, Beta /Gamma, and OEM customers would collaborate to unlock the scale benefits of the technology in question (ADAS and AD). The magnitude and distribution of potential scale benefits, however, were uncertain at the outset, which did not help to balance the equation for OEMs. Individuals at Omega hence explained how either the OEM customer had to be persuaded to enable integration of a standardized delivery from Omega, or Omega had to be persuaded into customizing its product delivery to the OEM customer. In the latter case, this would lead to negative effects for both Omega *and* its customers, which then collectively would have failed to unlock the scale benefits of the technology.

Furthermore, there were apparent organizational aspects of the offering scope-problem. Document B in 4.3.2.1 displayed how Omega's software delivery model was intended to work, including the feature of having *one* main software track (i.e., a standardized product) that can be seamlessly integrated with the production environments of Alpha and Beta, including the production environments of Beta's OEM customers. This type of delivery model was not novel *per se* in a software development context but represented a quite radical change for participants in the automotive industry. According to multiple participants in the study, one of the major pitfalls in software development is to abandon the policy of a main software track in favor of allowing customer adaptions. The reason, they claimed, is that the complexity of a more customized delivery tends to multiply within the organization. For example, it can lead to additional costs in the organizational dimension (such as having more administrative units, managers, and forums for internal coordination), not to mention the technological dimension (such as added efforts in the development, maintenance, testing, and validation of the software). Felix explained that to avoid such domino-effects was at the heart of a potential win-win between Omega, Beta, and the OEM customers.

> If we would translate that to how we work, let's say that we would let 10 customers onboard and that all customers would be allowed to get their exact wishes, what would happen then? Well, we would then have to develop 10 tracks or incarnations of the same software. What happens with our margins then? Well, it goes straight down the drain. So, it is about forming a global product offering which is so strong that it can be re-used by as many customers as possible. Otherwise, you won't be able to sustain margins on your products. (Felix)

4.5.2 A mechanism for problem-solving

The observation of simultaneous application of all three types of knowledge brings us to the finding of knowledge about a particular firm and industry as a *mechanism* for knowledge integration. When individuals in the study described how to manage knowledge integration, it appeared that a *synthesis* emerged at the intersection of the three types of knowledges. A way of describing this understanding (cf. synthesis) is that it appeared to represent knowledge about *what* Omega was trying to produce (i.e., the problems it was attempting to solve), *why* this was required (i.e., relative to the objectives Omega was trying to achieve), and *how* this should be accomplished (i.e., given the circumstances in which the process was embedded). Together, these aspects (what, why, how) appeared to be applied as a logic for how problems ought to be solved relative to the objectives of Omega and given the circumstances in play.

A fitting example of how this synthesis of knowledge was leveraged as a mechanism was the descriptions of why Omega had adopted a very fluid organization structure (see 4.3.2). David, for example, repeatedly referenced a relationship between the chosen organizational arrangement and the commercial and technological challenges that Omega was facing (cf. 'BAPO,' see 4.3.2.2). This synthesis appeared to inform David and other individuals at Omega about how to and how not to solve problems relative to the objectives of Omega. For example:

> If you know that the business is very uncertain and dynamic, then you need an organizational model which can adopt quickly. (David)

Another fitting example was the explanation of why the commercialization of autonomous driving was challenging, in which individuals typically referenced all three categories (technological, organizational, and commercial) of problems and how they interacted. For example:

> So, what you have is technological complexity, where you now have to say, OK, how will the market develop or even adopt to those technological complexities? Can we even succeed with this product development, and at what time? How do I come up with a product strategy which supports that? Who are the potential customers that we are going after? When can we plan in certain products and use cases? (Bastian)

It was also observed that it was possible for individuals to know more or to know less about this logic and that this had implications for problem-solving. Specifically, lower stocks of this knowledge appeared to leave an individual more exposed or prone to making decisions which would not result in or contribute to the achievement of Omega's objectives. In terms of variation in depth, the general observation was that individuals in the top management team appeared to have greater depth of this knowledge than lower levels of the organization. This is, however, a simplification that may be misleading since there were individuals at lower levels who also appeared to have quite a significant depth of this type of knowledge. Common for these individuals was rather that they had roles within the firm in which they were exposed to or responsible for problems that required all three types of knowledge, i.e., the type of interdependencies described in 4.5.1. For example, Alexander worked closely with Bastian (in the management team) and the CEO and was thus involved in solving some of the same problems as these senior executives. A common trait for individuals with less depth of this knowledge was instead that they were either very new to Omega, or new to the automotive industry. This suggests that the depth of this knowledge was subject to accumulation.

There is some support for this interpretation of the empirical material in the preliminary framework. First, in its depiction of mechanisms that can be applied by individuals to solve problems through a combination of knowledge (see 2.5.5). Second, that an individual's understanding (cf. 'representation') of a task may influence individual action (see 2.5.7.1). Furthermore, the preliminary framework contributes a language for how to describe fragments of what was observed. For example, some problems might require integration of multiple kinds of knowledge, which was discussed in 2.5.7.2; effectiveness of management is relative to the objectives of the firm, which was discussed in 2.5.7.1; and knowledge may be applied in a ‘satisficing’ manner, where its truth value is secondary to its potential to generate a desired outcome, which was discussed in 2.5.7.3. However, neither of these parts of the preliminary framework help to explain the observed interplay between these three parts and how the resulting type of knowledge was used as a mechanism. In this sense, the observation in question was surprising and thus warranted further investigation.

4.5.3 Firm-level and industry-level knowledge

The knowledge underpinning the mechanism described in 4.5.2 appeared to concern two distinct levels of analysis:

(A) Firm-level knowledge (i.e., about how to solve problems within the context of Omega) and

(B) Industry-level knowledge (e.g., about how to solve problems within the context of the automotive industry).

The purpose of applying both types of knowledge, however, was observed to be identical, i.e., as a logic for how problems should be solved relative to the objectives of Omega and given the circumstances in play. This division should hence not be interpreted as a disconnection between the two levels. On the contrary, the two levels of knowledge were applied in tandem to guide individual judgment about how to act.

For example, when the business development team judged which potential customers would be the best fit for Omega to sign commercial agreements with, the individuals in this team interacted to integrate their individual knowledge about how to prioritize their collective customer acquisition efforts. This process included (A) firm-level knowledge about how Omega could maximize the value of having more customers, such as knowledge about technological and organizational implications of entering into agreements with various OEMs. It also included (B) industry-level knowledge about how to navigate in the external environment in which Omega operated, such as insights about OEM customers’ problems to solve, and their procedures and criteria for selecting suppliers (i.e., such as Omega).

Another example of how this knowledge operated on two levels of analysis was the issue of customization versus standardization of Omega’s offering (see 4.5.1.3). Individuals from multiple functions within Omega (such as product management, business development, and architecture) and Omega’s management team interacted to solve this problem. This process included (B) industry-level knowledge about the technology in question (i.e., AD/ADAS) and trends in the automotive industry (such as knowledge about how competitors were composing their offerings), as well as (A) firm-level knowledge about implications of making adaptations for specific

OEM customers (such as knowledge about Omega's internal cost structure and ability to deliver on such agreements).

4.5.4 Specificity and idiosyncrasy

This observation takes the previously discussed duality (see 4.5.3) one step further by suggesting how an important feature of the mechanism of applying firm-level and industry-level knowledge was that the knowledge in question was *specific* for Omega and the industry in which Omega was acting.

4.5.4.1 Firm-specificity of knowledge about how to manage knowledge integration

Starting with firm-specificity, the empirical material illustrated that the knowledge in question, i.e., about how to manage knowledge integration, was not universal to all firms in the same industry but had to be applied differently for each firm. Three types of examples substantiate this point. First, data about Omega's strategy. Second, data about differences between Alpha and Beta/Gamma. Third, a comparison between Omega and one of its main competitors during the study (Waymo).

First, starting with Omega's strategy, there appeared to be two main factors which influenced the logic for how to benefit from the business opportunity of commercializing AD/ADAS: what Omega attempted to achieve and Omega's initial conditions. While Omega acted in the same technological and competitive landscape as its competitors, multiple interviewees referenced that there were two distinct ways of approaching the commercialization of ADAS/AD technology. The choice of approach, in turn, depended on the objectives that the firm wanted to achieve. The first was the evolutionary approach, which focused on developing technology that supports the driver of the car, i.e., ADAS and lower levels of driving automation (SAE International, 2021). The second was a more radical approach, aiming at developing a completely driverless car, i.e., the highest levels of driving automation ('Level 4' and 'Level 5'), and offering a mobility service, instead of selling cars to individual customers (SAE International, 2021). Omega had decided on adopting the more evolutionary approach:

> The next five-year strategy is to go after mass-market manufacturers with ADAS and to evolve. (Bastian)

This strategy clearly had implications for all three dimensions of problems related to Omega's objective, i.e., technological, commercial, and organizational. When speaking about competitors that had opted for the more radical approach of completely driverless cars, Bastian, for example, indicated that the cost-benefit trade-off (see 4.3.1.2) depended on the specific business model of a firm:

> So, their architecture looks different, and sensor costs are not so much of a hurdle, because the business model is to get rid of the driver. (Bastian)

Which strategy to employ also seemed to depend on circumstances that were specific to the individual firm, such as the initial conditions of Omega. Interviewees, for example, referenced that Omega had certain circumstances to consider which had implications for its strategy, such as Alpha's current business of producing cars and Beta's current business as a hardware supplier to OEMs. Another example was Bastian's argument that Omega's strategy should be grounded in its particular strengths and weaknesses.

> Where do we think Omega should play? Where do we see our niche? Where do we see our unique selling points and which markets do we want to explore first? (Bastian)

Secondly, the firm-specificity of the knowledge underpinning the mechanism also manifested in the divergent prioritizations among the owners of Omega. The knowledge underpinning how Beta/Gamma should achieve its own objectives appeared to make Beta/Gamma inclined to prioritize incremental ADAS product development within Omega. Conversely, the knowledge underpinning how Alpha should achieve its own objectives appeared to make Alpha inclined to prioritize radical AD product development within Omega. Despite acting in the same industry (i.e., identical external circumstances), there hence appeared to be firm-specific aspects which made Alpha and Beta/Gamma inclined to adopt different logics for how to capture the business opportunities associated with active safety technology.

Third, to make the point about firm-specificity of this knowledge even more apparent, it is possible to contrast Omega's approach to how a competitor (Waymo) was approaching the commercialization of active safety technology.[47] During the study, Waymo was considered being a front-runner within the industry and was explicitly committed to the more radical approach of developing AD technology for the purpose of becoming a key platform in an envisioned 'robo-taxi' market (i.e., which AD but not ADAS could enable). There were distinct circumstances which appeared to explain why Waymo's approach diverged from Omega's. For example, Waymo did not have any short-term revenue streams to protect or grow (cf. Beta/Gamma) and did not aim to become an OEM, i.e., which itself produced and sold vehicles to end-customers (cf. Alpha). Instead, through its owner Alphabet, Waymo had access to Google's dominant position as a customer interface for all things internet (such as search engine, maps, email, and entertainment). Furthermore, Alphabet had a recognized track-record in advanced software development (in other industries than automotive and active safety, but nonetheless) and an outspoken long-term ambition to become a leader in the nascent AD industry (including access to capital to enable this type of investment horizon). The initial

[47] Waymo was owned by Alphabet, the public holding company of the internet-giant Google.

conditions and objectives of Alphabet thus informed why Waymo's strategy diverged from Omega's, despite both firms acting in the same industry.

4.5.4.2 Industry-specificity of knowledge about how to manage knowledge integration

The method in this study was not designed to enable cross-industry comparisons (cf. as a multiple-case study design). With that disclaimer, there were indications in the empirical material that knowledge about how to manage knowledge integration could be *industry-specific*. This became apparent when interviewees juxtaposed the chosen logic for how to approach a problem at Omega with logics that were explicitly ascribed to specific industries. In particular, the practices and the logic of both the industries were repeatedly referenced in the empirical material: the *automotive* industry and the *software* industry.

For example, several interviewees described how the automotive logic that was employed by Beta/Gamma was an obstacle in the sales of Omega's products to OEMs. Since Omega depended on the sales team within Beta/Gamma to reach agreements with OEM customers (see delivery model in 4.2.5), this problem could not be circumvented. Specifically, it was described how Omega's products would be more competitive if sold as an integrated and optimized *system,* rather than as *components*, to be integrated by the OEM.

> Beta is a company which is extremely skilled at developing components and selling components. Now, they suddenly have to sell systems. (David)

The need to sell products as a system was, in turn, grounded in the nature of the technology in question, i.e., not a circumstance that was specific to Omega. Active safety systems depended on the integration of hardware with software that can run on a specific set of hardware (for example, control unit/-s and sensors). While this description may be a bit detailed for a reader without technological experience, this circumstance was a crucial point about how and how not to manage knowledge integration in the nascent AD industry:

> Let's say that Omega has developed a system, which is built on a software package that needs five components. If Beta sells two or three of those components to the OEM with our software, they are super pleased, because they have sold a lot. But the system which they have sold does not really exist, since the system we have designed requires all five components and not three. It can then be argued that the OEM must source those two components from somewhere else, which is fine, but who completes the task of integrating this into a complete system? (David)

Consequently, multiple interviewees explained that software was going to be relatively more important and valuable in the nascent AD industry compared with the current automotive industry.

> Today, they [Gamma] are basically selling sensors with our software as an attachment. I would have preferred it to be the other way around, meaning that you essentially give away the hardware. (Felix)

This transition of logic, from component sales (cf. the automotive industry-logic) to sales of an integrated system (inspired by the software industry-logic), thus highlighted the industry-specificity of knowledge about how to manage knowledge integration.

A second, more straightforward example of industry-specific knowledge was the numerous references to the previous experience of working with passive safety and active safety in commercial products. For example, the knowledge about passive safety technology included insights and data about car crashes which previously, at Alpha and Beta, had been used to improve passive safety features of cars. Now, at Omega, such insights could be leveraged to the problem of actively avoiding crashes and collisions. Regarding active safety, Peter thus argued that the accumulated experience of having worked with systems for active safety gave Omega an edge in the understanding of the use-case in which ADAS/AD technology was going to be applied. In reference to another competitor, Peter, for example, explained:

> Tesla has burned themselves multiple times, for example, by writing in the manual that the driver must have his/her hands on the wheel but then have a system which does not require hands on the wheel. (Peter)

Furthermore, it could also be interpreted that Omega attempted to combine experience from the automotive industry with practices from software development, i.e., at the intersection of two industry-specific logics (see, for example, 4.3.2.1 and 4.3.3.2). This presented the individuals in the study with interesting challenges, which will be explored in a forthcoming section on the development and evolution of the logic for the AD industry (see 4.5.6.2).

4.5.5 The influence of this mechanism on the management of knowledge integration

4.5.5.1 Positive influence on the management of knowledge integration

There were numerous observations in the study which highlighted the positive effects of individuals having a better comprehension of this firm-specific and industry-specific knowledge about how to manage knowledge integration. For example (by order of appearance): cost-benefit trade-offs (4.3.1.2); architectural principles (4.3.1.2); the 'BAPO' principle (4.3.2.2); which customers that would fit Omega's approach (4.3.2.1); introducing a subscription-based revenue model (4.3.3.2); the efforts to enable faster feedback-loops (4.5.1.1.); how many employees to hire (4.5.1.2); customization versus standardization of Omega's offering (4.5.1.3); understanding the competitive landscape (4.5.3); informing the specific strategy of Omega (4.5.4.1); the transition towards a different offering logic (4.5.4.2); and how to approach active safety in commercial products (4.5.4.2). There were, hence, multiple observations which indicated that individuals' understanding of this knowledge and ability to exercise the mechanism in question were not trivial but potentially of great value for Omega.

4.5.5.2 Negative influence on the management of knowledge integration

There were also potential adverse effects of this knowledge which are pertinent to report. As a general pattern, adverse effects were observed when the firm-specific and industry-specific knowledge about how to manage knowledge integration which individuals applied was flawed. Two types of flaws could be identified. First, when there were *contradictions* within the knowledge in question. Second, when there were *discrepancies* between the knowledge about how to manage knowledge integration and the circumstances in which individuals found themselves.

An illustration of the first type was the difference in objectives between Alpha and Beta and how this influenced the process within Omega. For starters, the influence of Alpha's and Beta's objectives was unmistakable within Omega:

> We got two companies which define our agenda. Everything from when we should be profitable to which products we should develop. (Eton)

Contradictions in the owner's objectives influenced knowledge integration within Omega in that they presented individuals with conflicting logics for how to make decisions and resolve specific problems. For example, the main purpose to co-create Omega for Alpha was to accelerate its development of active safety technology. While this included development of ADAS-products in the short-term, the main purpose of Omega for Alpha was to compete in the emerging industry for AD technology in the medium to long-term. This objective had its origin in the circumstance that Alpha was an OEM, and had to look for ways to differentiate its products and to create superior customer value (i.e., to sell more cars with better margins).

The purpose of Beta to co-create Omega was quite different, given its role as a supplier to multiple OEMs. While Beta did not communicate their strategy as overtly as Alpha, participants in the study shared that their interpretation was that Beta was more focused on developing ADAS products since these could be commercialized here-and-now. Although both Alpha and Beta embraced the prospect of capitalizing on their R&D-efforts by selling Omega's technology to other OEMs, Alpha seemed less inclined than Beta to do so if this could jeopardize Alpha's long-term ambitions within AD. Multiple interviewees referenced how this circumstance had implications within Omega. For example, Felix described how the attempts to introduce a subscription revenue model (see 4.3.3.2) were influenced by the respective inclination of Omega's owners to embrace a shift away from the established project-approach. Using the same reasoning, Alexander reflected on how different ownership structures (Beta was a public company, Alpha was privately owned) may have influenced their respective logic, for example, in the dimension of long-term versus short-term profits:

> How do we persuade them [Beta] to focus more on AD, which will have insanely low volumes initially and be very expensive? They are driven by their business. So, how do we align our objectives about AD? (Alexander)

Another illustration of negative effects was instances where there were discrepancies between individuals' understanding of how to manage knowledge integration and the external environment in which the process was embedded. For example, to introduce a new revenue model did not cause friction because the model as such was more intricate or advanced than the existing model, but because it went against the grains for how the relationship between the supplier and the OEM currently worked in the automotive industry. Another example was the discrepancy between the expectations of Omega's owners and the problems that Omega was currently working on solving:

> To track and share the status for those who provide us with capital is a challenge right now. They envision something completely different [than what we are doing], a car with a bed inside… (Eton)

Together, these observations frame the problem in a new way, relative to the preliminary framework. The empirical material showed that the knowledge about how to manage knowledge integration within Omega could be flawed. Consequently, this appeared to lead to more costly integration of knowledge, e.g., by focusing on the wrong things or doing the right things the wrong way. While this interpretation can almost be considered common sense, it was still a relevant finding, relative to the expected pattern. Logically, the remedy for such negative effect is to reconcile potential contradictions and to devise knowledge about how to manage knowledge integration without major discrepancies, relative to the circumstances in which the knowledge integration process is embedded. The observations in the study, however, suggest that this is easier said than done. Note that this last part is not surprising, given bounded rationality (see 2.4.1.1).

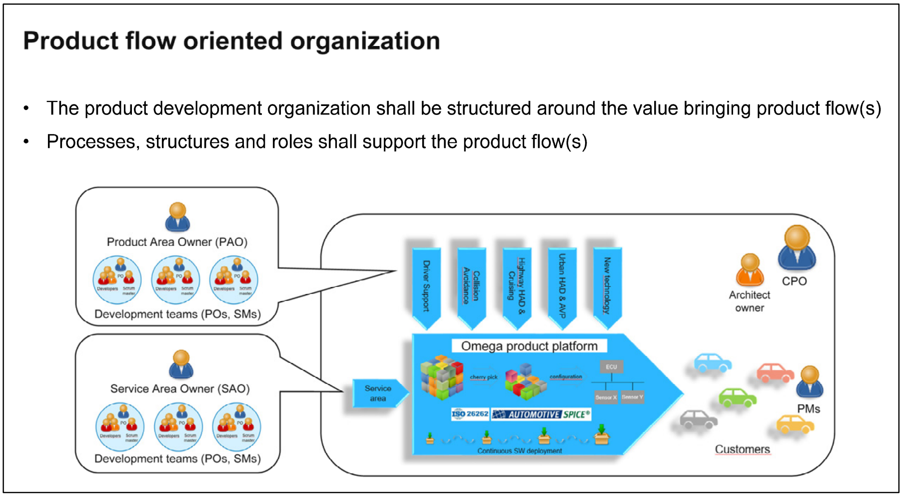
4.5.5.3 Practices to communicate knowledge about how to manage knowledge integration

A relevant question is what measures were undertaken at Omega to provide individuals with a sufficient understanding of how to manage knowledge integration, relative to the objectives of Omega. First, before presenting such measures, however, it is important to acknowledge that the knowledge in question was very dynamic and elusive in its expression and meaning. The elusive character of this kind of knowledge, in turn, seemed to depend on its origin, namely the individual synthesis of the three types of knowledge (see 4.5.1 and 4.5.2), and its high degree of tacitness, i.e., which only permitted imperfect transfer or communication (see 2.5.3.5). Consequently, there was no source for a perfect representation of this knowledge that was accessible during the study, neither for individuals at Omega nor for me as a researcher. My depictions throughout this chapter should, hence, be perceived as an attempt to capture an organizational phenomenon, rather than an account of tangible information. The following presentation of measures at Omega to communicate this kind of knowledge should be interpreted with this disclaimer in mind.

In terms of practices, a kind of codification effort was the various backlogs within Omega (see 4.3.2.2). For example, the 'strategy backlog' contained 'strategic themes' *("high level strategic direction")*, which informed individuals about what Omega should prioritize in its decision-making. The same can be said about lower levels of backlogs, such as the 'product backlog' and 'development backlog.' However, these backlogs foremost outlined *'what'* was prioritized, rather than *'why.'* More *why*-type of information to base individual judgment on was instead found in documents that communicated Omega's vision and mission. Felix described how the employees at Omega had been involved in this process and that the resulting document was not entirely a 'top-down' product from the management team.

> Everyone must know the strategic themes, so that one understands one's contribution to that direction. We have done work to revise the vision and mission, and not just in written form. (Felix)

Further insight into 'why' and 'how' could also be found in documents that depicted how Omega was approaching major problems, which had been identified by the management team, for example, the software delivery model (see Document B in 4.3.2.1), the juxtaposition between the project delivery approach and product development approaches (see Document D in 4.3.3.2), and the 'Product flow oriented organization' (see Document F below). Document F, for example, is not just a kind of organizational chart but can be understood as an attempt to illustrate *why* the molecule structure (see 4.3.2.2) was a preferred structural arrangement and how it is intended to function. For example, Document C explains that the *"product development organization shall be structured around the value bringing products flow(s)"* and that *"Processes, structures and roles shall support the product flow(s)"*).



Document F. Product flow oriented organization.

As pointed out earlier, all individual efforts, however, fell short in terms of capturing the nuances of the knowledge in question. Rather, a nuanced understanding appeared to emerge through aggregate interpretation of multiple efforts to communicate what Omega was attempting to achieve, why, and how. Interestingly, this circumstance presented individuals who had a significant comprehension of this kind of knowledge (e.g., individuals in the management team) with interesting choices about how much time and effort to invest in the communication of this knowledge to individuals without a requisite understanding. The metaphors of high and low resolution are helpful in conveying the cost-benefit trade-off of such decisions. Like a high-resolution image, a high-resolution representation of a concept is more accurate and leaves less room for individual interpretation. However, higher resolution requires more effort. A low-resolution representation conversely requires fewer efforts but is not as accurate and thus leaves more room for individual interpretation. As a general pattern, what was observed at Omega was that most efforts to convey firm-specific and industry-specific knowledge about how to manage knowledge integration were of the low-resolution type. The observed approach was hence pragmatic (contemplating cost-benefit) rather than adamant about accuracy.

Lastly, the distributed organization structure, which was discussed in 4.3.2.2, was consequential for choices regarding practices for communication of this knowledge. The main implication of this organizational arrangement was that it exposed many individuals in Omega to strategic decisions. As a consequence, it appeared that more individuals had to be endowed with an understanding of the firm-specific and industry-specific knowledge about how to manage knowledge integration at Omega.

Hence, this is compared with, say, a centralized structure in which all major decisions are centralized to the top of the metaphorical pyramid. A relationship, of sorts, was thus observed between the degree of decentralized organization structure and the number of individuals that needed an understanding of the knowledge in question.

4.5.6 Knowledge evolution and growth

A degree of simplification has so far been imposed (i.e., in 4.5) by primarily discussing *application* of knowledge about how to manage knowledge integration relative to the objectives of a firm (see 4.5.1–4.5.5). What was also observed was that this kind of knowledge was subject to *change* during the study. Observations regarding the growth of firm-specific knowledge (see 4.5.6.1) and industry-specific knowledge (see 4.5.6.2) will thus be presented in this section. Interestingly, this feature appeared to make the communication and application of the knowledge in question even more difficult (see 4.5.6.3). Lastly, practices that Omega employed to influence the trajectory of industry-specific knowledge will be presented (see 4.5.6.4) as a complement to 4.5.5.3 (on practices to communicate knowledge about how to manage knowledge integration).

4.5.6.1 Growth of firm-specific knowledge about how to manage knowledge integration

Several interviewees referenced that the decision by Alpha and Beta to start Omega included a first version of a 'business plan.' In their description of this business plan, a provisional logic had been outlined for how to solve all three kinds of problems in a way that would capture the perceived business opportunity. For example, this logic supported the strategic decisions to attempt to sell Omega's product offering to multiple OEMs through Beta and to agree on a 'reference hardware architecture' built on Beta's components.

From the start of Omega's operations in April 2017 and throughout the case study, new insights about how and how not to achieve Omega's objectives were then continuously generated. This was done partly through Omega's internal confrontation with various commercial, technological, and organizational problems, and partly as a result of changes in the external circumstances. For example, insights from early interactions with potential customers appeared to have a sobering effect. Specifically, this external input challenged internal ideas about how Omega could drastically increase the speed of its technological development (see 4.3.2.1 and 4.5.1.1).

Through such feedback from internal problem-solving (see, for example, 4.3.2.1) and external interactions (see, for example, 4.5.1.3), the knowledge about how to achieve Omega's objectives seemed to continuously evolve, throughout the study, to better fit the circumstances in play. The strategy of Omega (see 4.5.4.1), as it evolved, was thus observed to be a combination of new and existing knowledge. Accordingly, it is reasonable to depict this changed state as a growth and evolution of knowledge.

4.5.6.2 Growth of industry-specific knowledge about how to manage knowledge integration

Mirroring the observation in the previous section regarding firm-specific knowledge about how to manage knowledge integration, the industry-specific knowledge about how to manage knowledge integration appeared to evolve during the study. More specifically, the knowledge that evolved about how to act in the nascent emerging autonomous driving industry was interpreted to be the result of a *combination* of knowledge about how to manage knowledge integration in the automotive industry and software industry. Interchangeably, such knowledge will be referred to as a 'logic' in this section.

The approach to compare the software industry logic with the automotive industry logic was not my own interpretation, but an approach that was used repeatedly by interviewees in the study. Starting with the *automotive* industry, this industry appeared to be very influenced by the logic of industrial manufacturing. For example, knowledge about how to procure factor inputs, assemble material components, organize large-scale manufacturing, and develop new products through long projects (see 4.5.1.1). Due to its production and distribution of material goods, the automotive industry is also very capital intensive. In terms of value proposition, diverse aspects such as safety and reliability, brand/prestige, luxury/comfort, environmental aspects, economic aspects, and reliability/quality were emphasized by different car brands.

The *software* industry logic, in contrast, appeared to be quite different, relative to the automotive industry. For example, the main output is immaterial goods (i.e., code). This enables potentially extreme economies of scale, due to near zero marginal-cost (see 4.5.1.3). As a consequence of this property of software technology (i.e., typically leading to software platforms with low customizability), the buyer-supplier relationship is often skewed toward more power for the supplier, i.e., compared with the automotive industry. Furthermore, development of software technology typically favors agile principles over waterfall-projects (see 4.3.2.1 and 4.5.1.1). Instead of payment upon delivery (of projects), the subscription revenue model is commonly employed among software companies, i.e., granting the customer access to but not ownership of the product. In terms of value proposition, efficiency (e.g., through automation) and user experience were implied to be common selling points. For example, regarding user experience, the practice of *design thinking* was attracting attention:

> I believe that is very powerful. We got to learn from end-customers. Not necessarily what they say they want, but how they use our products. (Alexander)

As was highlighted in 4.5.5.1 and as this comparison between the automotive and software industry logics reveals, a significant part of the meaning is lost in the process of articulating and codifying this kind of knowledge. With this disclaimer in mind, Table C summarizes the comparison between the software and automotive industry in quite simplified terms.

Table C. Illustrative simplification of respective industry logic.

Illustrative problems to solve	***Automotive industry***	***Software industry***
Main output from knowledge integration	Material technology	Immaterial technology
Offering logic	Component	System
Customer value proposition	Safety, brand/prestige, luxury/comfort, environmental aspects, economic aspects, and reliability/quality	User experience and efficiency/automation
Supplier-buyer relationship	The OEM in the driver's seat (high buyer power)	The software producer has more (supplier) power
New product development	Projects, often lasting years. Slow feedback loops.	Agile, iterations measured in weeks. Fast feedback loops.
Revenue model	Upon delivery	Subscription
Cost model	Capital intensive – industrial production and distribution	Knowledge intensive – high fixed costs and low marginal costs

Differences between the two industries and subsequent problems in reconciling contradictions between respective logic were referenced by, for example, Leo (cf. 4.5.5.2). Leo highlighted that autonomous driving technology involved integration with hardware that currently was developed according to the automotive industry logic. Since the principles underpinning agile development originated in purely software-producing settings, Leo indicated that it would cause friction to apply these principles without adaptation:

> Within the automotive industry, there are a lot of requirements you must consider. We don't want to speak about milestones, but, in practice, there are milestones. (Leo)

This brings us to the observation that the logic for the nascent emerging autonomous driving industry appeared to be a *combination* of knowledge about how to solve problems in the automotive and software industry (see Table C). In the current state, i.e., during the study, the logic for the autonomous driving industry could be described as a foremost automotive industry logic, which also attempted to invoke knowledge about how to solve problems from the software industry. A key circumstance that Omega could not neglect, which supported this interpretation, was that practically all potential customers of Omega (as well as both Omega's owners) were still entrenched in the automotive industry logic.

Despite this, Omega was far from neutral about the direction in which it preferred the logic of the autonomous driving industry to evolve. Omega's desired state appeared to be almost the opposite of the current state: a logic foremost inspired by software industry-knowledge, which also leveraged knowledge about how to solve problems in the automotive industry. For example, Bastian elaborated on how Omega attempted to change the current *modus operandi* industry toward practices that were clearly inspired by the software industry, e.g., in terms of a model for new product development (see 4.3.2.2) and revenue model (see 4.3.3.2).

> [We are trying to] change it into a digital business model, where the hardware stays the same, but the content and valuation are in the software. And this could then go from a one-time sales into a continuous revenue stream. You know, like your phone, how it has a framework to host multiple apps. The content is in the apps. (Bastian)

4.5.6.3 Complicating the communication of knowledge about how to manage knowledge integration

A consequence of the growth and evolution of knowledge (i.e., as discussed in 4.5.6.1 and 4.5.6.2) was that this further complicated the task of communicating firm-specific and industry-specific knowledge about how to manage knowledge integration (see 4.5.5.3).

To begin with, it was illustrated in 4.5.6.1 and 4.5.6.2 how this knowledge was a kind of 'moving target.' Consequently, cost-benefit judgments had to consider the risk that changes in external or internal circumstances could drastically alter parts of the knowledge in question. This risk appeared to restrain any impulse to produce a 'high-resolution' representation of this kind of knowledge.

Furthermore, new learnings were typically *distributed* among multiple individuals, each holding a piece of the evolving puzzle. The growth of this knowledge was hence observed to be an interaction-intensive process. In summary, considering both findings (i.e., moving target and distributed learning process), it is thus reasonable to suggest that growth and evolution of this kind of knowledge made the task of communicating such knowledge more difficult rather than easier.

4.5.6.4 Practices for influencing the trajectory of industry-specific knowledge about how to manage knowledge integration

This section will focus on practices to influence the evolution of industry-level knowledge (cf. 4.5.6.2). First, it should, however, be acknowledged that Omega's influence over the trajectory of this industry-level knowledge was proportional to its position in the industry, i.e., quite limited. This is because the industry-level knowledge about how to manage knowledge integration was distributed among individuals in all firms in the industry, i.e., beyond the scope of Omega's control (see 4.5.4.2).

The logic for when to intervene (such as which developments of this knowledge to support or obstruct) appeared to be grounded in the firm-specific knowledge about how to manage knowledge integration, i.e., in the objectives of Omega. For Omega to be able to compete against well-funded competitors with an origin in the software industry (i.e., used to fast software development), it was suggested that Omega needed to increase its own speed for technological development (see 4.3.2.1). Thus, as described in 4.5.6.2, Omega attempted to influence other firms in the industry (e.g., OEM customers and other suppliers) to adopt practices inspired by the software industry (see, for example, 4.3.2.2 and 4.5.1.1).

To depict *how* Omega attempted to influence the growth of this knowledge in the preferred direction, the notion of persuasion was key (see 4.4.1.2). Specifically, the observations suggested that part of the answer in how to manage the evolution of industry-specific knowledge lies in the capacity of a firm to persuade other subjects. Three types of practices for persuasion were observed to be employed by Omega during the study. First, the main opportunity to persuade subjects in the external environment was through *bilateral interactions*, for example, with potential and existing OEM customers. In turn, the dynamics of such bilateral interactions were described to be influenced by pre-existing industry structures, about which individuals could know more or know less. For example, interviewees indicated that the susceptibility of OEMs to Omega's persuasion efforts depended on the market position of the OEM customer and the relative importance of the OEM as a customer for Omega.

A second type of practice was *marketing activities,* such as participation at renowned technological exhibitions, copywriting on Omega's webpage, employer branding activities (e.g., toward university students), and interviews in national and international media (predominantly featuring Omega's CEO Oliver). A common theme in these activities was that Omega appeared to be actively 'selling' its own version of the industry-logic to its peers. This was also interesting, since it was a clear break with the norm of not sharing crucial learnings that can be used by competitors to improve their approach to the same problems. For example, in an interview for an industry publication, Oliver described how Omega had invested a lot of efforts in organizational arrangements that enable faster technological development than its competitors (cf. 4.3.2.2), shared his view on several technological problems (such as application of AI in safety critical features), and discussed Omega's outlook on the commercial landscape (e.g., stating that he thought that there was only going to be a handful of companies which delivered robust and safe AD systems after 2023).

A third type of practice was to enter inter-firm *partnerships* with suppliers, as part of the ambition to offer OEMs a more integrated system (of both hardware and software). While such partnerships foremost had the mentioned rationale (to enable an integrated offering), it is also possible to interpret these partnerships as an effort to promote a more system-oriented approach, i.e., versus the component-oriented approach in the current state. For example, statements that were released to the press in conjunction with the announcement of new partnerships typically emphasized this orientation, as well as other themes that were aligned with Omega's preferred trajectory for the industry. There is, thus, some overlap between this type of practice and the second type (i.e., marketing activities).

4.6 Relational characteristics

In summary, the empirical results largely replicated the expected pattern regarding the influence of relational characteristics. Two main findings can, however, be highlighted, which are not sufficiently explained by the preliminary framework. First, the established conception of how to manage the characteristic of *collective identity and aspiration* needs to be extended to encompass also the mechanism of applying firm-specific and industry-specific knowledge about how to manage knowledge integration (see 4.5). A second finding, which spanned across all five relational characteristics, was that the preliminary framework does not sufficiently appreciate the extent to which the interplay between subjects is driven by *persuasion* (see also 4.4.1.2).

4.6.1 Social capital and trust

The importance of *trust* was a recurring theme in interviews, which, in line with the expected pattern, appeared to facilitate the process and lead to less costly integration of knowledge. Generally, the depictions of trust also confirmed the expected pattern of trust as a type of social capital that is accumulated over time. For example, there was unanimous agreement that efforts to build trust were important mechanisms for knowledge integration, relative to the circumstances in which Omega operated.

The opposite mechanism to trust, i.e., of imposing more *control*, was conversely implied to be an inappropriate response. Three main reasons were presented. First, more control would slow down the process. This went against the idea and logic of starting Omega in the first place (see 4.2 and 4.5.4.1), e.g., since it would risk making Omega uncompetitive in the industry in which it acted. Secondly, more control would require more managerial roles, which would directly add costs. Third, control was in many instances not feasible due to the high degree of tacitness of the knowledge to be integrated, i.e., it makes it difficult to transfer knowledge to the individual who hypothetically would impose control (see 2.5.3.5).

An interpretation of the data is that trust-building represents a type of organizational knowledge, which can be cultivated and exercised as a mechanism by both managers (such as Isak, Gustav, and Eton) and individuals without managerial responsibility (such as Hugo, Alexander, and Carl). For example, Isak, a manager for multiple teams, described efforts to cultivate trust as an investment in an environment which was more conducive to knowledge integration.

> You need to invest time to build that trust. Because I am not a technological contributor, I do not contribute with technological knowledge to the team's development. But through dialogue and questions, I can make sure that they think along new lines of thought, that they have an environment which enables them to be high performing. (Isak)

4.6.2 Coupling

The *molecule structure* at Omega, which was very loosely coupled compared to traditional, hierarchical bureaucracies, was an illustrative example of how the degree of coupling influenced the knowledge integration process. In this organizational arrangement, molecules (i.e., individuals and teams) interacted like how an organism evolves and continuously adapts to its environment (see 4.3.2.2). The molecule structure thus resembles the concepts of a *cellular organization* (Miles et al., 1997) and *adhocracy* (Mintzberg, 1979). Another example of loose or tight coupling was the employment of employment of *holacracy* and *self-organization* at Omega.[48] These approaches to organization of subjects can be understood as the opposites of structures in which the intra-team organization is a managerial responsibility. An imperative to make such arrangements function productively, thus, seemed to be to have very motivated employees.

The costs of coordination to manage these organizational arrangements was observed to be significant in the study, e.g., requiring significant mutual adjustment (Enberg, 2007; Thompson, 1967). However, it was also interpreted that arrangements with tighter coupling could likely have been even more costly to employ, given the characteristics in play and participants' descriptions of how they interacted to solve problems. For example, the presence of problem characteristics such as task uncertainty, novelty and complexity, and knowledge specialization, differentiation, and relatedness rendered many traditional mechanisms, such as planning, control, and vertical information transfer, quite ineffective at Omega. The observations in the study are hence encompassed within the expected pattern in the preliminary framework, i.e., influence of coupling will depend foremost on other problem characteristics.

[48] For reference, the following is a definition of holacracy: *"Holacracy is a new way of structuring and running your organization that replaces the conventional management hierarchy. Instead of operating top-down, power is distributed throughout the organization – giving individuals and teams freedom while staying aligned to the organization's purpose"* (Holacracy.org, 2021).

4.6.3 Collective identity and aspirations

The management of collective identity and aspiration was especially emphasized by interviewees who were part of Omega's management team. Their main response to this characteristic is captured by the previously presented efforts at Omega to equip individuals with firm-specific and industry-specific knowledge about how to manage knowledge integration knowledge (see 4.5). The empirical material indicated that the purpose of such communication efforts was two-fold: coordination and motivation. This effect can be interpreted through the perspective of the influence of collective identity and aspirations.

4.6.3.1 Coordination

First, collective identity and aspiration were observed to function as *coordination* mechanisms, i.e., to ensure that individual action was aligned with the purpose of the joint venture (see 4.2). Coherence between individual decisions (cf. to play as a symphony) was deemed to be important at Omega, which made issues of coordination consequential. The decentralized organization structure, which was employed at Omega (see 4.3.2.2), made this issue even more urgent.

The metaphor of low and high resolution was used in 4.5.5.3 to capture differences in depth and accuracy of communication of firm-specific and industry-specific knowledge about how to manage knowledge integration. A low-resolution version of this kind of knowledge appeared to be the preferred choice for how to communicate this knowledge to all employees. Interestingly, relative to the expected pattern for this characteristic, this response appeared to improve coordination within Omega. This observation highlights the task of fostering collective identity and aspiration within a firm (cf. Runsten & Werr, 2020; Werr & Runsten, 2013). For example, decisions regarding *how much* effort to invest in the formulation and communication of the 'what,' 'why,' and 'how' (see 4.5.2).

4.6.3.2 Motivation

In summary, observations regarding motivation also confirmed the expected pattern, namely that more collective identity and aspiration led to less costly integration of knowledge. The data suggested that motivation was not direction-agnostic but a matter of persuading individuals to act in line with a *specific* logic, i.e., that which was implied by the firm-specific and industry-specific knowledge about how to manage knowledge integration (see 4.5.2). There were multiple forces that appeared to influence individuals to not act according to this kind of knowledge. For example, individuals could primarily be motivated by other aspects than the prospect of achieving Omega's objectives, such as to work with cutting-edge technology:

> "I rather want to do this other, super fun task, where I can think freely and be groundbreaking." That can be hard to comprehend, apparently. What is it really that the company is paying my salary for? (Joe)

Eton highlighted that such mindsets could lead to conflicts, e.g., when prioritizations based on Omega's strategy required individuals to stop working on a task that they were motivated to work on:

> People may think that is the wrong decision, but from what perspective was that the wrong decision? Does that consider the product or the entertaining technological task you would have been involved with? (Eton)

Thus, Alexander highlighted the importance of managing expectations for individuals. For example, Alexander explained that the automotive industry was very tough, and that this aspect might come as a shock for newcomers in the automotive industry.

> If you don't deliver at the expected standard, then a SWAT-team from the OEM comes and starts working here. And forces, yes forces, individuals to work overtime. That is how it works. (Alexander)

Joe similarly described that everyone in his team did not yet understand how the industry works (cf. industry-specific knowledge, see 4.5.4.2 and 4.5.6.2), and that expectation-gaps could be an issue for motivation. For example, not understanding the ramifications of not completing one's own task in time:

> That is not just a matter of a project delay for the customer or for us. It can be that a customer is involved; it can be that a supplier is involved. That machinery is quite huge, and everyone does not maybe have a comprehension of that. (Joe)

To remain motivated, however, was not merely a matter of managing expectations, e.g., by having more knowledge about how the industry works. Alexander, for example, described that personality traits also mattered:

> There are a lot of people like that here, who do not get sad if they get yelled at by a German manager at an OEM. Others here…would jump off the roof if that happened. (Alexander)

Finally, the empirical material indicated that this characteristic was susceptible to *time*. There were, for example, many individuals at Omega who involuntarily had been part of the carve-out from Alpha. Eton's estimation, however, was that there was a gradual decrease in self-interest over time, and a gradual increase in motivation and identification with the new company.

> Initially, you perhaps thought more selfishly. Though "what do I do in this company?" […] You change, however, toward becoming more a part of the company. What do *we* do to make this company succeed? […] Now, it is more that people question the direction [of Omega]. "Why don't we do 'this,' why don't we do 'that.'"

> Those are complaints at a better level, because then you are at least invested in that the company should succeed. (Eton)

4.6.4 History and path dependence

Historical paths were observed to be very influential during the study, in line with the expected pattern. Both positive and negative influence, in terms of integration costs, were observed. In this specific case, the positive effects were not observed to be as influential as the negative effects at Omega.[49]

4.6.4.1 Negative influence

There were numerous accounts of how the history and path dependence influenced knowledge integration, in some instances by leading to more effort. To begin with, the historical account by David of how Omega got started portrayed how the joint venture was the result of two paths converging (see 4.2.5). David described how Alpha invited multiple suppliers to an event in 2014 to probe their interest in sharing development costs for active safety technology (cf. AD/ADAS). For context, Alpha and Beta had a customer-supplier relationship going back multiple decades. This was relevant since the logic underpinning Omega's strategy appeared to still be influenced by this starting point, i.e., although this logic had evolved and grown more sophisticated since those early discussions in 2014.

Furthermore, Gustav discussed how the respective history of Omega's owners (i.e., Alpha and Beta) and the history of the automotive industry influenced how Omega currently approached several technological problems. Gustav, for example, described that individuals who originally had worked at Beta were used to being a supplier to OEMs, and that individuals who originally had worked at Alpha (including Gustav himself) were used to being buyers of components from suppliers. This led to clashes between different logics for how to approach problems (e.g., sales of components versus systems) and meant that individuals who previously had worked at Alpha had to adopt to a new role:

> Our previous colleagues at Alpha are buyers, and we are suppliers. How much of a supplier-relationship should we have, and how much strategic partners should we be? We benefit from our personal networks at Alpha but, well, we still have to think about how to build it in a way which is sustainable over time. (Gustav)

Regarding the negative influence of historical paths, Felix described that he was worried that too much of the knowledge underpinning Alpha's strategy would

[49] A word of caution regarding this result is that this relational characteristic is more sensitive to the longitudinal perspective than other characteristics in the framework. Hence, it might be too early to determine the influence of this characteristic, due to the methodology which was employed in this study.

persist among individuals who had previously worked at Alpha. Specifically, Felix was worried that this would not blend well with the approach that Felix and the management team were devising (see 4.5.2 and 4.5.5.3). At a large internal event, Felix thus decided to take a stand by challenging the extent to which Omega should remain on the same path as Alpha:

> We had a large workshop in December [2017], where I presented this proposal [regarding organizational arrangements]. And yeah sure, many almost choked a bit. But after we had talked it through, then most expressed that this was how we wanted to run the company. Because I challenged them by asking 'is it a small Alpha we want to build or something new, modern?' We were on our way toward building a small Alpha. (Felix)

Similarly, Hugo discussed how the persistence of paths (cf. 'lock-in') sometimes caused individuals to not think through problems properly, i.e., how to solve a problem relative to the objectives of Omega:

> It can be instances of "we have done this at Alpha, we know how to do this, what people want, let's go that direction," instead of investigating what Omega ought to do. (Hugo)

Felix likewise described that individuals' previous experiences were counter-productive for Omega's efforts to establish new organizational arrangements (see 4.3.2). In his description, individuals who were accustomed to a traditional pyramid had a hard time letting go of norms and practices associated with this type of arrangement. For example, Felix described that many individuals wanted to be at the top of the 'pyramid' and thus be in a position to tell other people what to do. As a result of this ambition, Felix concluded that:

> The report that you send upward in a hierarchy is always gold-plated; you don't want to demonstrate your failures. That is how it works in pyramids. That which is uncomfortable is filtered out. (Felix)

4.6.4.2 Positive influence

The accounts above (in 4.6.4.1) foremost deal with how this characteristic was a *problem* for knowledge integration. It should thus also be stated that historical paths could have a positive influence, i.e., entail *opportunities*. Consider the previously presented characteristic of collective identity and aspirations (see 4.6.3). The history of each owner arguably made knowledge about the Omega and the nascent industry for autonomous driving more relatable (cf. 2.5.3.3) and thus easier to apply (cf. 'self-reinforcement' in 2.5.4.4). For example, Alpha and Beta's respective history of promoting safety appeared to facilitate a buy-in regarding Omega's strategy in the technological dimension, i.e., a more incremental approach (see 4.5.4.1):

> We are on an evolutionary safety-first path. Meaning to place one step after the other. (Bastian)

Another example was that Alpha was perceived to have a very high social status in the city in which Omega's headquarters was situated. My own interpretation was hence that it was quite attractive for individuals in this city and region to become an employee at Omega. Especially so considering that the objectives of Omega, to develop and commercialize cutting-edge technology, could contribute to the continued success of Alpha. Hence, these 'initial conditions' appeared to make it easier for Omega to persuade individuals to join and to contribute to the achievement of Omega's objectives (cf. 'employer branding').

4.6.5 Proximity

Less geographical distance between individuals was largely discussed as beneficial for knowledge integration in the study, since this enabled less elaborate forms of interaction. For example, Alexander discussed how sitting next to Carl made it easier to coordinate various issues, especially by facilitating ad-hoc interactions:

> That is just how it organically turned out. We sit next to each other, those of us who work more closely together haha! (Alexander)

Conversely, vast geographical distances were discussed as problematic for knowledge integration. Hugo, for example, explained how he had not yet managed to find the time or financing to travel to Detroit to meet colleagues in his team in-person:

> Another challenge is our team in Detroit. We have not been able to meet in-person yet. Presentations, Skype, and Slack have been our main methods. There were discussions about traveling there for a week, but that was never funded. (Hugo)

Regarding the influence of proximity on knowledge integration, the results in the study hence confirmed the expected pattern in the preliminary framework.

4.6.6 The interplay of persuasion in the context of relational characteristics

The role of persuasion that was presented in 4.4.1.2 also informed new interpretations of the influence of relational characteristics. Specifically, the relevance of the rhetorical framework to explain this kind of interplay between subjects appeared to inform *why* the relational characteristic had the influence on knowledge integration which was observed. Consider, for example, how much should we trust each other? How can we persuade employees to adopt a shared identity and aspiration? How much should we allow historical paths to influence the present?

Looking more closely at social capital and trust, the varying presence of trust appeared to lead to varying boundaries for persuasion. In instances of high trust between subjects, the hurdle for persuasion appeared to be lower. As a result, individuals appeared to spend *less* effort on persuasion in high-trust instances. This can be compared to instances in which there was less trust between subjects, which conversely appeared to require *more* persuasion efforts. The effort to persuade potential OEM customers to enable continuous deployment/integration (i.e., to mutually benefit from faster technological development) was an illustrative example (see 4.3.2.2 and 4.5.6.4).

The account of influence from history and path dependence (see 4.6.4) was an illustrative example of how relational characteristics were open to negotiation. For example, Felix even explicitly described how he attempted to persuade Omega's top management as well as regular employees to refrain from replicating too much of the knowledge that had been employed at Alpha. The same pattern, i.e., how relational characteristics were subject to persuasion, was also observed for coupling, proximity, and collective identity and aspiration. For example, regarding collective identity and aspiration, Martin described how he tried to install a culture of cost awareness by appealing to employees' sense of 'business smartness.' For example, regarding proximity, Alexander described that to not work at the headquarters made it more difficult for one of his colleagues (Robin) to bolster support and get buy-in for his proposals. For example, regarding coupling, Felix described how rigid organization structures may lead to unwanted implications, such as making it harder to persuade managers to share their budgets with other teams.

Note that this interpretation does not contradict the observations which were presented in 4.6.1–4.6.5. Instead, this finding tells us something about relational characteristics more broadly, in relation to the interplay between subjects in the knowledge integration process, which was not sufficiently explained in the preliminary framework.

4.7 Knowledge characteristics

In summary, the preliminary framework rather well explained the influence of knowledge characteristics which was observed in the study. Three main findings, however, deviated from the expected pattern. First, knowledge locus appears to contain two distinct knowledge characteristics which should be treated individually. One characteristic which describes the aspect of *locus* (i.e., internal/external), and one characteristic which describes the aspect of *absence/existence* of knowledge. Second, the empirical results showed that the description of knowledge complementarity was not complete in the preliminary framework. Specifically, the *opposite* of complementarity is a potential that was observed in the study, but which is not discussed in previous literature. Third, the data confirmed the relevance of treating *specialization* (cf. knowledge depth) as its own knowledge characteristic.

The presentation of empirical data below will follow the same order as the preliminary framework, i.e., not in the order of significance for the case or whether the findings were surprising.

4.7.1 Specialization

According to the literature, a distinctive trait of difficult problems is that they require integration of *specialized* knowledge. The expected pattern of more knowledge specialization leading to more costly integration was generally confirmed in the study. However, previous attempts to consolidate knowledge characteristics (Brusoni & Prencipe, 2011; Carlile & Rebentisch, 2003; Enberg, 2007; Tell, 2011, 2017) have not included these characteristics as a separate 'variable.' The observations in the study showed that this needs to change.

For example, more depth of specialization caused certain mechanisms, such as articulation and transfer of knowledge, to become either unfeasible or extremely time-consuming. This was due to cognitive limitations of both the sender (the ability to transmit knowledge accurately) and the receiver (the ability to comprehend and integrate the transmitted knowledge accurately), i.e., in line with the preliminary framework (see 2.4.1.1). A particular type of instance where deep knowledge was essential was in the creation of new knowledge. This was because knowledge creation, in some sense, represents an increased depth of knowledge. The necessity of knowledge creation was especially evident in the technological dimension, in which Omega attempted to solve previously unsolved problems:

> In some regards, it is a novel area. The knowledge is new, and the advancement in development is quite radical, not incremental. More like a paradigm, in terms of the magnitude of what should be accomplished. It is an unexplored terrain. (Kenneth)

Interestingly, Kenneth also connected deep specialization with judgment (see 4.4.1.1). For example, he described that having less prior experience (i.e., less deep knowledge) impaired his ability to make accurate judgment calls:

> Even if you would do an analysis of risk in advance, then it is really difficult to identify what has high risk unless you have deep previous experience within the area. (Kenneth)

In accordance with this view on experience, multiple interviewees indicated that deep specialization was often *accumulated* over time. Kenneth, for example, explained how some knowledge was acquired through learning by doing:

> Sometimes, you must test and run into a brick wall, and only then understand. (Kenneth)

An implication of this observation is that time appears to be a resource when it comes to depth of specializations, i.e., which needs to be expended to gain deeper knowledge about how to solve certain problems. For example, individuals in teams that developed features did not know *ex ante* what they needed from the data infrastructure which Kenneth and his colleagues were building.

4.7.2 Differentiation

4.7.2.1 Integration of different specializations

The observed pattern was that more differentiation of knowledge (and thus less shared knowledge) generally appeared to lead to more costly integration of knowledge, in line with the preliminary framework. For example, Bastian described how multiple, different specializations had to be combined to make decisions about the strategic themes and the product roadmap (see 4.3.2.2):

> Pelle: Let's talk about the roadmap, the definition of business needs. Which other functions within Omega are also involved or are you heavily dependent on? Or is this very much autonomous and up to you and Alexander?
>
> Bastian: No, the roadmap is a [product of] teamwork.

Bastian then described that this involved knowledge about the market (such as which features are in demand and which growth areas are identified), knowledge about the technology (such as inputs from engineers about current capabilities and emerging technology), knowledge about product development (such as current priorities and progress), knowledge about the financial situation (such as to understand available bandwidth and resource allocation), and knowledge about Omega's owners objectives (such as changes in priorities, due to changes in external circumstances). To combine all this knowledge, in turn, required the involvement of multiple individuals from multiple parts of the firm:

> So, you include business; you include product. You include engineering and research, and we include our owners. (Bastian)

Another illustration of the observed pattern was how more shared knowledge facilitated integration. Alexander, for example, described how the product and business functions had to invest effort to better understand their respective knowledge domains (cf. technological and commercial knowledge):

> Both teams must have an overview which they have never needed in the past. Product must think business, and business must think product. (Alexander)

Furthermore, when an individual possessed multiple specializations, this was clearly beneficial for the knowledge integration process (i.e., again confirming the expected effects of shared knowledge). Carl, for example, explained how his prior experience from other roles enabled him to contribute to problems which other functions than his own were responsible for:

> Regarding specific knowledge, my contribution when I am in engineering teams is my experience of working with sourcing, working with the business part; in an earlier job, I even had responsibility for accounting and to deliver a result. (Carl)

4.7.2.2 Fit between individual knowledge and Omega's priorities

Felix explained an interesting drawback of having very differentiated knowledge in a firm: the potential fit or discrepancy between individual knowledge and Omega's objectives (see 4.3.2.2 and 4.5.2). While this finding followed the expected pattern in terms of cost implications, it is worth highlighting because of its relevance for the influence of objectives in management of knowledge integration. Specialization was clearly necessary to undertake particular tasks (see e.g., 4.3.1.1). However, Felix pointed out that the *value* of different individual specialization depended on Omega's current prioritization (cf. 'objectives'), which was manifested in its levels of backlogs (see 4.3.2.2). For example, according to Felix, a team that can solve only one type of problem, however important, only maximizes its contribution to Omega when the backlog *exactly mirrors* the capacity of that team:

> Because when they have free bandwidth, then they can't use that to complete other tasks. If they are overloaded, then no one can help them. This is something you must think through! (Felix)

Felix then described how investments in flexibility (cf. Ravasi & Verona, 2001) was a key response, i.e., so that teams and individuals could undertake different tasks than its primary specialization. Such investments were deemed necessary to be able to adapt to changes in the 'business' (cf. 'BAPO'), which Omega was engaged in:

> When the day comes that we receive a new order in a cool domain, how do we solve that then [without flexibility]? Should we not be able to allocate resources to that area? What do you do then? Then you have a cost for something in your company which you are not selling! (Felix)

Felix described that this facet of knowledge differentiation is a key aspect of how firms in the software industry can radically increase productivity, below referred to as ‘velocity’:

> The answer is that you don’t want to be stuck waiting for the only team that can undertake a certain feature, but you want to use the team that is available because they just finished another feature. This is how you increase the flow velocity and get many, many more features out to the market. (Felix)

4.7.3 Relatedness

In line with the expected pattern, a higher degree of relatedness of knowledge was quite uniformly discussed as an enabler of less-time consuming or effortful mechanisms for integration. For example, Hugo explained that there were different types of knowledge about software development in his team, and that the extent to which these were related was not trivial:

> To develop software for the cloud is quite distinct from development of code for an embedded system in a car, which has other architectural principles. (Hugo)

This pattern was even more apparent beyond interactions within individual teams, such as in interactions across organizational functions. For example, when engineers had to explain quite advanced technological knowledge to individuals who worked with business development.

4.7.4 Complementarity

4.7.4.1 Synergies

The observations in the study pointed in the direction of the expected pattern, namely that less complementarity of knowledge leads to more costly integration. An observation which substantiates this pattern was the mechanism of using firm-specific and industry-specific knowledge about how to manage knowledge integration (see 4.5). This was an illustrative example of how there could be a synergetic relationship between different types of knowledge (commercial, organizational, technological). For example, the scope and customizability of Omega’s offering clearly required all three categories of knowledge to be combined (see 4.5.1.3). The product of integration in this instance was arguably more valuable (cf. ‘larger’) than the sum of its individual parts, i.e., the different specializations which were combined.

Synergies were also possible *within* knowledge domains, such as within technological knowledge. Kenneth, for example, explained that his team had previously worked too independently, and as a result had failed to accumulate enough insights about what the end-users (e.g., software developers in various teams) of their data platform actually required.

> A lot is lost in translation during the distillation-process. It turns into a whispering-game: what is received from the sender turns out to not be what the sender intended. (Kenneth)[50]

Such insights, about the end-users' problems to solve, would have been complementary since they would have enabled Kenneth and his colleagues to produce a better output (i.e., a more useful data platform), and which, in turn, would have enabled developers within Omega to solve their respective problems more effectively. Consequently, multiple participants in the study advocated investments in acquiring complementary knowledge, e.g., through mechanisms such as internal job-rotation within Omega and more investments in end-to-end collaboration across functional boundaries.

4.7.4.2 The opposite of synergies

Nonetheless, knowledge differentiation did not always lead to synergies. What was also observed in the study were instances where differentiation of knowledge was *destructive,* rather than productive for the knowledge integration process. For example, when individuals were making choices about which people to involve in joint problem-solving (a common mechanism at Omega to solve problems which require multiple specializations), it was not necessarily the case that inviting *more* people would make the process more effective (i.e., lead to a better output) or efficient (i.e., lead to the same output at a lower cost). On the contrary, when the relatedness of an individual's knowledge was extremely low and when the contribution of that knowledge to the output was expected to be minimal, there were good reasons to *not* invite that person to participate in joint problem-solving. Hence, the output of that joint problem-solving could become *worse* by the inclusion of that individual, for example, by having to spend time and effort on transferring knowledge, simply to enable that person to even comprehend what was being discussed.

Another observation which demonstrated this pattern was the use of trans-specialists as a substitution mechanism (cf. Postrel, 2002, 2017). Alexander, for example, described that instead of exerting effort (his own and others) on the transfer of sophisticated technological knowledge, it was often more efficient to coordinate with an individual (the trans-specialist) who already possessed sufficient knowledge on both Alexander's problem and the technological problem in question. Altogether, the observations in the study indicated that there is something akin to the *opposite*

[50] The metaphor 'whispering game' refers to the children's game known as 'broken telephone.'

of knowledge complementarity, i.e., where the products of integration efforts are *smaller* and the sum of its parts.

4.7.5 Tacitness

Tacitness of knowledge was expected to make integration of knowledge more costly and the empirical material confirmed this expected pattern. It was repeatedly referenced how individual abilities were often grounded in experience (cf. 'knowledge,' which was very difficult to articulate or transfer. Joe, for example, described how experienced engineers could pick up on cues that other people would not notice:

> You can sit down in a car with someone that just hears something and reacts. It becomes very apparent when somebody has that type of ability and experience, especially when you don't have access to that person. (Joe)

The costs of articulating tacit knowledge were very tangible. Below, Joe, for example, reflected on the cost-benefit of delegating a problem to another individual in his team:

> Sometimes when I am writing, I feel like it would have been faster for me to just solve the task myself, versus writing down what someone else has to do. (Joe)

A fundamental type of tacit knowledge in the study was the previously described firm-specific and industry-specific knowledge about how to manage knowledge integration relative to the purpose of Omega (see 4.5). The implications of the tacitness of this knowledge, e.g., implications for how to communicate this knowledge to new employees, were in line with the expected pattern (see 4.5.5.3).

Lastly, and also aligned with the preliminary framework, *learning by doing* was a common mechanism in the case when dealing with tacit knowledge. Hugo, for example, suggested that this method was especially important when transferring knowledge across team boundaries, i.e., referring to instances with less shared and more unrelated knowledge:

> It can be information which has been collected over a long period of time from many sources. Such knowledge can potentially be transferred, but it would require a lot of effort to produce pedagogical material. Hence, it might be easier to just get the other team to come over and sit next to you. (Hugo)

4.7.6 Locus

The empirical material indicated that this problem characteristic should be treated as two distinct, although related, knowledge characteristics. First, the *locus* of knowledge (internal/external) and, second, the *absence/existence* of knowledge. Both aspects were discussed in the preliminary framework (see 2.5.3.6).

4.7.6.1 Internal/external locus

The degree to which knowledge was more accessible to an individual on the spectrum of internal/external locus (i.e., within the team, within the organizational unit, outside the boundaries of Omega, and outside the span of control of Omega's owners, and so forth) appeared to facilitate less costly knowledge integration. Conversely, less accessible knowledge (e.g., located outside the boundaries of Omega) appeared to lead to more costly integration of knowledge. Both these patterns were in line with the preliminary framework.

4.7.6.2 Absence/existence

The binary question of knowledge existence or absence was also observed to follow the expected pattern, i.e., absence of knowledge typically leads to more costly integration of knowledge. Problems which demanded accurate solutions, such as certain technological problems (see 2.5.7.3), for example, required significant efforts to create new knowledge if knowledge was absent. However, absence of knowledge was not observed to halt the process in many instances. Even when the required knowledge on how to solve a problem did not exist, decisions still had to be made to move the venture forward. A senior manager even joked about the absurdity of this predicament, of being responsible for making high-stakes decisions in the absence of knowledge:

> You are more than welcome to write a dissertation about how to manage uncertainty and complexity in the start-up of new companies... (Eton)

A common response to knowledge absences was thus to exercise individual judgment (see 4.4.1.1). Accordingly, when individuals did not have all the knowledge required to solve a problem in an optimal way, they appeared to rely on rules-of-thumb (cf. 'heuristics') for how to get decisions approximately right (cf. 'satisficing'). An example of such application of heuristics was the mechanism of applying firm-specific and industry-specific knowledge, i.e., which did not provide a definite 'answer' to the specific problem but indicated how the problem could be solved to be advantageous, relative to Omega's objectives (see 4.5).

4.8 Task characteristics

Task characteristics are presented last of the three categories of characteristics due to the lack of surprising results about this category of characteristics. Note that this yardstick is not the same as the influence that these characteristics were observed to have during the study, which was substantial. Especially complexity and uncertainty were interpreted to be two of the most influential characteristics in the Omega-case.

4.8.1 Complexity

Complexity appeared to lead to more costly integration in the case, in line with the expected pattern. The multiple facets of complexity (i.e., decomposability, analyzability, and interdependencies) were all observed, with the expected effect on integration costs. The phenomenon of *near-decomposability*, for example, was manifested in how individual tasks were parts of a larger whole. Alexander explained how this type of complexity led to more coordination efforts. For starters, it was not always clear in Omega's organization structure (see 4.3.2.2) who had the mandate to make a certain decision. Even when this could be determined, Alexander described that efforts were then needed for that person to understand the 'bigger picture,' i.e., how the various pieces in question fit together (cf. firm-specific and industry-specific knowledge (see 4.5). This process was not trivial (see 4.5.5.3) and could involve multiple individuals:

> And then, everybody who understands the bigger picture has to coordinate with the decision-maker until he or she understands the bigger picture. (Alexander)

Regarding complexity as *analyzability*, many of the tasks which individuals in the study discussed appeared to be very demanding cognitively. There were, of course, ample amounts of simple tasks to solve as well, such as responding to basic requests for information over e-mail or to book the venue for a meeting. However, tasks that were central to the achievement of Omega's objectives, such as advanced technological development, typically displayed low analyzability. Discussions of responses to analyzability illustrated this point, e.g., by pointing out that problem-solving was a more appropriate response than planning in such instances:

> In a non-complex situation, you can plan by using a GANTT-chart. With complex problems, the task starts by solving the problem. (Eton)

Multiple examples of *interdependencies* were presented in 4.3 and 4.5.1. In line with the general expectation (Enberg, 2007; Thompson, 1967), this characteristic appeared to lead to more costly integration of knowledge.

4.8.2 Uncertainty

In summary, the empirical material followed the expected pattern, which was outlined in the preliminary framework. The observations regarding uncertainty will be presented using three categories in Melander and Tell (2014), i.e., which mirror the categorization of problems and knowledge in 2.3.2.

4.8.2.1 Technological uncertainty

Omega was exposed to significant technological uncertainty during the study. Bastian described this predicament by using the analogy of painting a wall. In an instance without uncertainty you can deduce how long it will take to paint the wall white:

> If I paint this wall and put in five hundred hours, this wall will be white. (Bastian)

Following this analogy, Omega did not know 'how big' the wall was, and if they had 'the right color' or 'the right tools' to paint the wall (i.e., to solve the technological problems of enabling autonomous driving):

> So, we don't know if it will be done in five hundred work hours. (Bastian)

This made it virtually impossible for individuals at Omega to estimate accurately how long it would take to solve the technological problems that Omega was facing. This, in turn, made it equally difficult to communicate when its products for ADAS and AD would be ready for delivery to OEM customers:

> Pelle: How do you know where in the process you are?
>
> Eton: Yes, that is a good question. Where are we in the process? There are a lot of people, both within and outside Omega, who want to know.

Eton, for example, explained how this circumstance (i.e., technological uncertainty) was a problem for coordination between teams in Omega and for decisions regarding allocation of bandwidth (cf. 'resources') within Omega. In response to this characteristic, Omega tried to make estimations bottom-up based on inputs from the product owner and each team regarding, i.e., what they estimated they could accomplish within a given 'product increment' (cf. 4.3.2.1). From those agile estimates, a kind of overview could then be produced by aggregation of these inputs. Eton, however, pointed out that the reliability of this method was *very* dubious, not least due to the external pressure to deliver faster:

> However, it is very easy to shoot outside the target. Depending on input-variables, there can be a difference of five years between estimates! Then it is tempting to tinker with the inputs; for example, 'if you could do this just a little faster…' (Eton)

Another mechanism which Omega employed in response to technological uncertainty was to construct a process with faster feedback loops (see 4.5.1.1). Time was, hence, observed to be an important lever to reduce uncertainty (cf. reference to time as a resource in 4.7.1).

4.8.2.2 Commercial uncertainty

In addition to the uncertainty in the technological dimension, there was significant uncertainty in the commercial dimension for Omega. Eton discussed how this incentivized investments in flexibility (cf. 'BAPO' in 4.3.2.2 and Felix's description on how to achieve 'velocity' in 4.7.2.2), i.e., to avoid a lock-in with an initial plan that would almost certainly be flawed:

> We have to constantly be looking at the compass, running to a tree in the woods, looking at the compass again. It is like orientation in the woods without any trails. (Eton)

Other illustrative examples of commercial uncertainty were that Omega did not know how many or which customers it would or should sign agreements with in the near-term or long-term (i.e., apart from its owner Alpha, which was onboarded as a customer by default (see 4.2)), which product offering to develop (i.e., that OEM customers would prefer over competing offerings), and, quite consequentially, how end-customers (i.e., consumers of transportation) would adopt active safety technology once it reached the market.[51] Consequently, Alexander believed that an important response by Omega to the commercial uncertainty was to not commit too much to the initial strategy and purpose of the joint venture (cf. 4.5.6):

> Who knows, maybe we do not make full-suite AD/ADAS features in ten years? Perhaps we are experts in integration and validation. Or, perhaps we become a safety-company, or a company making services…who knows what we will do, what our main business really is going to be. (Alexander)

4.8.2.3 Organizational uncertainty

In the organizational dimension, there were some quite fascinating decisions that had to be made, despite the degree of uncertainty that was present. Such an instance was when internal specialists could not agree among themselves what the best solution was to a problem that had been delegated to them. In such instances, the preferred (i.e., decentralized) approach broke down, and the decision instead had to be escalated up the hierarchy. The issue with this approach, however, was that the knowledge which was necessary to understand this problem was quite unfeasible to transfer from internal specialists to the manager, i.e., who suddenly was responsible for making this decision. In addition to knowledge characteristics, such as deep specialization (see 4.7.1) and tacitness (see 4.7.5), the manager in question was also an individual who had cognitive limitations for what he/she could learn within a short timeframe (cf. bounded rationality, see 2.4.1). Eton consequently described how it was impossible for him to know which expert to trust in such instances:

[51] There was very little information about how customers would adopt SAE level 3–5 applications (SAE International, 2021).

> Thus, it is very difficult when there are two specialists who disagree. It is virtually impossible. You almost have to conduct a lottery…or to lock them in a room for a week. (Eton)

4.8.2.4 A paradox

Interestingly, these observations of uncertainty in the technological, commercial, and organizational dimensions highlighted a paradox regarding how a firm can manage extreme uncertainty. Ironically, the only certainty in a context with extreme uncertainty, such as in the Omega-case, appears to be that high degree of uncertainty. This paradox appeared to make certain responses appropriate even though they were very costly, such as Omega's investments in flexibility (see 4.8.2.2). This is an interesting rule-of-thumb, which was not discussed in the preliminary framework. The underlying logic of these findings, however, is in line with the overall expected pattern, namely that more uncertainty leads to a need for more costly responses. The certainty in question, hence, concerns the *response* to the problem, not the degree of uncertainty of the problem to be solved.

4.8.3 Novelty

Task novelty either induced individuals to search and learn existing knowledge or meant that individuals had to confront knowledge absences (see 4.7.6.2). This pattern was observed regardless of whether the novel task was simple or difficult, i.e., in terms of its other characteristics. In line with the expected pattern, more novelty of problems appeared to lead to more costly integration of knowledge.

Consider, for example, the agile practices that were implemented at Omega (see 4.3.2). Regardless of how appropriate these responses were, relative to the types of problems which Omega was confronting, these organizational arrangements were a novelty for many individuals at Omega. Individuals, thus, had to learn how to be effective in the context of these new arrangements, which itself was suggested to introduce another layer of difficulty:

> Back during my time at Alpha, we had our structures and decision meetings. It was infinitely slower. Here, it is faster, but at the cost of formal documentation and clarity about which decisions that have been taken. (David)

Several interviewees also discussed the challenges of being a sort of start-up (i.e., a novel organization) with an expectation to rapidly recruit several hundred new employees. Martin, for example, explained how he and his team had to devote a lot of time and attention to get basic features and processes in place, such as the IT infrastructure and to be able to pay out salaries, manage parental leave, and so on. Similarly, Eton explained that this led to quite ambitious weekly targets for how many individuals HR was supposed to recruit, which would have been a difficult task, even in a mature (i.e., not new) company that knew what types of competences it needed (i.e., which Omega was still in the process of figuring out):

> 'Go out and vacuum-clean the market for talent,' even though we were not very sure yet about what we need. (Eton)

4.8.4 Frequency

The general observation was that lower frequency led to more costly integration of knowledge, in line with the expected pattern in the preliminary framework. Many key problems at Omega concerned tasks with low frequency, often even being unique instances that would occur but once. For example, the task of solving a previously unsolved technological problem or making the first impression with a potential OEM customer.

However, this did not mean that all tasks had low frequency. On the contrary, Felix, Hugo, Leo, and other participants in the study described how they attempted to make the product development-process more iterative (i.e., which would increase the frequency of certain tasks). For example, several practices within development teams were recurring, such as daily stand-up meetings, code reviews, 'demos' after each product increment, sprint reviews (i.e., more focused on the output from the sprint), and team retrospectives (i.e., more focused on the way of working within the team). Part of the rationale for establishing such recurring elements was to facilitate a degree of learning, namely that individuals would become better at these practices over time. This was also in line with the expected pattern, namely that higher frequency of tasks leads to less costly integration of knowledge, i.e., as previous experience can be accumulated over time and re-used.

4.8.5 Heterogeneity

Generally, task heterogeneity was observed to lead to more costly integration of knowledge, i.e., in line with the expected pattern. Heterogeneity on the individual level was quite tangible. Many interviewees, for example, expressed that they were expected to take on quite a wide array of tasks. For example, tasks that were new or recurring, complex or simple, certain or uncertain, frequent or infrequent, requiring a single or multiple specializations, application or creation of knowledge, and to establish new relationships or manage existing relationships, within or outside Omega. A general observation, however, was that there appeared to be more homogeneity on the individual level than on the team level, and that heterogeneity increased as the scope of the group grew. Hence, there was more homogeneity in the team than in the organizational unit to which the team belonged, and more homogeneity within Omega than compared to its owners, Alpha and Beta. This too was rather unsurprising, given that a need for specialization favors division of labor (see 2.1.3).

4.9 Epilogue

The case study was limited to the period between April 2017 and June 2018. However, it would be unfortunate to not share key developments which took place after the case study for two main reasons. First, events that took place after the end of the case period may further increase our understanding of what transpired during the case. For example, by confirming or rejecting previous interpretations of the empirical material. Secondly, additional data have indirectly (and unintentionally) been collected after the case study. For example, by reading news about Omega, its owners, and the autonomous driving industry. Since such data likely influenced my interpretation of the empirical material, it is fair to share key developments with the reader.

The most consequential development after the case study period was the agreement between Alpha and Beta/Gamma to terminate the joint venture and pursue independent efforts within active safety. The publication of this news, in April 2020, coincided with the launch of Omega's first generation of ADAS products. These will remain in a passive IP-holding company, to enable both Alpha and Gamma to benefit from their investments in the development of these products. Notably, the joint venture was hence not ended until it had yielded this output for its owners.

In a statement that was released by Beta, the headline was that Gamma and Alpha have decided to pursue opportunities within ADAS and AD separately. In this split, it was described that Gamma would absorb employees and technology related to ADAS, and Alpha would absorb the employees and technology related to AD. The statement also included a practical explanation of how Omega's geographical office sites were to be divided. The press release notably included references to knowledge, especially commercial and technological, which appeared to inform this course of action. For example, Gamma shared its internal estimations for the demand for ADAS products in the coming decade. Gamma stated that it intended to continue its efforts to develop solutions for autonomous driving, but at a pace in line with general adoption and commercialization of autonomous driving technologies Lastly, it was communicated that Alpha and Beta settled on a cash payment to bridge the difference in value, which each party had acquired through this proposed arrangement. Notably, it was Alpha who had to pay Gamma approximately US$15 million.

Alpha also released a statement on the same day, in which there were noteworthy differences compared with the press release by Gamma. Most notably, the headline of the press release underscored Alpha's commitment to accelerate its efforts to develop autonomous driving technology. The statement by Alpha also highlighted that this was the best course of action to optimize the potential of the two different technologies (ADAS and AD) that had been part of Omega's scope. Furthermore, the statement included the news that a new company ('Kappa') was to be created, owned solely by Alpha. The purpose of Kappa, according to Alpha, was to commercialize unsupervised AD software and to become one of the few global platforms for this technology. Kappa, the new company, is currently pursuing its objectives at the time of writing this text.

Multiple interpretations can be presented about this course of events, which transpired almost two years after the case period ended. If only highlighting one aspect, these developments arguably reinforced the interpretation that the objectives of firms influence knowledge integration, i.e., which has been presented throughout this chapter (see 4.3 and 4.5). For example, these developments confirmed the observation (see 4.5.4.1 and 4.5.5.2) that there were problems for individuals at Omega which had their origin in the different objectives and consequent logics of Beta/Gamma (emphasizing ADAS) and Alpha (emphasizing AD).

5 Analysis

The analysis revealed several additions to the preliminary framework in terms of the answer to the purpose of this study, i.e., *how knowledge integration is influenced by the objectives of a firm*. The structure of this chapter is based on the modules in the preliminary framework. Indeed, this decision should be interpreted as a confirmation of the relevance of the model (see Figure A in 2.2.2) which was used to construct the preliminary framework (see Figure B in 2.7). A difference, relative to chapter 2 and chapter 4, however, is the sequence by which these modules will be discussed in this chapter. The modules have been ordered by relevance (i.e., to an answer to the purpose of this study) and progress (i.e., relative to the preliminary framework), leading to the following structure in the chapter:

5.1 An objective requiring integration of knowledge

5.2 Management of knowledge integration

5.3 Subjects involved in the knowledge integration process

A presentation of the revised theoretical framework (5.4) will then end the chapter. As in Chapter 4, the object of study (see 2.1 and 2.6) will not be discussed separately but will be treated as the effect which these modules (5.1–5.3) and the revised theoretical framework (5.4) aim to explain.

5.1 An objective requiring integration of knowledge

5.1.1 Toward an objective-driven mode of explaining knowledge integration

In the introduction chapter, an argument for a more strategic perspective on knowledge integration was presented (see 1.4.2), resulting in the purpose of this study (see 1.5). In that discussion, it was highlighted that most previous research have attempted to explain knowledge integration from another perspective, referred to as the 'established view' in 1.4.1. From such previous research (i.e., which focus on how to respond to various problem characteristics), we know that this is a viable mode of explaining knowledge integration that has expanded our understanding of knowledge integration and how to manage such processes tremendously.

Consequently, a large share of the preliminary framework was devoted to this part of our pre-understanding, dealing broadly with implications from various problem characteristics (see 2.5.1–2.5.6).

However, there were also parts of the preliminary framework, which dealt with what we know about objectives that require integration of knowledge (see 2.3) and how objectives may influence the management of knowledge integration (see 2.5.7). The findings in this study suggest that these parts can be synthesized to its own alternative mode of explaining knowledge integration. The currently dominant mode of explanation focuses on how problem difficulty depends on various problem characteristics. This new mode, in contrast, focuses on how the objectives of a specific firm inform which courses of action are effective in a knowledge integration process to solve certain problems.

This section (5.1.1) will discuss how this mode of explanation can become a viable approach, alongside the established mode of explanation (see 1.4.1). First, the foundation (logical and theoretical) for this mode of explanation will be revisited (cf. 1.4.2). Secondly, the empirical relevance of the objective-driven mode and, third, potential arguments against this interpretation will be discussed. Fourth, the question of co-existence and compatibility between the two modes will be examined. In the next section (5.1.2), definitions of key building blocks within this mode of explanation will be proposed, to facilitate the application of this mode of explanation in future studies of knowledge integration.

5.1.1.1 The foundation for an objective-driven mode of explaining knowledge integration

In the introduction chapter, the move toward a more strategic perspective was motivated based on an identified weakness in the currently dominant mode of explaining knowledge integration, i.e., that the management of knowledge integration *only* depends on the problem characteristics in play. This established perspective was problematized and the grounds for a more strategic perspective were outlined, leading to the purpose of this study. The fundamental assumption in this alternative mode of explanation is that firms' objectives and the circumstances for this endeavor are also relevant. Hence, there is more to the management of knowledge integration than the sum of various problem characteristics (cf. 'aggregate problem difficulty' in 2.5.1).

The objectives of a firm and the circumstances which influence the achievement of these objectives will henceforth be referred to as the *strategic context* of a firm. Although this is a broad term with multiple possible interpretations, it enables a condensed way of talking about this feature of businesses, which hopefully is simple to adopt.

A fitting theoretical starting point for this mode of explanation is the definition of knowledge integration as a product of a *purposeful combination* of knowledge

(Berggren, Bergek, Bengtsson, & Söderlund, 2011; Tell et al., 2017a), which clearly brings the notion of objectives to the core of knowledge integration. From the notion of objectives, it is then possible to derive *problems to solve*, which require integration of knowledge (Nickerson & Zenger, 2004; Simon, 1947; Tell et al., 2017a). In terms of how to understand such problems to solve, there was plenty of research in the literature review which suggested that there are three thematic types of problems (technological, organizational, and commercial) which may require knowledge integration.

This approach to the management of knowledge integration, from here on referred to as the *objective-driven mode*, can be clarified through a comparison (see Table D) with the established view (see 1.4.1), from here on referred to as the *characteristic-driven mode*. The main similarity is that both modes of explanation attempt to explain what makes the management of knowledge integration effective.[52] Beyond this similarity (i.e., regarding 'dependent variable'), however, the two modes diverge. In particular, the two modes diverge, in terms of the respective emphasis on the strategic context: where the characteristic-driven mode does not treat the strategic context as pertinent, the objective-driven mode in contrast positions the strategic context as fundamental. This difference has significant implications for how each mode explains what makes the management of knowledge integration effective.

In its essence, the objective-driven mode focuses on the objectives of a firm to explain how to and how not to integrate knowledge effectively. For example, when individuals at Omega were confronted with alternative ways of approaching a problem, they appeared to consider whether or not a certain approach would be in line with the objectives of Omega. See, for example, 4.5.4.1 regarding how to allocate resources to the development of ADAS versus AD products, and 4.5.1.3 regarding how to strike the balance between standardization and adaptations in the offering to customers.

In the characteristic-driven mode, there is no theoretical basis for incorporating objectives (see 2.3.1) or different kinds of problems derived from these objectives (see 2.3.2) into the explanation of how to or not to manage knowledge integration effectively. Focus is instead solely on the characteristics which make problems vary in aggregate difficulty (see 2.5.1). As was outlined in 2.5.6.2, such problem characteristics matter since difficult problems are assumed to require more costly mechanisms than less difficult problems. The 'independent variables,' i.e., the causes, which explain effective management of knowledge integration in this mode are thus the categories of characteristics which were outlined in 2.5.2–2.5.4 (task characteristics, knowledge characteristics, and relational characteristics). Through this perspective, the meaning of effective management appears to be the least costly

[52] Compare with the definition of 'management' in 1.3 as the *"judicious use of means to accomplish an end"* (Merriam-Webster Dictionary, 2022a).

response, given the aggregate problem difficulty and the specific problem characteristics in play.

Through the perspective of the objective-driven mode, another answer emerges for what makes the management of knowledge integration effective. Foremost, management is considered effective, relative to the likelihood of achieving the objectives of a firm (cf. 2.5.7.1) under certain circumstances. It is arguably reasonable to discuss this prospect in terms of a 'likelihood' to avoid confusion about the extent to which individual firms can influence market outcomes. For example, the achievement of firms' objectives is subject to uncertainty (Alvarez & Barney, 2005; Knight, 1921) and involves systems of problems. Applying the previously outlined principle of reduction (i.e., deriving problems from objective), the 'independent variables' in the objective-driven mode become the different thematic types of problems and knowledge (technological, organizational, and commercial).[53] The objective-driven mode, hence, highlights the central feature in the overall theory of knowledge integration that different types of problems require integration of different types of knowledge (e.g., Carlile, 2002; Grant, 1996b; Kogut & Zander, 1996; Postrel, 2002; Spender, 1996).

	The Characteristic-driven mode	**The Objective-driven mode**
Summary	The characteristics of the particular problem to be solved influence the management of knowledge integration	The objective that requires particular problems to be solved influences the management of knowledge integration
Assumption regarding the strategic context	Not pertinent	Fundamental
Mode of explanation	Different problem characteristics explain how to and how not to integrate knowledge effectively	The objectives of a firm explain how to and how not to integrate knowledge effectively
'Dependent variable'	Effective management of knowledge integration	Effective management of knowledge integration
'Independent variables'	Task characteristics Knowledge characteristics Relational characteristics	Technological problems and knowledge Organizational problems and knowledge Commercial problems and knowledge
Meaning of 'effective management'	Minimum costly response, given the aggregate problem difficulty and specific problem characteristics	Maximum likelihood of achieving the objectives of a firm under certain circumstances

Table D. Comparison between the two modes of explaining knowledge integration.

5.1.1.2 The empirical relevance of the objective-driven mode

The relevance of the outlined objective-mode of explaining knowledge integration can be demonstrated through application, using the empirical material presented in Chapter 4. At Omega, there was ample support for the assumption that the strategic context influenced how individuals at Omega approached knowledge integration. For example, knowledge about the objectives of Omega (see 4.5.2) was observed to influence decision-making on various levels of the firm, e.g., knowledge about *what* Omega was trying to produce, *why* this was required, and *how* this should be

[53] See 2.3.2 in the preliminary framework.

accomplished. Similarly, knowledge about the circumstances for the knowledge integration process was also referenced repeatedly by participants in the study, such as knowledge about the industry (see 4.5.4.2), competitors (see 4.5.1.2), customers (see 4.3.3.1), and Omega's owners (see 4.5.1.3).

The meaning of 'effective management' was, in turn, revealed by the purpose of mobilizing such knowledge. Both in explicit statements (see 4.5.5.3) and implicit hints from participants, it was evident in the study that the purpose of solving certain problems was tethered to the objectives of Omega. For example, several interviewees reflected on how some individuals at Omega appeared to be more interested in learning about new technology than finalizing deliveries to customers (see 4.6.3.2) and discussed this as a problem, relative to the objectives of Omega. There were, however, no illusions at Omega about the extent to which individuals could determine that certain objectives were achieved. Rather, my interpretation was that decisions were made with the intent to maximize the probability of the desired outcome. For example, the organizational arrangements that were presented in 4.3.2 were deemed to be necessary investments (i.e., requiring significant thought and effort to design and implement) to provide individuals with better conditions for the type of knowledge integration that Omega's objectives required but were not considered guaranteed to work. The same goes for the attempts to introduce a subscription-based revenue model (see 4.3.3.2) and the design of Omega's offering to the customer (see 4.5.1.3).

In line with the expected pattern outlined in 2.5.7.3, the feature of satisficing was also more pronounced for commercial and organizational problems compared with technological problems. However, technological problems were also observed to be exposed to objectives, such as through the practice of recurring prioritization (every 6 weeks) of backlog items (see 4.3.2.1 and 4.3.2.2). As illustrated in Chapter 4 and in most of the examples provided in this section, the notion of different types of knowledge (technological, organizational, and commercial) arguably provides a productive language for how to discuss the influence of objectives in the knowledge integration process. Evidence for the prevalence of these types of problems and knowledge (i.e., in line with the expected pattern in 2.3.2) was presented in 4.3. The observations in the study (see 4.3 and 4.5) also decisively confirmed the expected pattern that each category of problem requires the corresponding type of knowledge to be resolved (see 2.5.7.2).

In summary, the foundation for an *objective-driven mode* of explaining knowledge integration (outlined in 5.1.1.1) can quite easily be applied to the empirical material from this study to make sense of the influence of objectives. A more surprising finding, which also supports the foundation for the objective-driven mode, was the observation that firm-specific and industry-specific knowledge about how to manage knowledge integration could be applied as a mechanism by individuals (see 4.5). This observation, which will be analyzed in depth in the forthcoming 5.2, is arguably *very* difficult to explain by merely relying on the characteristic-driven mode (Brusoni et al., 2005; Carlile, 2002; Enberg, 2007; Grant, 1996b; J. C. Huang & Newell, 2003; Newell et al., 2004; Tell, 2011).

However, this observation makes clear sense through the objective-driven mode. Furthermore, the additional theoretical concepts to be introduced in 5.2.1 are quite difficult to apply in the context of knowledge integration theory, without acknowledging the influence of the firms' objectives and the consequent need to solve different kinds of problems (Burgers et al., 2008; Court, 1997; De Luca & Atuahene-Gima, 2007; Demarest, 1997; Frishammar et al., 2012; Nickerson & Zenger, 2004; Ramesh & Tiwana, 1999; Tanriverdi & Venkatraman, 2005; Tell et al., 2017a; Tiwana, 2004; Tsoukas & Vladimirou, 2001). At the very least, the iterative process between the empirical material and theory, which rendered the objective-driven mode, was influential in the discovery of the findings that will be presented later in this chapter. As a consequence, the forthcoming section 5.2 is divided into a first part which focuses on findings related to the objective-driven mode (5.2.1–5.2.6) and a second part which focuses on findings related to the characteristic-driven mode (5.2.7–5.2.9). Likewise, the two modes are reflected in the revised framework, to be presented in 5.4.

5.1.1.3 Arguments against the objective-driven mode

Several arguments *against* the proposed conception (i.e., as presented in 5.1.1.1) have also been considered in the analytical process. A first argument is that each type of problem (i.e., technological, organizational, and commercial) appears to be somewhat mirrored by a category of problem characteristics (i.e., task, knowledge, and relational). There were some tendencies in the empirical material which, I would argue erroneously, could lead one to embrace such a viewpoint. For example, organizational problems (i.e., which intrinsically deal with the interplay between subjects) typically highlight aspects of knowledge integration that can be described through the language of relational characteristics (such as trust and history/path dependence). However, the issue with this argument is that the difficulty of organizational problems was also observed in the study to depend on task characteristics and knowledge characteristics, i.e., all three types of problem characteristics. For example, an organizational problem could exhibit more or less novelty (Carlile, 2004; Carlile & Rebentisch, 2003; Takeishi, 2002), involve more or less uncertainty (Alvarez & Barney, 2005; Beckman et al., 2004; Castellucci & Carnabuci, 2017), or require more or less deep knowledge (Brusoni et al., 2005; Grant, 1996b; Postrel, 2002). Thus, the argument that each type of problem corresponds to one of three categories of problem characteristics is incomplete.

A second argument against the proposed conception could be that the meaning of knowledge differentiation in knowledge integration (i.e., that different problems require different types of specialized knowledge) is already 'priced into' the overall theory of knowledge integration. However, I would submit that this assumption (e.g., in reference to division of labor) is taken too lightly, by not problematizing *why* there are different problems to solve. Arguably, in the literature, the characteristic-driven mode foremost considers differentiation of knowledge through the prism of *problem difficulty* (Brusoni et al., 2005; Enberg, 2007; Szulanski, 1996; Tell, 2011; Tell et al., 2017a; Tsai & Ghoshal, 1998; Zahra et al., 2020; Zollo & Winter, 2002). For example, the emphasis in this literature is on *how many* domains of knowledge does a resolution to a problem require, and on the *relatedness* or *complementarity* of the knowledge which is currently (i.e., before combination) not shared among individuals (Breschi et al., 2003; Grant, 1996b; J. C. Huang & Newell, 2003; Postrel, 2002; Van de Ven & Zahra, 2017). Hence, the characteristic-driven mode does a poor job at explaining why different types of knowledge are required to solve a problem and which different categories of knowledge this involves (cf. 2.3.2). This argument hence traces back to the original critique in Chapter 1 of whether the established view of explaining knowledge integration through the perspective of problem-characteristics is *complete* or not. In Chapter 1, based on a review of available literature, I argued that there are grounds to problematize this perspective. In light of the empirical material in this study, I would argue that this case is even stronger and that this second argument, consequently, is inadequate.

A third angle would be to conceive the categorization of different types of problems (cf. 2.3.2) as a task characteristic, i.e., alongside complexity, novelty, and so forth. For example, by introducing a new problem characteristic called 'task type.' However, this would not make sense, as the function of problem characteristics is that they describe the source of problem difficulty, i.e., on a scale from low to high (Tell, 2011). In this study, there was no support for an interpretation that a certain type of problem (e.g., technological problems) is more difficult than the other two types. Similarly, an argument could be to conceive the different types of knowledge as a knowledge characteristic, i.e., alongside depth of specialization and tacitness. For example, by introducing a problem characteristic called 'knowledge type.' This, however, runs into the same problem as the introduction of a new task characteristic. Thus, a main problem for this third argument is that objectives, problems, and the knowledge needed to solve those problems through a purposeful combination are not logically contained within the characteristic-driven mode of explanation. In addition to not rejecting the proposed conception of the objective-driven mode, this is arguably a strong argument for *complementarity* of the two modes (to be discussed further in 5.1.1.4).

Fourth, there were empirical cues which might lead one to try to explain the objective-driven mode solely through the lens of interdependencies between problems (cf. 2.5.2.1). Granted, interdependencies between problems were highlighted both in the introduction chapter (e.g., 1.4.3.2) and in the empirical material (see 4.3, 4.5, and 4.8.1). However, it would be a mistake to reduce the relevance of firms' strategic context to the characteristic of task complexity. The most apparent problem with such an approach is that there are features within the objective-driven mode which are *not* driven by complexity. For example, that management is effective relative to the objectives of a firm (see 2.5.7.1 and 4.5.2), such as completion of a process within certain constraints in terms of time and resources (see 2.3.1). Another example was the demonstration of each type of problem in 4.3, i.e., which dealt with each type separately before discussing interdependencies between the three types in 4.5.1. Hence, it makes more sense to apply complexity (i.e., such as interdependencies) as a task characteristic that explains the degree of difficulty of various types of problems (e.g., a technological problem). Again, this is an argument for the compatibility and complementarity of the two modes of explaining the management of knowledge integration (see the upcoming 5.1.1.4).

In summary, considering these arguments against the objective-driven mode, the foundation presented in 5.1.1.1 appears to be on solid ground. This indicates that the objective-driven mode is a viable alternative mode of explanation *alongside* the characteristic-driven mode.

5.1.1.4 Complementarity of the two modes

Before discussing the relationship between the two modes, it is constructive to first comment on the standing of the characteristic-driven mode. Already in the introduction chapter, it was granted that the characteristic-driven mode (in 1.4.1 discussed as the 'established view') is a powerful explanation of knowledge integration. The empirical results from the study (see 4.6–4-8) will be analyzed in depth in forthcoming 5.2.7–5.2.9. However, it can already in this section be stated that the empirical material largely confirmed the expected pattern in the preliminary framework (see 2.5.1–2.5.6). This is important to acknowledge since it means that the conception of an alternative mode of explaining knowledge integration, i.e., the objective-driven mode, was *not* intended as a rebuttal of the characteristic-driven mode. What we are faced with is rather two modes of explanation, which *both* appear to be valid. The main question is, thus, to what extent do they complement each other (i.e., lead to a more satisfying explanation of the management of knowledge integration when applied simultaneously) or are in competition (i.e., provide conflicting or contradictory answers). As was already indicated in 5.1.1.3, my conclusion is that the two modes are complementary and that they render a superior explanation when applied simultaneously.

A primary reason for this interpretation is that the two modes ascribe a different meaning to 'effective management' of knowledge integration. The characteristic-driven mode emphasizes the least costly response, given the problem difficulty and the specific characteristics that are in play, and the objective-driven mode emphasizes the probability of achieving a firm's objectives under certain circumstances. My interpretation, thus, is that the two modes emphasize different effects, but that these effects are two sides of the same coin.

There was ample support for this interpretation in the empirical material. To begin with, all three categories of problem characteristics (i.e., task, knowledge, and relational characteristics) need to be applied to get a comprehensive understanding of the degree and source of difficulty for a focal problem, regardless of its main type (i.e., technological, organizational, or commercial). For example, an understanding of the level and source of problem difficulty informed how various problems at Omega (see 4.3 and 4.5) could be solved in the least costly, yet feasible, manner. Equally, knowledge about objectives and the circumstances for achieving them informed how a problem of high difficulty (e.g., involving tacit knowledge of multiple different specializations) had to be approached to maximize the likelihood of achieving the objectives of the firm. As an example, the adoption of a development process with fast feedback loops at Omega (see 4.3.2.1 and 4.5.1.1) was not only a response to task uncertainty, but it was informed by knowledge about the technology, the competition, and how to organize this type of integration activity (i.e., advanced software development). Furthermore, the notion of 'likelihood' in the achievement of objectives (see 5.1.1.1) can clearly be better understood through the prism of problem characteristics.

5.1.2 The building blocks of the objective-driven mode

To facilitate the adoption of the objective-driven mode in future research, it is constructive to clarify several ontological questions, which this novel approach highlights.

5.1.2.1 Definition of objectives

As was outlined in 5.1.1.1, the distinctive trait for the objective-driven mode is its assumption that the strategic context is central to the understanding of how to manage a knowledge integration process effectively. Naturally, a main building block of the objective-driven mode is, therefore, the *objectives* of a firm. 'Objectives' were defined in 2.3.1 as *"something you are trying to do or achieve : a goal or purpose"* (Britannica Dictionary, 2022a). In the context of this chapter and the revised theoretical framework, 'objectives' will therefore be defined as *that which a firm is attempting to achieve.*

It is necessary to highlight 'firm' in this definition, since there might be different ideas about what the objective is among individuals within a firm. However, firms are (typically) not democracies but bureaucracies, in which mandates to make decisions originate from the firm's shareholders. Thus, 'that' which a firm is attempting to achieve is ultimately defined by the individual/-s who have been delegated this responsibility by the firm's shareholders. When push comes to shove, this clarifies who defines the objectives of a firm. This was observed in the empirical material. For example, how the management team at Omega prioritized the 'strategy backlog' and how this was used as a framework for prioritization in lower-level backlogs (see

4.3.2.2), and how the owners of Omega (Alpha and Beta) provided directives to the management team at Omega regarding what to achieve (see 4.5.5.2). To nuance this description, it was, however, also observed that the individuals with the mandate to define Omega's objectives were not impervious to influence, e.g., from Omega's owners, employees, customers, suppliers, and other stakeholders.

It is also notable that the term 'objectives' (e.g., Grandori, 2001; Hansen, 1999; Kalling, 2003; Nickerson & Zenger, 2004; Nonaka, 1994; Ramesh & Tiwana, 1999; Simon, 1947; Spender, 1996) was chosen over alternative terms or labels.[54] A main difference between these terms is whether the knowledge about the term can be made explicit without its meaning becoming lost in translation. For example, a 'goal' is arguably suggestive of something tangible, i.e., which is feasible to make explicit without a significant loss of meaning. A 'purpose' or 'vision,' on the contrary, is arguably more high-flying and can encompass more dimensions, i.e., which makes it less feasible to communicate effectively. 'Objectives,' I would argue, balances between the two extremes. That which a firm is attempting to achieve is not merely a 'gut-feeling' or a vague picture of an end-state, but it has a rationale which individuals can attempt to express (see 4.5.5.3). At the same time, the objectives of a firm are not just a collection of words or numbers. As in the introduction chapter, the notion of 'strategic intent' in Hamel and Prahalad (1989) may be applied to make sense of this dimension of objectives.

5.1.2.2 Definition of the strategic context

Several references were made in 5.1.1 to the 'strategic context' of a firm. As was admitted, this is quite a loose and indistinct term. Yet, it is useful to include such a term since it performs two functions. First, it highlights that each effort to integrate knowledge is based on an objective. Second, it points out that this effort does not exist in a vacuum but is exposed to the circumstances in which that process is embedded, such as markets, regulation, competition, the general-purpose technology platform, culture, and so on. In accordance with its use in 5.1.1, the strategic context of a knowledge integration process can be defined as *that which a specific firm is attempting to achieve and the circumstances for this endeavor*.

The former part of this definition clearly refers to the notion of 'objectives,' which was defined in 5.1.2.1. The latter part is less straightforward but is encompassed by the building blocks, which are defined in 5.1.2.3 and 5.1.2.4 and their respective literature.

[54] Alternative terms and labels include *goals* (Becker & Zirpoli, 2003; Brusoni et al., 2021; Ceci & Prencipe, 2017; Grant, 1996b; Johansson et al., 2011; Okhuysen & Eisenhardt, 2002; Postrel, 2017; Tsai & Ghoshal, 1998; Tsoukas & Vladimirou, 2001; Van de Ven & Zahra, 2017; Willem et al., 2008; Zahra et al., 2020), *purpose* (L. Bengtsson et al., 2011; Berggren, Bergek, Bengtsson, & Söderlund, 2011; Tell et al., 2017a), *mission* (Huber, 1991; Rauniar et al., 2019; Tsoukas, 1996), *vision* (Drucker, 1988; Normann, 1975), and *aspiration* (Winter, 2000).

5.1.2.3 Definition of technological, organizational, and commercial

Definitions of the three types of problems and knowledge were provided in the literature review (see 2.3.2.1). The empirical results confirmed the meaning of these three thematic categories (see, for example, 4.3). Therefore, the same definitions will be employed throughout this chapter and in the revised framework.

5.1.2.4 Definition of problems, knowledge, and solutions

The objective-driven mode emphasizes the importance of correspondence between a type of problem and the type of knowledge needed to solve that problem by applying a categorization of different types of problems and knowledge (see 5.1.1). From this rationale, two building blocks can be identified. First, the *problems* which can be derived from the objective of a firm (see 5.1.2.1). Second, the *knowledge* to be integrated. Additionally, the output from knowledge integration should arguably be a third building block. See, for example, the object of study in 2.1 and the model which was used in the preliminary framework in 2.2.2. Third, in the context of the objective-driven mode, the term *solution* is a fitting term to describe outputs that represent an integration of knowledge. A 'solution' can be defined as *"a way of solving a problem or dealing with a difficult situation"* (Oxford Learner's Dictionary, 2022) and thus fits squarely with the emphasis on problems in knowledge integration. As was illustrated in 4.3.1.1, solutions can be both material (such as hardware, a physical drawing, or a contract) or immaterial (such as software, a digital drawing, or a decision). Table E combines these three building blocks (problem to solve, knowledge to be integrated, and output from knowledge integration) with the categorization of types of problems that firms can expect to encounter (cf. 2.3.2) to provide a language for speaking about the objective-driven mode.

Table E. The different types of problems, knowledge, and solutions within the objective-driven mode.

Problem to solve	Knowledge to be integrated	Output from knowledge integration
Technological problems	Technological knowledge	Technological solutions
Organizational problems	Organizational knowledge	Organizational solutions
Commercial problems	Commercial knowledge	Commercial solutions

These three building blocks can also be used to address the specific gap regarding structural convergence across the three categories (see 1.4.3.3), for example, how types of *knowledge* are defined (e.g., Burgers et al., 2008; Demarest, 1997; Frishammar et al., 2012; Tanriverdi & Venkatraman, 2005; Tsoukas & Vladimirou, 2001). Using the building blocks in Table E, technological knowledge can, for example, be defined as knowledge about how to produce and manage technological solutions, such as the products and services that Omega's offering was comprised of (see 4.3.1 and 4.5.1.1). Using the rationale in this example, a general formula can be proposed: *a type of knowledge is knowledge about how to produce and manage the corresponding kind of solution*.

It is arguably relevant to include both 'produce' and 'manage,' since a general definition should encompass both the creation of new solutions (e.g., development of software) and the administration of existing solutions (e.g., maintenance of software). The analysis of empirical material confirmed that this general formula is applicable to all three categories of knowledge in the objective-driven mode (see Table F).

Table F. Proposed definitions of knowledge across all three types.

Type of knowledge	*Proposed definition*	*Examples of solutions in the empirical material*
Technological knowledge	knowledge about how to produce and manage technological solutions	Products and services in Omega's offering (see 4.3.1)
Organizational knowledge	knowledge about how to produce and manage organizational solutions	Organizational structures and processes (see 4.3.2)
Commercial knowledge	knowledge about how to produce and manage commercial solutions	Agreements between Omega and customers (see 4.3.3)

5.2 Management of knowledge integration

The first part of this section (5.2.1–5.2.6) will primarily deal with findings related to the *objective-driven mode* (see 5.1.1).

The second part of this section (5.2.7–5.2.9) will primarily deal with findings related to the *characteristic-driven mode* (see 5.1.1).

5.2.1 Introducing additional theory

The empirical material revealed that the management of knowledge integration in accordance with the objectives of Omega relied on a *synthesis* of multiple types of knowledge (i.e., technological, organizational, and commercial). For example, in 4.5.2, it was described how the decisions regarding organizational structure were influenced by knowledge about the dynamics of competition and knowledge about the rate of technological development. In 4.5.1.3, it was described how the design of Omega's offering (cf. customization versus standardization) was influenced by knowledge about how to unlock scale benefits of ADAS/AD technology. In 4.3.3.2, it was described how the attempt to introduce a subscription revenue model was influenced by knowledge about preferable organizational arrangements for faster development of the kind of technology in question (i.e., ADAS/AD).

Moreover, this kind of synthesized knowledge appeared to inform individuals about firm-specific and industry-specific aspects of how to manage the knowledge integration process (see 4.5.3–4.5.4). For example, it was described how industry-specific aspects, such as the internal organizational arrangements of Omega's potential customers (see 4.3.2.1) and power in the buyer-supplier relationship (see 4.3.3.1 and 4.5.6.2), were obstacles for the implementation of Omega's preferred offering design (see 4.5.1.3) and revenue model (see 4.3.3.2). Regarding firm-specific aspects, it was observed how Omega approached the business opportunities related to ADAS/AD differently from several of its competitors and how such differences were grounded in Omega's initial conditions, including the resources and priorities of its owners, Alpha and Beta/Gamma (see 4.5.4.1).

Importantly for this section, these observations were not possible to explain merely through the characteristic-driven mode, i.e., which has been the dominant explanation in prior research on knowledge integration. As was discussed in 5.1.1.1, the three categories of problem characteristics appear to explain another facet of management of knowledge integration, namely the minimum costly response, given the problem characteristics in play. What was observed at Omega was something else, which triggered a need to read and consult additional literature *outside* the scope of knowledge integration theory. As was pointed out in Chapter 3, this practice is a strength of abductive methods for theory development (cf. to stand 'on the shoulders of giants').

The reading of additional literature revealed that there are two prior strategy-concepts, which appear to share fundamental qualities with the observations in the study: the *business idea* and the *industry recipe*. For example, there were multiple references in the empirical material to a kind of knowledge about how problems are typically solved in a certain industry (presented in detail in 4.5.4.2 and 4.5.6.2). This clearly resembles the view by Spender of a *"professional common sense,"* which is characteristic for each industry and that *"everyone who knows this industry understands"* (Spender, 1989, p. 6).

Moreover, there were numerous references in the empirical material to a kind of knowledge about how to solve problems which was specific to Omega, i.e., rather than the industry (see, for example, 4.5.2 and 4.5.4.1). A similar pattern was detected in literature on business models, in particular within research which approach the business model as a cognitive structure, schema, or representation (e.g., Doz & Kosonen, 2010; Martins et al., 2015; Massa et al., 2017; Tikkanen et al., 2005). Moreover, it was discovered that there is a relevant antecedent to that contemporary literature in Normann (1975), which introduced *the business idea* as a concept to capture this elusive kind of knowledge.[55]

Granted, other interpretations of the empirical material are also possible. For example, the empirical material could also have been viewed through the prism of innovation (e.g., Christensen & Rosenbloom, 1995; Crossan & Apaydin, 2010; Damanpour, 1991; Tushman & Anderson, 1986) and strategic alliances (e.g., Das & Teng, 1998; Dyer & Singh, 1998; Mowery et al., 1996). However, there are already numerous contributions on knowledge integration and innovation (Andersson & Berggren, 2011; Bacon et al., 2020; L. Bengtsson et al., 2017; Berggren, Bergek, Bengtsson, Hobday, et al., 2011; Brusoni et al., 2005, 2021; Dabhilkar & Bengtsson, 2011; De Luca & Atuahene-Gima, 2007; Magnusson & Lakemond, 2011; Tell, 2011; von Hippel, 1994) as well as knowledge integration and inter-firm collaboration (e.g., Appleyard, 1996; Becker & Zirpoli, 2003; Beckman et al., 2004; Grant & Baden-Fuller, 2004; Johansson et al., 2011; Klessova et al., 2020; Mowery et al., 1996; Subramanian & Soh, 2017; Swan & Scarbrough, 2005; Takeishi, 2002; Werr & Runsten, 2013; Zirpoli & Camuffo, 2009). Considerably less has been written on the topic of knowledge integration and the business idea/business models (Bashir & Farooq, 2019; Brusoni et al., 2021; Burgers et al., 2008; Cestino & Matthews, 2016; Demarest, 1997) and industry recipes (Spender, 1996, 2002; Tsoukas, 1996; Tsoukas & Vladimirou, 2001).

This state of play and the previously mentioned resemblance between observations in the study and the concepts in question, therefore, motivated a quite thorough review of previous research on business ideas and industry recipes. Several new questions emerged as a consequence of applying these concepts in a knowledge integration context and through iteration between theory and the empirical material (see 3.2 and 3.6), which appeared to be relevant for the purpose of this study. For example:

- What is the *knowledge-foundation* of applying the business idea and industry recipe as a mechanism in the knowledge integration process? (See 5.2.2)
- Why is the mechanism of applying the business idea and industry recipe relevant for *effective management* of knowledge integration? (See 5.2.3)
- How can we understand the *evolution* of the business idea and industry recipe through the perspective of knowledge integration? (See 5.2.4 and 5.2.5)
- What are the implications of these findings about the objective-driven mode for a more *strategic perspective* on knowledge integration theory? (See 5.2.6)

[55] The original work by Normann (1975) was published in Swedish but was later translated and published in English with the title *Management for Growth* (Normann, 1977). Quotes from this contribution will reference the English version, i.e., Normann (1977), although this contribution will predominantly be referred to as Normann (1975), i.e., which is the original version.

To facilitate the forthcoming discussion about these questions, the meaning of the business idea and the industry recipe will be introduced (see 5.2.1.1–5.2.1.2) and defined in the context of knowledge integration theory (see 5.2.1.3–5.2.1.4). As previous research on the business idea, business model, and industry recipe are outside the scope of knowledge integration theory (i.e., beyond what the reader of this text is assumed to comprehend), this introduction of additional theory will be quite detailed.

5.2.1.1 Introducing the business idea

Firm-level knowledge about how to create and appropriate value is a theme in the literature on *business models* (e.g., Amit & Zott, 2001; Hedman & Kalling, 2002, 2003; Johnson et al., 2008; Osterwalder et al., 2005). This theme is especially salient in the literature, which approach business models as *cognitive/linguistic* schema, structures, or representations (e.g., Doz & Kosonen, 2010; Martins et al., 2015; Massa et al., 2017; Sund et al., 2020; Tikkanen et al., 2005). In this approach, it is implied that a distinction is possible between *knowledge* about how to configure a business model and the *actual configuration* of a business model. As will become clear throughout this section, this interpretation makes even more sense when considering the earlier work by Normann (1975), which introduced the 'business idea' as a concept to capture this kind of knowledge.[56]

This section (5.2.1.1) will be structured to reflect these four facets of the reviewed literature. First, the original work by Normann will be introduced. Second, mainstream literature on business models will be introduced, with a particular focus on how these concepts integrate theory across the strategic management domain into a kind of holistic framework. This second segment will, however, be kept relatively brief, in favor of a more extensive review of the cognitive literature on business models. Fourth and lastly, the differences between *knowledge* about how to configure a business model (i.e., the 'business idea') and the *actual configuration* of a business model will be discussed. The support in the empirical material for the relevance of literature on the business idea and business models was presented briefly in the introduction to 5.2.1 and will become increasingly substantiated throughout this chapter.

[56] Other researchers in the SIAR-community, such as Rhenman, Bruzelius, and Skärvad, should also be recognized for their contribution to the business idea-concept; see, for example, Bruzelius and Skärvad (1974).

Normann (1975, 1977) described the 'business idea' in the following way:

> Behind the conditions that the product-market analysis can reveal, there is often some kind of *superiority*, for example superior knowhow or superior competence, which is built into the company's organizational structure or embodied in the people who work there. An expression which can designate this often very complex and rather undefinable knowhow is the *company's business idea*. (Normann, 1977, pp. 27–28)

Normann (1975), hence, positioned the business idea as a type of *knowledge*. This implies that the business idea is a type of specialization, i.e., which individuals can acquire a more or less deep understanding of. The purpose of this kind of knowledge is unambiguous in the context of firms, namely to benefit economically from a given situation: *"The business idea is an expression of concrete conditions existing in a company; it describes the company's actual way of functioning – as it is sometimes rather disrespectfully put, its 'way of making money'"* (Normann, 1977, p. 38).

The business idea has three main components, according to (Normann, 1977, p. 31):

- The 'niche or market segment'
- The 'product system,' and
- The 'organization structure, resources, organized knowledge.'

It is quite striking how these main components mirror the three thematic types of problems that were outlined in the preliminary framework (see 2.3.2) and observed in the study (see 4.3 and 4.5.1). Hence, the meaning of the 'niche or market segment' resembles *commercial* problems; the meaning of the 'product system' resembles *technological* problems; and the meaning of the 'organizational structure, resources, organized knowledge' resembles *organizational* problems (see 2.3.2.1).

Furthermore, the business idea-concept by Normann (1975) emphasizes conformance between the market (i.e., what customers want and what competitors provide) and the product system (i.e., the offering which the business brings to the market), as well as between the product system and the internal features of a firm (e.g., what type of offering the firm is able to produce). This feature was also expressed in Normann's (1971) earlier work: *"In describing the process of product development, therefore, it is necessary to distinguish between the levels of environment, product, and organization; furthermore, the description of one level must take the other two into account"* (Normann, 1971, p. 203). The underlying logic is hence to perceive the business idea as a *system*, i.e., for dominance of the niche (in the environment), in which the firm is acting: *"The business idea is a system, an aggregate of elements which form a complex pattern. Or perhaps it would be more accurate to say that the business idea expresses the unifying principle of such a system"* (Normann, 1977, p. 37).

The work by Normann (1975) has been recognized as an antecedent to the business model concept in some contributions (Gibe & Kalling, 2019; Hedman & Kalling, 2002, 2003). It is, however, fair to describe this reference as somewhat overlooked by mainstream research on business models. Another overlooked contribution on the kind of knowledge in question is arguably the seminal work by Drucker (1954) on 'management by objectives.' Drucker (1954) does not mention the 'business idea' nor 'business model,' which perhaps is why this work is not a common reference in mainstream research on business models. Notably, the same systemic feature, i.e., as in Normann (1975), is reflected in Drucker's emphasis on conformance between decisions within a firm:

> And one of the most crucial jobs in the entire decision-making process is to assure that decisions reached in various parts of the business and on various levels of management are compatible with each other, and consonant with the goals of the whole business. (Drucker, 2010, p. 343)[57]

Furthermore, Drucker implied that this requires a certain type of knowledge, applied by supervisors (cf. 'managers') to make sense of how to achieve the objectives of a firm: *"He needs knowledge about the company's operations, its structure, its goals and its performance without which his own objectives cannot be meaningful"* (Drucker, 2010, p. 314).

Moving on to literature on the *business model*-concept. As for the purpose of the business idea (Normann, 1975), the purpose of the business model is to explain how firms create value and capture value (Chesbrough & Rosenbloom, 2002; Teece, 2010; Zott & Amit, 2010). Moreover, the systemic feature is also salient in the business model-concept (e.g., Afuah & Tucci, 2003; Magretta, 2002; Zott et al., 2011; Zott & Amit, 2010). However, a significant difference is that the business model literature integrates and builds on multiple perspectives on strategy that have emerged in the decades following the work by Drucker (1954) and Normann (1975). Consequently, the business model concept has a stronger theoretical foundation, i.e., in comparison with the business idea by Normann (1975). For example, theories regarding the industrial organization ('I/O') and competitive forces-perspective (Porter, 1980), transaction cost economics ('TCE') (Williamson, 1979, 1981), the resource-based view ('RBV') (Barney, 1991; Peteraf, 1993), and the activity/value chain-perspective (Porter, 1985) are integrated into the business model frameworks by Hedman and Kalling (2003), Osterwalder et al. (2005), and Amit and Zott (2001). For example, Hedman and Kalling (2003) illustrated (see Figure F) how these separate theoretical perspectives can be combined into a holistic framework.

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[57] *The Practice of Management* (Drucker, 1954) was originally published in 1954. Quotations are cited from the e-book edition, published in 2010.

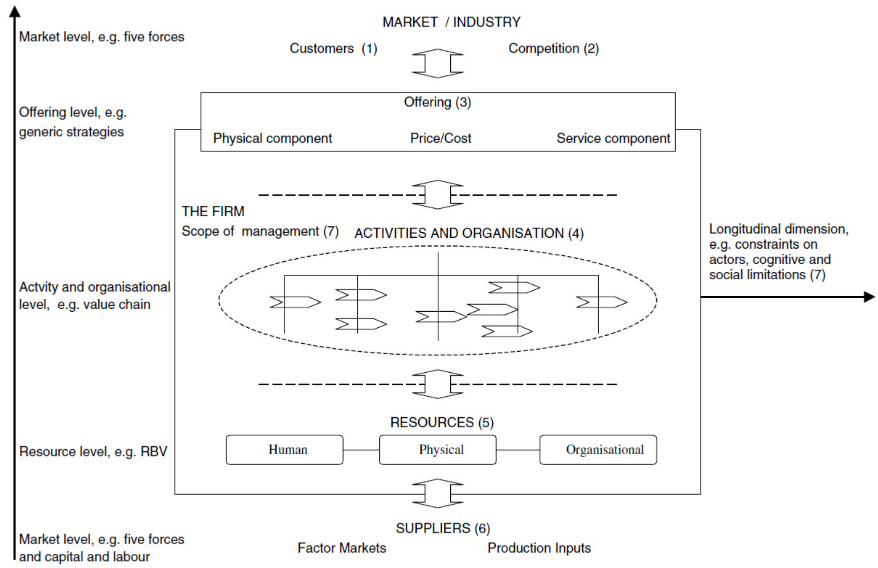

Figure F. The components of a business model (Hedman & Kalling, 2003, p. 53).

An especially relevant contribution which supports this integration of theoretical perspectives is the 'determinants of success' framework by Porter (1991). Similar to Normann (1975), this approach (see Figure G) combines both internal and external features into a systemic framework, thus responding to the criticism of Porter's previous work (Porter, 1980, 1985) by proponents of RBV (Gibe & Kalling, 2019; Hedman & Kalling, 2003). Additionally, Porter (1991) emphasized a division between the *cross-sectional* problem[58] and the *longitudinal* problem.[59] The emphasis of the longitudinal dimension is quite a significant addition, since it enables the strategy process-perspective (e.g., Chakravarthy & Doz, 1992; Mintzberg, 1978) to be coherently integrated into the business model framework (cf. Hedman & Kalling, 2002, 2003). Note, however, that Porter (1991), like Normann (1975) and Drucker (1954), is not a common reference in the reviewed business model literature.

[58] Framed as a *"chain of causality"* (Porter, 1991, pp. 98–99), to explain *"differing competitive success at any given point in time"* (Porter, 1991, p. 95).

[59] Framed as the *"dynamic processes by which firms perceive and ultimately attain superior market positions"* (Porter, 1991, p. 95).

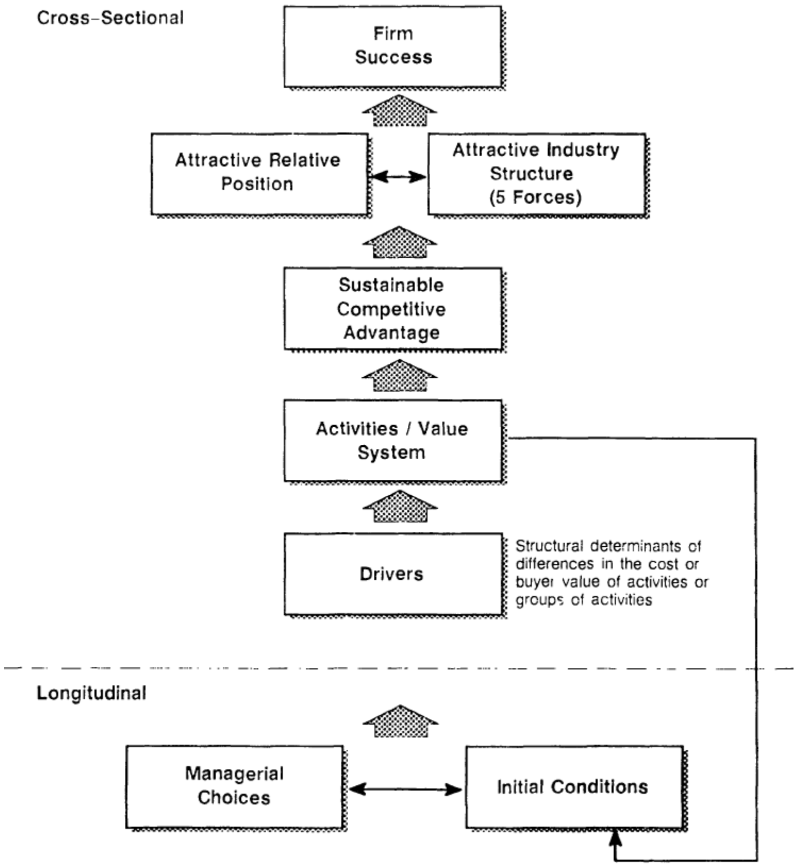

Figure G. The determinants of success in distinct businesses (Porter, 1991, p. 100).

Within the growing literature on the business model-concept, there is also research which approach business models as *cognitive* or *linguistic* schema, structures, or representations (Aspara et al., 2013; Baden-Fuller & Morgan, 2010; Chesbrough & Rosenbloom, 2002; Doz & Kosonen, 2010; Magretta, 2002; Martins et al., 2015; Massa et al., 2017; Sosna et al., 2010; Spender, 2014a; Sund et al., 2020; Velu & Stiles, 2013). This approach is especially relevant since the meaning and function of 'business models' in this literature appear to be very similar to the meaning of the business idea (Normann, 1975). For comparison, consider the definition of 'business model schema' by Martins et al. (2015):

> Business model schemas can be defined as cognitive structures that consist of concepts and relations among them that organize managerial understandings about the design of activities and exchanges that reflect the critical interdependencies and value creation relations in their firms' exchange networks. (Martins et al., 2015, p. 105)[60]

Like the business idea, the purpose of these cognitive structures is to inform individuals in a firm about how to benefit economically from present circumstances: *"So business models stand as cognitive structures providing a theory of how to set boundaries to the firm, of how to create value, and how to organise its internal structure and governance"* (Doz & Kosonen, 2010, p. 371). Furthermore, the systemic feature of business models (Drucker, 1954; Hedman & Kalling, 2003; Normann, 1975; Porter, 1991; Zott & Amit, 2010) is emphasized by several authors within the cognitive approach to business models. For example, Tikkanen et al. (2005) stated: *"The business model framework is systemic. [...] The major implication to management is that strongly developing one component of the business model always has network effects to other components"* (Tikkanen et al., 2005, p. 805).

Several different rationales have been employed to identify the cognitive dimension of business models (Doz & Kosonen, 2010; Martins et al., 2015; Massa et al., 2017; Tikkanen et al., 2005). Doz and Kosonen (2010) make a distinction between the 'objective' (actual) relationships between the firm and its environment (e.g., contracts and processes) and the 'subjective' representation of these relationships among individuals in a firm's management group. Martins et al. (2015) separate the 'cognitive view' on business model change from the 'rational view'[61] and the 'evolutionary view.'[62] Crucial for Martins et al. (2015) is that the latter views are *"designed or evolved to be optimal for their competitive conditions and change primarily in response to exogenous shocks"* (Martins et al., 2015, p. 102).

In contrast, their work on the 'cognitive view' focuses on how individuals can innovate business models in the absence of exogenous shocks, through structured cognitive processes.[63] Martins et al. (2015), however, admit the potential for an overlap between the evolutionary and cognitive views, especially in the initial phase, i.e., before experimentation and learning becomes the central mode of development (Chesbrough, 2010; McGrath, 2010; Sosna et al., 2010). This overlap

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[60] Note that both the language (e.g., design of 'activities' and 'exchanges') and logic in Martins et al. (2015) explicitly build on the definition of business models by Amit and Zott (cf. Amit & Zott, 2001; Zott et al., 2011; Zott & Amit, 2010).

[61] That is, to conceive business models *"as purposefully designed systems [...] that reflect rational managerial choices and their operating implications"* (Martins et al., 2015, p. 101) and optimized systems of activities (cf. Zott & Amit, 2010).

[62] That is, to conceive business models products of problem-solving and trial-and-error relative external conditions or stimuli. (Martins et al., 2015)

[63] Such as 'analogical reasoning' and 'conceptual combination' (Martins et al., 2015).

is even more tangible in Tikkanen et al. (2005), who appear to merge the two views in their conception that *"the entire business model is a complex web of both material and cognitive components that changes through incremental mutations – whether intentional or purely evolutionary"* (Tikkanen et al., 2005, p. 802).

This division by Tikkanen et al. (2005), i.e., between 'material' and 'cognitive' components, hence resembles Doz and Kosonen (2010). The review by Massa et al. (2017) introduces a fourth kind of categorization. Massa et al. (2017) distinguish the interpretation of business models as 'cognitive/linguistic schema' from business models as the 'attributes of a firm' (i.e., as an empirical phenomenon, for example, archetypes such as subscription, freemium, disintermediation, and platform) and as 'formal conceptual representations' describing the activities in a firm (i.e., simplified attempts to articulate, visualize, or in other forms make the business model explicit, such as by pointing out its fundamental components[64]).

Common for these interpretations (Doz & Kosonen, 2010; Martins et al., 2015; Massa et al., 2017; Tikkanen et al., 2005) is that they too (cf. Drucker, 1954; Normann, 1975) imply that there is a type of *knowledge* which subjects can apply in decision-making related to the management of a firm. Regarding the application of cognitive schema, structures, or representations in a knowledge integration setting, there is work on subjects' collective identity and aspirations (see 2.5.4.3 in the preliminary framework) which indicates that this is a viable approach (e.g., Runsten & Werr, 2020; Werr & Runsten, 2013). Further grounds for this cognitive approach to business models can also be found in research using similar terms, such as 'strategic schema' (Daft & Weick, 1984; Nadkarni & Narayanan, 2007; Prahalad & Bettis, 1986), 'strategy frame' (Huff, 1982), and 'cognitive maps' (Calori et al., 1994; Fiol & Huff, 1992; Gavetti & Levinthal, 2000).

Combined with work on the business idea (Drucker, 1954; Gibe & Kalling, 2019; Hedman & Kalling, 2002, 2003; Normann, 1975), the literature on cognitive structures and schema (Doz & Kosonen, 2010; Martins et al., 2015; Massa et al., 2017; Sund et al., 2020; Tikkanen et al., 2005) arguably support a view in which there is a principal difference between *knowledge* about a business and the *actual configuration* of a business, for example, manifested in concrete organizational arrangements (see 4.3.2), products and services (see 4.3.1 and 4.5.1.3), and agreements with customers and suppliers (see 4.3.3.1). Henceforth, the 'business idea' will be used to describe the former. Accordingly, 'business model' will be used to describe the latter, the 'objective' (cf. Doz & Kosonen, 2010) or 'material' (Tikkanen et al., 2005) configuration of a business. Note that this ontological distinction comes with epistemic ramifications, in that the 'business model' of a firm then (i.e., through the prism of realism) exists whether or not we have knowledge about it (Burrell & Morgan, 1979). The business idea, on the other hand,

[64] This approach was notably popularized by, for example, Osterwalder et al. (2005, 2010). Massa et al. (2017) position this approach to sit in between the two other interpretations.

is in this outlined division tethered to and defined by knowledge (Doz & Kosonen, 2010; Martins et al., 2015; Massa et al., 2017; Normann, 1975; Sund et al., 2020).

There is support for this view within the reviewed literature. For example, Hedman and Kalling (2002) implied a distinction between the evolution of the business model (i.e., as an ‘effect’) and knowledge (i.e., as a ‘cause’ of this effect): *“Knowledge is required as the vehicle by which firms and business models evolve, and it is the ability to learn and assimilate new knowledge that eventually makes business progress”* (Hedman & Kalling, 2002, p. 95). Normann (1975) also seemed to agree that the business idea is different from the actual arrangements of a firm:

> We want a concept which includes not only ideas about the market and the role of the company in the external environment (i.e., *what* is to be dominated), but also *what is to be done* to transform these ideas into concrete arrangements. It is not enough to say ‘we are in the transportation business’ […] there is no business idea until a formula or ‘earning money in the transport business has been found, and until this formula has been translated into organizational and other arrangements. (Normann, 1977, pp. 34–35)

Similarly, Bettis and Prahalad (1995) made a distinction between ‘underlying structures and foundations’ (cf. the business idea) and ‘visible features’ (cf. the actual configuration of a business model). Building on Prahalad and Bettis (1986), Chesbrough and Rosenbloom (2002, p. 550) positioned the ‘heuristic logic’ as an antecedent to the discovery of a business model. The distinction between resources in a firm and knowledge about how to use them for the benefit of a firm is also central in Spender (2014a).[65] The tacitness of such knowledge (cf. Normann, 1975) was emphasized in Spender's (2014c) linguistic perspective on business models:

> It is most obviously so when we focus on its operating language, how those in the firm talk about what they are up to. But the BM’s value-creating potential is always beyond being fully articulated, especially its capacity for responding opportunistically to the dynamics of knowledge absences. (Spender, 2014c, p. 145)

5.2.1.2 Introducing the industry recipe

The industry recipe-concept was introduced by Spender (1989) and is an established reference regarding industry-specific knowledge, featuring in some of the most cited contributions in the strategic management domain (e.g., Grant, 1996b; Inkpen & Tsang, 2005; Kogut & Zander, 1996; Lane & Lubatkin, 1998; Weick, 1995; Wenger et al., 2002). The industry recipe-concept (Spender, 1989) will be used to describe observations of industry-specific knowledge in Chapter 4, such as the automotive industry, software industry, and the emerging industry for autonomous driving

[65] In reference to Penrose (1959), Spender, for example, stated that *“it is not the firm’s resources that matter; rather it is the management team’s knowledge about how to use them”* (Spender, 2014c, p. 145).

(described as a combination of the former two). See, for example, the illustrative simplification of respective logic for the automotive and software industries in 4.5.6.2. To set the scene, Spender (1989) described the discovery and meaning of industry recipes in the following way:

> Having worked in several different industries before I began my research work, I already suspected that managers often deal with the problems that uncertainty creates in ways that are characteristic of that industry – part of what experienced managers take uncritically as professional common sense. I now focused on this body of knowledge – what everyone who knows this industry understands – and gave it the name 'industry recipe'. (Spender, 1989, p. 6)

Spender (1989) used the notion of an 'organization's rationality' to unpack this concept, which he claimed *"defines the organization as, in essence, a body of knowledge about the organization's circumstances, resources, causal mechanisms, objectives, attitudes, policies and so forth"* (Spender, 1989, p. 171). Consequently, Spender argued that activity in the firm *"is managed, at the most fundamental level, through the ideas adopted by the people in the organization"* (Spender, 1989, p. 171).

This emphasis on ideas is interesting since it implies that a type of knowledge exists which informs individuals about how to solve problems (cf. description of the business idea in 5.2.1.1). Spender's work on the industry recipe, however, diverges from work on the business idea (Normann, 1975) and business models as cognitive schema, structures, and representations (Doz & Kosonen, 2010; Martins et al., 2015; Massa et al., 2017) in that Spender (1989) foremost emphasizes the *industry-level*, i.e., versus the firm-level (cf. Castellucci & Carnabuci, 2017). For example, Spender (1989) clearly takes his departure in work on similarities within industries, such as the work on *strategic grouping* (e.g., Hunt, 1972)[66]: *"If shared patterns of belief are common amongst those we believe to be competitors we must ask why"* (Spender, 1989, p. 198).

Spender, however, critiqued the work on strategic grouping for being nested in an industrial economics-framework which, according to Spender, disregards individuals' confrontation with uncertainty and exaggerates the rationality of individuals (Spender, 1989). The industry recipe-concept is, on the contrary, grounded in a view of strategy which emphasizes individual judgment and bounded rationality (see 2.4.1). A practical example of such a similarity or difference is the 'clockspeed' of different industries (Fine, 1998; Nadkarni & Narayanan, 2007). In such research, industries are suggested to vary in the rate of industry change (Nadkarni & Narayanan, 2007) in three dimensions: product, process, and organization (Fine, 1998).

[66] Notably, this literature was also influential for the work by Porter (1980, 1981) and other contributors to the 'industrial organization' field (e.g., Bain, 1968; Mason, 1939).

Moreover, the industry recipe-concept is an interesting addition to the discussion about objectives in the preliminary framework (see 2.3), in that these shared patterns across industries may depend on similarities of objectives and consequent problems to solve (Aspara et al., 2013). The compatibility between the industry recipe-concept and knowledge integration theory has also partly been discussed in the work by Spender (1996, 2002) and Tsoukas (1996).[67]

Two similar contributions that also can be applied to make sense of industry-specific knowledge about how to manage knowledge integration are the concepts of 'dominant logics' (Bettis & Prahalad, 1995; Prahalad & Bettis, 1986) and industry logics for value creation.[68] Prahalad and Bettis (1986), for example, discussed the repertoire of tools and the mindset which the top management (in a diversified firm) can mobilize to make decisions in line with the characteristics of certain businesses. The feature of applying such knowledge as a mechanism (cf. 4.5.2) is even more pronounced in their later work: *"We have come to view the dominant logic as an information filter"* (Bettis & Prahalad, 1995, p. 7). Bettis and Prahalad (1995) even apply a reasoning which is not too dissimilar from the features of knowledge integration theory (see 1.2.3) when they explain how knowledge about how to achieve objectives is 'incorporated' (cf. 'integrated') into an organization's outputs.[69] Furthermore, Prahalad and Bettis (1986) emphasized the *lock-in* which a logic may impose on individual decision-making in present (cf. 2.5.4.4). This was indeed observed in the study, for example, the perceived influence of Alpha in the logic employed at Omega (see 4.6.4). Notably, this feature also influenced later work on business models, such as Chesbrough and Rosenbloom (2002): *"Heuristic logic is required to discover an appropriate business model, and an established corporation's 'sense-making' task will be constrained by its dominant logic, which is derived from its extant business model"* (Chesbrough & Rosenbloom, 2002, p. 550).

Johansson (2008) discussed industry logics for value creation, such as the value 'chain' logic in industrial organizations and the 'shop' logic in professional services firms. In a way, this work also describes industry-specific knowledge about how to benefit economically from knowledge integration, i.e., beyond solving a problem in

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[67] These contributions, however, are foremost focused on a knowledge-based 'theory of the firm.' In Tsoukas (1996), the industry recipe primarily serves as an illustration of how knowledge is constructed among subjects in a firm. In Spender (2002), more support can be found for the compatibility between knowledge integration (e.g., references to Grant, 1996b) and the industry recipe-concept (e.g., the discussion about front-facing and back-facing knowledge). Mainstream theory on knowledge integration has not embraced this approach, nor referenced the industry recipe to any significant extent.

[68] Note, however, that neither Prahalad and Bettis (1986) nor Johansson (2008) are exclusively demarcated to the industry-level of analysis.

[69] *"'Relevant' data are filtered by the dominant logic and by the analytic procedures managers use to aid strategy development. These 'filtered' data are then incorporated into the strategy, systems, values, expectations, and reinforced behavior of the organization"* (Bettis & Prahalad, 1995, p. 7).

a vacuum. Furthermore, Johansson (2008, p. 271) positioned (industry) logics as a *"conceptual tool for practitioners,"* i.e., resembling the concept of 'mechanisms' within knowledge integration theory (cf. 4.5.2). Finally, the ontological and epistemological foundation in Johansson (2008) appears to be quite compatible with the features of knowledge integration (see 1.2.3). For example, Johansson (2008) discussed how competences are 'represented' (cf. integrated) in a firm's output: *"organization should consider its balance between competences, individual and collective, and how these are represented in its output and thus its physical resources"* (Johansson, 2008, p. 272).

The ontological discussion in 5.2.1.1 about the difference between a business idea and a business model is also relevant for the meaning of the industry recipe. Similar to the meaning of the business idea (including cognitive representations of a business model), the industry recipe appears to represent the *knowledge* about actual structures and relationships within an industry (see 4.3 and 4.5.4.2). The different types of knowledge underpinning the industry recipe will be discussed further in the upcoming 5.2.2.4.

5.2.1.3 Defining the business idea and industry recipe in the context of knowledge integration

The business idea has not previously been applied in the context of knowledge integration theory. Similarly, there are very few examples of references to the industry recipe in previous knowledge integration literature.[70] Consequently, it is helpful to define the meaning of these two concepts in the context of knowledge integration before applying these concepts in the forthcoming analysis.

Based on the additional theory which was introduced (see 5.2.1.1 and 5.2.1.2) and the observations that were presented throughout Chapter 4 (see 4.5 in particular), the two concepts will be defined in the following way:

- The 'business idea' will be used to describe *firm-specific knowledge about how to benefit economically from knowledge integration*.
- The 'industry recipe' will be used to describe *industry-specific knowledge about how to benefit economically from knowledge integration*.

Two disclaimers should be acknowledged to nuance these proposed definitions. First, the meaning of 'knowledge' in these definitions is not intended to imply omniscience, i.e., that this knowledge is 'complete' or 'true.' On the contrary, to achieve economic benefit is rightfully described as an uncertain and risky enterprise, in which the true relationships between causes and effects are not known *a priori* and can even be difficult to establish *ex ante* (Arrow, 1962; Knight, 1921; Spender, 2014a). This means that the 'knowledge' in question is most likely *incomplete*

[70] Tsoukas (1996) and Spender (2002) are the only exceptions that were identified.

and/or *flawed*, e.g., that there are discrepancies between this knowledge and the circumstances in question (see 4.5.5.2). Normann (1975) discussed this potential in terms of 'misfits,' i.e., between (or within) a firm's circumstances, idea-system, an organizational structure. This view of knowledge was reflected in the preliminary framework, for example, in 2.1.2 regarding the definition of knowledge (cf. Spender, 1998) and in 2.3.2.8 regarding commercial knowledge (cf. Demarest, 1997). This view is also commensurate with the assumption of bounded rationality of individuals (see 2.4.1.1). To summarize, the meaning of 'knowledge' in these definitions of the business idea and industry recipe should thus be interpreted through the metaphor of a 'recipe' rather than as a truth claim (see upcoming 5.2.1.4).

Second, it is conceivable that a firm has other objectives than to benefit economically. In such cases, the above definitions could easily be changed from 'how to benefit economically from' to 'how to achieve a firm's objective through.' I do, however, maintain that it is a useful simplification to emphasize economic benefit since this is what most efforts to integrate knowledge boil down to in the context of private enterprise. Normann (1975) and several authors on the cognitive perspective of business models (e.g., Doz & Kosonen, 2010; Martins et al., 2015) made the same clarification regarding the purpose of this knowledge (cf. 'way of making money' in Normann (1975)).

5.2.1.4 The 'recipe'-metaphor

It is first important to clarify that the 'recipe'-metaphor will apply equally to the business idea and industry recipe in this chapter. This is despite the fact that different languages will be used to describe this knowledge on the firm-level ('idea') and the industry-level ('recipe').

A central feature of the recipe-metaphor by Spender (1989) is that it is deliberately *non-deterministic* (Aspara et al., 2013; Baden-Fuller & Morgan, 2010; Kogut & Zander, 1992; Spender, 1989). This positions knowledge about the business idea and industry recipe into a pragmatic perspective, in which causality is secondary to *satisficing* (Demarest, 1997; Drucker, 1954; Simon, 2018; Winter, 2000). Consider the following passage from Spender (1989), which clearly downplayed the ambition to establish 'universal relationships':

> With the notion of recipe in mind, we can think about contingency theory in a rather different way […] Instead of looking for universal relationships between strategy and structure, or environmental turbulence and management style, we might see contingency theory as capturing some managerial judgements about how firms should be organized to best cope with certain environmental conditions. (Spender, 1989, p. 193)

The high-level of uncertainty (see 4.8.2) and complexity (see 4.8.1) which individuals had to manage at Omega support this conception of recipes. For example, Bastian's analogy about painting a wall of an unknown size and Eton's conundrum about not knowing how close or far away Omega was from solving certain technological problems (see 4.8.2.1). The metaphor of 'recipes,' thus, resembles the concept of *heuristics*. Spender (1989), for example, argued that:

> recipes are merely suggestive about the consequences of following them, though they also imply cautions against ignoring them. But they say nothing about the consequences of following different lines of action. They are more like road maps which show only the correct route; once off that route they offer the traveller no guidance. (Spender, 1989, p. 6)

A similar perspective of this kind of knowledge was offered by Kogut and Zander (1992): *"Knowing how to do something is much like a recipe; there is no substantive content in any of the steps, except for their capacity to produce a desired end"* (Kogut & Zander, 1992, p. 386). This heuristic feature can also be interpreted in Porter's (1991) division between theoretical 'models' and 'frameworks,' in which the latter considers the complexity between multiple variables and how this requires a more qualitative, inductive mode of reasoning (Gibe & Kalling, 2019; Porter, 1991). The heuristic feature is also present in Chesbrough and Rosenbloom (2002), e.g., in their description that new information (cf. knowledge) is *"filtered through a heuristic logic that was established from previous success"* (Chesbrough & Rosenbloom, 2002, p. 550).

Furthermore, this view of knowledge is present in other contributions on the cognitive perspective on business models, for example, Baden-Fuller and Morgan (2010) who stated that the a business model can *"act as a recipe for creative managers"* (Baden-Fuller & Morgan, 2010, p. 156). Lastly, this heuristic feature is also present in Normann's (1975) suggestion that firms' business idea may relate to one of three archetypical orientations: market-orientation, production-orientation, and raw material-orientation.

In summary, the forthcoming analyses which invoke these two concepts should be interpreted through this non-deterministic application of the recipe-metaphor. For example, regarding the business idea, this was not observed to be firm-specific knowledge about how to benefit economically from knowledge integration in a causal sense, but a heuristic which informed individuals about how to make satisficed decisions, relative to Omega's objectives (see 4.5.2).

5.2.2 The knowledge-foundation of the business idea and industry recipe

5.2.2.1 The business idea as a synthesis of different types of knowledge

The concept of combination is central to knowledge integration theory (Carlile & Rebentisch, 2003; Enberg, 2007; Okhuysen & Eisenhardt, 2002; Tell, 2011). In line with this quality, the empirical material suggested that the business idea is a *synthesis* which occurs at the interaction between the three categories of knowledge (illustrated in upcoming Figure J). This conception of the business idea, i.e., as a product of combination, can be demonstrated by an analysis of degrees of overlap.

First, there were problems in the study which primarily required integration of the corresponding type of knowledge (see Figure H). This was in line with the expected pattern that was outlined in 2.5.7.1 (Burgers et al., 2008; Enberg, 2007; Ravasi & Verona, 2001; Tanriverdi & Venkatraman, 2005; Tiwana, 2004). This observation was especially common when the problem was very simple, especially in the dimension of interdependence (cf. complexity). For example, efforts at Omega to produce and manage quite basic organizational solutions (such as to enable payroll and parental leave) did not appear to warrant the need to mobilize other categories of knowledge. This was also observed for problems that required deeply specialized knowledge. In such instances, for example, previously unsolved technological problems (see 4.3.1 and 4.7.1), the value-added from integration of unrelated knowledge appeared to be marginal (see 4.7.4.2).

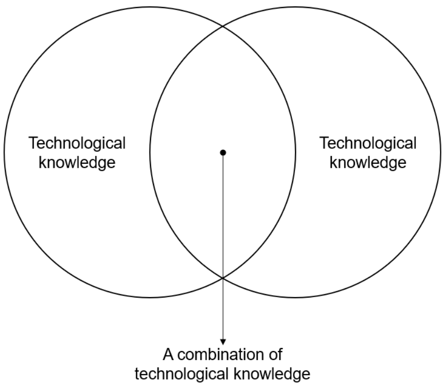

Figure H. A combination of one type of knowledge (for example, technological knowledge).

Second, there were problems, which, in addition to the corresponding type of knowledge, required integration of an additional category of knowledge, i.e., a combination of *two* types of knowledge. For example, decisions that involved cost-benefit trade-offs illustrated how technological problems could be impregnated by commercial aspects (4.3.1.2). Figure I depicts how such interdependent problems required a combination of two types of knowledge. Note that this finding also applies to problems requiring a combination of organizational and technological knowledge, for example, to set up a 'continuous product stream' in 4.3.2.1, as well as problems requiring a combination of commercial and organizational knowledge, such as the reference to 'agile contracts' in 4.3.2.1. This pattern was indicated in the preliminary framework (see 2.3.2.9 and 2.5.7.2), although less corroborated than the first instance of combining knowledge of the same thematic type.

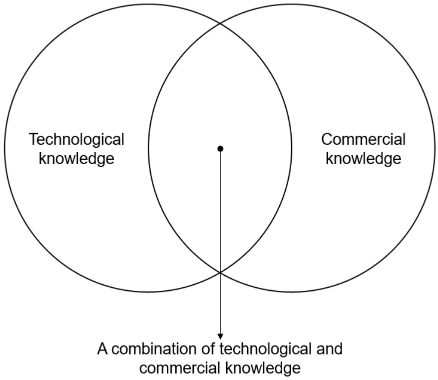

Figure I. A combination of two types of knowledge (for example, technological and commercial knowledge).

Third, and which previous theory explained the least (see 2.3.2.9 and 2.5.7), there were problems in the study which required the combination of all *three* types of knowledge to be solved effectively, relative to Omega's objectives. This type of combination of knowledge, hence, constitutes another level of overlap compared with the type of combination depicted in Figure I (i.e., combination of *two* categories of knowledge). To guide decision-making in such instances, individuals appeared to apply a *synthesis* of the three types of knowledge (see 4.5.2). There were numerous examples in the empirical material which substantiate this interpretation, e.g., as summarized in 4.5.5.1. For example, the problem of scope and customizability of Omega's offering illustrated how an effective solution to this commercial problem required a consideration of interdependencies across all three categories (4.5.1.3). Furthermore, the conviction that the product development approach would be a better fit with Omega's business idea than the project delivery approach (see 4.3.3.2) was an illustration of how this synthesis of knowledge was applied as a *heuristic*. In line with the recipe-metaphor (see 5.2.1.4), this conviction did not mean that it would have been impossible for Omega to work according to the project delivery approach, or that the product development approach necessarily would produce the desired benefits.[71] The point is that the two approaches were judged to not be equally likely to produce the desired result, and that all three types of knowledge were combined to inform individual judgment about how to approach such problems (see 4.5.1).

Following these observations of a need to combine all three categories of knowledge to manage knowledge integration in line with the objectives of Omega, Figure J depicts the business idea as a synthesis of all three types of knowledge. Note that Figure J encompasses all possible combinations, i.e., involving one, two, or three categories of knowledge.

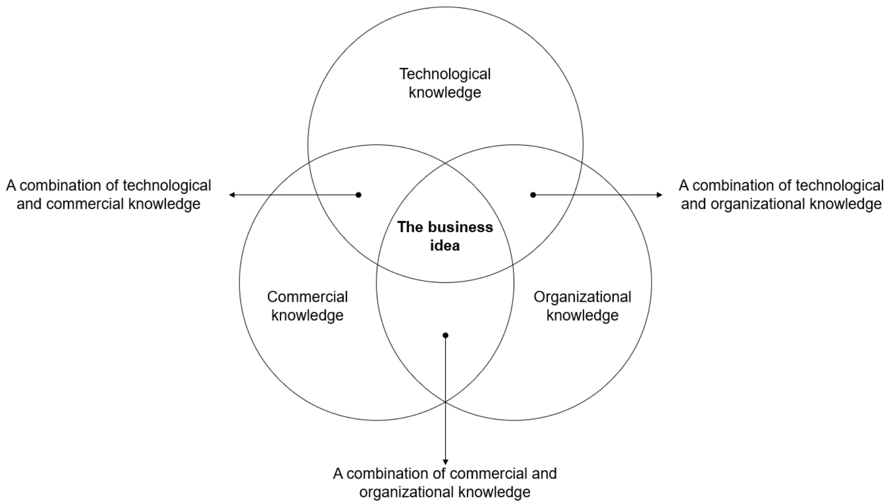

Figure J. The business idea as a synthesis of commercial, technological, and organizational knowledge.

The preliminary framework does not sufficiently explain this observation, although some authors have indicated parts of what was observed. To begin with, the general work on interdependencies, i.e., without references to the types of problems and knowledge, foremost focus on the implications of this characteristic for integration costs, not achievement of firms' specific objectives (Carlile & Rebentisch, 2003; Grandori, 2001; Grant, 1996b; Nickerson & Zenger, 2004). Regarding management of knowledge integration, it was outlined in 2.5.7.1 how the effectiveness of management integration is relative to the objectives of a firm. In 2.5.7.2, it was outlined how some problems might require integration of multiple types of

[71] For example, payment upon project delivery (i.e., a type of commercial arrangement) does not prohibit the organizational arrangements, which Omega preferred (see 4.3.2). Likewise, organizational arrangements, which typically are associated with the project delivery approach (such as to be organized according to a fixed scope), do not prohibit practices for faster feedback from customers, i.e., to facilitate faster technological development (see 4.5.1.1).

knowledge, grounded in more specific work on interdependencies across multiple types of problems (see 2.3.2.9). None of the references in either part of the preliminary framework (i.e., 2.5.7.1 and 2.5.7.2), however, propose that these two aspects of the management of knowledge integration are interrelated. More specifically, which also is not discussed in this literature, the findings in this study suggest that the former (management relative objectives) has a knowledge foundation which can be explained through the latter (i.e., in accordance with Figure K). Additionally, no part of the preliminary framework (2.5.7 or otherwise) invokes the business idea or any similar concept to explain the purpose of this simultaneous application of all three types of knowledge (see 5.2.1.3).

The additional literature (see 5.2.1) was more illuminating on this issue. For example, the systemic feature is salient, both in work that reference the business idea (Gibe & Kalling, 2019; Hedman & Kalling, 2002, 2003; Normann, 1975) and in work on business model schema (Chesbrough & Rosenbloom, 2002; Doz & Kosonen, 2010; Magretta, 2002; Martins et al., 2015; Massa et al., 2017; Spender, 2014c). Another interesting contribution was the work on co-production of value between customer and supplier by Normann and Ramirez (1993), referenced e.g., in Johansson (2008). Consider the example of banks introducing ATMs ('automatic teller machines') in Normann and Ramirez (1993): *"This is not merely a change in technology or even in the transaction itself. It is a change in the entire value-creating system. The scene, the script, the roles of the relevant actors have all been transformed"* (Normann & Ramirez, 1993, p. 69).

This notion informed interpretations of interdependencies between customer and supplier that were observed in the study.[72] For example, the potential win-win between Omega and OEM customers seemed to depend on knowledge about how to unlock value in the specific technology (see 4.5.1.3) and efforts to persuade potential OEM customers to adopt certain organizational arrangements (see 4.3.2.2). This observation is not easy to explain through the preliminary framework, but arguably makes sense through a perspective which emphasizes the objectives of the respective subject and the types of problems to solve, which this entails.

The additional theory introduced in 5.2.1, however, *does not* attempt to explain a possible knowledge-foundation for the business idea, i.e., which has been demonstrated in this section and is depicted in Figure J. A conclusion is thus that, to make sense of the observations in this study, it is essential to apply knowledge integration theory *together* with the additional literature that was introduced in 5.2.1. Another way of putting this finding is that knowledge integration theory may help to explain the process of solving problems through a combination of knowledge, and the business idea-concept may help to explain the source of interdependencies and synergies within systems of problems.

[72] Compare with 'reciprocal' interdependence (Grant, 1996b; Thompson, 1967).

5.2.2.2 Idiosyncrasy of the knowledge underpinning the business idea

An important finding about the business idea, which was highlighted in the empirical presentation, is that the knowledge underpinning the business idea is *specific* to the particular firm (see 4.5.4.1). This has normative implications, in that the synthesis of knowledge which is effective in one firm may not be as effective in another firm in the same industry. Although this research project was designed as a single-case study, the empirical material included some points of comparison between Omega and other actors which support this interpretation. For example, the logic underpinning Omega's strategy, the differences in approach to active safety of Alpha and Beta/Gamma, and the comparison between Omega and a key competitor (see 4.5.4.1). A fourth type of data which supports this interpretation was observations from my own interactions with multiple potential OEMs, as part of the project for Omega (see 3.5.3).[73] Rather than approaching the business opportunity in the same way, each OEM appeared to have its own approach to commercialization of ADAS and AD technology. For example, how advanced and expensive this technology was allowed to be (i.e., to fit within different value propositions), and how much the technology from a supplier (such as Omega) had to be customized (i.e., to fit the OEM's hardware platform).

Such differences in strategy between various industry participants did not appear to merely be a matter of coincidence or individual preference. Rather, two aspects were observed to make a business idea specific: the specific objectives which each firm attempted to achieve (cf. 2.3), and the initial conditions of each firm (see 4.5.4.1). The differences in *objectives* can arguably be described using the preliminary framework, which points out that different types of problems need to be solved depending on the objective (e.g., Burgers et al., 2008; Demarest, 1997; Melander & Tell, 2014; Pisano, 1994; Tanriverdi & Venkatraman, 2005; Tiwana, 2004; Wikström & Normann, 1994). The relevance of *initial conditions* is only partly described in the preliminary framework, for example, in Hobday and Bergek (2011), Pisano (1994), and L. Bengtsson et al. (2017). The role of initial conditions, however, is clearer in the additional theory that was introduced in 5.2.1. Specifically, the business model literature (e.g., Hedman & Kalling, 2003) include references to RBV, which are quite established on this issue (e.g., Barney, 1991). Consequently, Porter (1991) highlighted the influence of initial conditions on how firms attain attractive competitive positions or devise superior ways to solve a problem: *"These initial conditions may reside within an individual firm or [...] in the environment which the firm is based. Initial conditions clearly influence feasible choices as well as constrain them"* (Porter, 1991, p. 105).

Furthermore, a major assumption which underpins the SIAR school of thought, for example, represented by Normann (1971, 1975), is that a certain business opportunity is tethered to the specific circumstances in which the firm is operating

[73] This data was not disclosed in Chapter 4, for reasons stated in 3.3.4 and 3.8.

(Gibe & Kalling, 2019; Spender, 1989). This perspective, discussed as 'situation-based analysis' in Normann (1975, my translation), was, in turn explicitly inspired by contingency theory, e.g., Lawrence and Lorsch (1967). Spender (1989) described that in this perspective, *"managerial rationality is local rather than universal, but local to the firm rather than to the industry"* (Spender, 1989, p. 195).

The extent that each business idea is specific can, however, be nuanced. It is certainly possible that some of the knowledge which underpins different business ideas is shared among different firms, and that the degree of shared knowledge may vary between industries (e.g., due to industry maturity). Aspara et al. (2013), for example, claimed that *"beliefs about the firm's businesses and their value-creating links are often shared by other actors or stakeholders in the industries/communities in which the firm operates"* (Aspara et al., 2013, p. 461).

This is a fair concern, i.e., that different business ideas are not *completely* idiosyncratic. The main point, however, remains intact: business ideas appear to vary between firms, e.g., because the circumstances for how to integrate knowledge is local to the firm (Barney, 1991; Hedman & Kalling, 2003; Normann, 1975; Porter, 1991; Spender, 1989, 2014a). As will be discussed further in 5.2.4 (on the evolution of a business idea), this property (idiosyncrasy) has normative implications for the management of knowledge integration. Moreover, this would be an interesting question to study further, preferably using a method in which N>1 (e.g., a multiple-case design or a hybrid/quantitative approach).

5.2.2.3 The industry recipe in comparison with the business idea

The industry recipe was observed to share the property with the business idea of being a synthesis (cf. combination) of all three types of knowledge (i.e., as depicted in Figure J in 5.2.2.1). The industry recipe was also observed (see, for example, 4.5.4.2 and 4.5.6.2) to share the property that this synthesis was *specific* to a certain industry (cf. discussion of idiosyncrasy in 5.2.2.2).

A major difference between the business idea and the industry recipe, however, was that the knowledge underpinning the industry recipe appeared to be *common* (cf. shared) for all participants in the same industry. Consider the comparison between the automotive industry and software industry logics in 4.5.6.2. This was based on common themes that emerged in multiple descriptions of the setting in which Omega was acting. Another instance which revealed this property of the industry recipe was that it was a problem for Omega that the automotive industry logic was common to all participants. For example, this made it more difficult for Omega to introduce new practices (see 4.5.6.4), such as continuous deployment and integration of software in end-customers' vehicles (see 4.3.2.1). The interviews that I conducted with multiple OEMs during the first phase of the study illustrated the same pattern (see 3.5.3). There is, hence, a degree of triangulation between different data sources that support the interpretation that the industry recipe was shared among participants in the same industry. This observation is not explained by the preliminary framework but can be understood quite well through the literature on industry-level knowledge (Bettis & Prahalad, 1995; Johansson, 2008; Prahalad & Bettis, 1986; Spender, 1989, 2002) which was introduced in 5.2.1.2.

Lastly, this finding can be combined with the interpretation that the business idea is idiosyncratic to each firm (see 5.2.2.2) to propose a new conception of the 'whole' body of knowledge regarding how to economically benefit from knowledge integration, in which the business idea and the industry recipe are its two collectively exhaustive parts (see Figure K). Their main difference, in addition to the level of analysis (i.e., firm versus industry), in this conception is the extent to which the knowledge is specific to a particular firm or common for all industry participants.

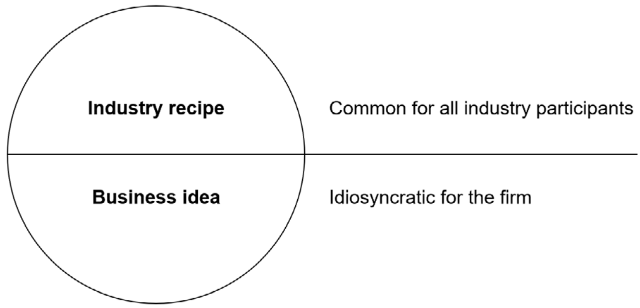

Figure K. A proposed relationship between industry recipe and business idea, as parts of a 'whole' body of knowledge about how to benefit economically from knowledge integration.

5.2.2.4 Introducing additional literature to further explain the knowledge-foundation of the industry recipe

The industry recipe was observed to follow the synthesis-conception, which was described for the business idea (see Figure J in 5.2.2.1). There were, however, observations of industry-level problems and knowledge in the empirical material which the preliminary framework does not sufficiently explain. In addition to the theory which was introduced in 5.2.1.2, additional literature about the types of problems were consulted to explain these observations. Note that these additions should be interpreted as sub-categories of the three categories of problems in the preliminary framework (see Table G).

First, references in the empirical material to the dynamics of *competition* can be addressed through the seminal competitive forces-framework by Porter (1980, 1991). Although the preliminary framework lends some understanding to this phenomenon, for example, through contributions on customer knowledge (Eslami, 2017; Eslami & Lakemond, 2016; Tanriverdi & Venkatraman, 2005) and general knowledge (Court, 1997; Frishammar et al., 2012; Ramesh & Tiwana, 1999), this was a highlighted gap in the problematization of previous knowledge integration research (see 1.4.3.1). Specifically, the work by Porter (1980, 1991) informs interpretations of how knowledge about the competition (such as internal rivalry, threats of new entrants, and threats of substitutes) could be applied to guide individual judgment. These include, for example, knowledge about different competitors' offerings (see 4.5.1.3), trends in the automotive industry (see 4.5.3), and customers' problems to solve (see 4.3.2.1). Moreover, the dynamics of negotiation and persuasion (see 4.3.3.1) can clearly be understood through the lens of bargaining power of buyers and suppliers (Porter, 1980, 1991).

Secondly, references in the empirical material to different *macro-problems* (such as legal, regulatory, or political issues related to commercialization of AD technology) can be addressed through the ubiquitous PEST(-EL) framework (Aguilar, 1967; Gibe & Kalling, 2019; Yüksel, 2012). PESTEL describes the setting that a firm is acting in through six types of problems: political, economic, socio-cultural, technological, environmental, and legal (Yüksel, 2012). Arguably, the six types of problems in PESTEL can be mapped against the three categories in the preliminary framework. First, one could interpret legal aspects (e.g., regulation of the market for AD technology) and socio-cultural aspects (e.g., customer expectations and trust in AD technology) to be part of the commercial category. Second, political, economic, and environmental aspects could be considered part of the organizational category (i.e., as problems with how to organize society, markets, and infrastructure). Third, technological aspects, such as the general purpose technology platform (Bresnahan & Trajtenberg, 1995; Gambardella & McGahan, 2010), obviously fit within the technological category of problems. (Gibe & Kalling, 2019; Yüksel, 2012)

Third, references in the empirical material to industry-level dynamics of *technology* could be addressed through literature on technology and innovation management (Godin, 2017). For starters, differences between *incremental and radical* innovation (cf. continuous and discontinuous technological trajectories) illuminate characteristics of ADAS and AD technology, which were quite consequential in the Omega-case (Christensen & Rosenbloom, 1995; Dosi, 1982; Tushman & Anderson, 1986). For example, the degree to which it was productive to adopt a component versus system-logic (see 4.5.4.2). Secondly, contributions on industry structure, which are grounded in the properties of technology, such as Utterback and Suárez (1993), were also found to be useful. This approach complements the work by Porter (1980, 1991), which does not consider the properties of technology to the same extent. For example, statements in the Omega-case about the future competitive landscape were often grounded in an expectation of how many technology platforms would survive an initial shakeout in the industry (see 4.5.4.1 and 4.9). Third, the distinction between architectural and component knowledge (Abernathy & Clark, 1985; Henderson & Clark, 1990) also appears to be useful. Notably, this feature of technology was discussed in the preliminary framework, although not related to the industry recipe (e.g., Brusoni & Prencipe, 2011; Chen et al., 2020; De Boer et al., 1999; Sanchez & Mahoney, 1996; Takeishi, 2002).

Table G. Summary of theories, which inform the industry recipe.

Categories of problems and knowledge in the objective-driven mode (see 5.1)	***Theory in the preliminary framework which informs the industry recipe***	***Additional theory which informs the industry recipe***
Technological	• Product knowledge (Tanriverdi & Venkatraman, 2005) • Technological/technical knowledge (Burgers et al., 2008; Galbraith, 1990; Tiwana, 2004) • Domain-specific knowledge (Brusoni & Prencipe, 2011; Court, 1997; Frishammar et al., 2012; Ramesh & Tiwana, 1999)	• Technological aspects in PESTEL (Yüksel, 2012) • Technology management (Christensen & Rosenbloom, 1995; Dosi, 1982; Tushman & Anderson, 1986; Tushman & O'Reilly, 1996; Utterback & Suárez, 1993) • Innovation management (Abernathy & Clark, 1985; Christensen, 1997; Godin, 2017; Henderson & Clark, 1990)
Organizational	• Inter-firm coordination (Argote & Ingram, 2000; Ceci & Prencipe, 2017; Lane & Lubatkin, 1998; Liebeskind, 1996; Takeishi, 2002; von Hippel, 1990; Zirpoli & Camuffo, 2009) • Inter-firm collaboration (L. Bengtsson et al., 2011; Bergek et al., 2011; Dabhilkar & Bengtsson, 2011; Johansson et al., 2011; Swan & Scarbrough, 2005)	• Political aspects in PESTEL (Yüksel, 2012) • Environmental aspects in PESTEL (Yüksel, 2012) • Economic aspects in PESTEL (Yüksel, 2012)
Commercial	• Customer knowledge (Eslami, 2017; Eslami & Lakemond, 2016; Tanriverdi & Venkatraman, 2005) • Market kowledge (Åkerman, 2015; Burgers et al., 2008; De Luca & Atuahene-Gima, 2007; Zhou & Li, 2012) • General knowledge (Court, 1997; Frishammar et al., 2012; Ramesh & Tiwana, 1999) • Business domain knowledge (Tiwana, 2004)	• Competitive forces (Porter, 1980, 1991) • Legal aspects in PESTEL (Yüksel, 2012) • Socio-cultural aspects in PESTEL (Yüksel, 2012)

It is also notable that these additions to our understanding of industry recipes can be applied to the generic objectives, which were discussed in 2.3.1. For example, it was pointed out in the preliminary framework that the objective of completing an integration process within time and resource constraints (see 2.3.1.2) lacks a theoretical foundation in current literature on knowledge integration. In particular, the work by Porter (1980, 1991) on competitive forces in industries is quite illuminating on this point of individual knowledge about how to accomplish this type of objective. For example, the question of how many employees to employ within Omega appeared to apply knowledge about the competition (see 4.5.1.2). The addition of this literature, hence, also improves our understanding of how knowledge integration can be managed, relative to the objectives of a firm (see 2.5.7.1 and 2.3.1).

To summarize, an improved understanding of the industry recipe can be attained through these three additions (the competitive forces-framework, the PESTEL-framework, and literature on technology and innovation management). Arguably, these additions are a constructive step toward resolving the gap regarding exogenous aspects, which was highlighted in Chapter 1 (see 1.4.3.1).

5.2.3 Effective management of knowledge integration – a framework for the objective-driven mode

In summary, this section presents a theoretical explanation for the observation in the study that decisions which are aligned with a specific firm's business idea and industry recipe are superior, relative to decisions which deviate from this knowledge (see 4.5.2 and 4.5.5). Specifically, this section provides a framework for effective management from the perspective of the objective-driven mode (see 5.1.1). Arguably, this framework represents quite a substantial development, relative to the parts of the preliminary framework which discussed the influence of objectives on the management of knowledge integration (see 2.5.7). In comparison with the mainstream explanation of effective management, which focuses on the influence of problem characteristics (see 2.5.1–2.5.6), the contrast is even more evident. The root-cause for this contrast was discussed at length in 5.1.1.1.

Crucially, the previously presented knowledge-foundation of the business idea and industry recipe (see 5.2.2) provides a novel foundation for this explanation of effective management. The resulting picture arguably advances our understanding of how objectives influence the process of knowledge integration, i.e., the purpose of this study.

5.2.3.1 A mechanism for coordination and motivation

The observation that the business idea and the industry recipe could be applied as a *mechanism* by individuals will serve as a starting point (see 4.5.2). Multiple important problems at Omega displayed interdependencies between the different categories of problems (see 4.5.1). To solve such interdependent problems in accordance with Omega's objectives appeared to require knowledge about a certain 'fit' between various parts of the system of problems (cf. what, why, and how; see 4.5.2). Knowledge about how to accomplish this fit was, hence, a mechanism for integration which individuals could employ to increase the probability of achieving Omega's objectives (see summary of examples of positive influence in 4.5.5.1). As was discussed in 5.2.1.1 (introducing the business idea), this interpretation of the empirical material also implies that this kind of knowledge (cf. the business idea and industry recipe) is its own kind of specialization, i.e., which individuals can know more or less about (see 4.5.2).

First, the observations indicated that knowledge about the business idea and industry recipe could be applied as a *coordination* mechanism, to steer individual decision-making in a certain direction (see 4.6.3.1). The role of such knowledge in the compatibility of decisions made in various parts of a firm, for example, was discussed by Drucker (1954) in the additional theory which was introduced in 5.2.1.

Second, the observations indicated that knowledge about the business idea and industry recipe could be applied as a kind of *motivation* mechanism (Baxter et al., 2013; Grant, 1996b; Kalling, 2003a; Malik et al., 2020; Spender, 2014d), to persuade individuals to act on behalf of and for the benefit of Omega (see 4.6.3.2). This mechanism can hence be part of the resolution of problems described in the principal-agent theory, i.e., that agents and stewards in a firm do not necessarily act in accordance with the objectives of its shareholders (Bartlett & Ghoshal, 1993; Jensen & Meckling, 1976; Nickerson & Zenger, 2004). Also, this can be viewed as a contribution to the discussion on *collaboration* problems (Adler & Kwon, 2002; Dabhilkar & Bengtsson, 2011; Johansson et al., 2011; Lindkvist et al., 2011; Postrel, 2017; Tsai & Ghoshal, 1998).

That this mechanism could be used for these dual purposes is supported by the preliminary framework. For example, see 2.1.3 on types of integration problems and 2.5.4.3 on expected implications of having a higher degree of collective identity and aspiration (Bhandar et al., 2007; Willem et al., 2008).

5.2.3.2 Alignment of decisions with the business idea and industry recipe

The relevance of the business idea and industry recipe for the management of knowledge integration is tethered to the conception of individual decision-making as the main mode for how organizational processes are driven forward (Simon, 1947). Faced with difficult problems, individuals in the study appeared to rely on their judgment to make satisficed decisions, relative to the objectives of Omega (Demarest, 1997; Drucker, 1954; Simon, 2018; Spender, 2014a; Winter, 2000). As was explained in 5.1.1.1, the meaning of 'effective management' in the objective-driven mode emphasizes the likelihood of achieving the objectives of a firm under certain circumstances. This view builds on the expectation in the preliminary framework that management is effective relative to the objectives of a firm (see 2.5.7.1).

In essence, the empirical results suggested that effective management of knowledge integration depends on the application or misapplication of the business idea and the industry recipe. Application and misapplication can be reframed as decision-making, which is aligned with a) the business idea and b) the industry recipe. 'Alignment' should not be interpreted as a *binary* term but as a spectrum, i.e., the extent to which a decision deviates from the business idea or industry recipe.

Through a combination of these two variables, i.e., a) the business idea and b) the industry recipe, four types of management can be imagined in a framework for effective management. To begin with, decisions that are aligned with both the business idea and industry recipe could be anticipated to be the most effective type of management. This proposition is grounded in observations of positive influence from the depth of this knowledge, summarized in 4.5.5.1, and the definition and meaning of these concepts in the context of knowledge integration (see 5.2.1.3 and 5.2.1.4). The opposite, i.e., decisions which neither were aligned with the business idea nor the industry recipe, was accordingly observed to be the least effective way of managing knowledge integration (see, for example, 4.5.5.2). Although a crude simplification, this interpretation of the empirical material results in a heuristic framework for effective management which would explain the observed pattern.

Accordingly, decisions which are only aligned with one type of knowledge (e.g., the industry recipe) but not with the other (e.g., the business idea) can be anticipated to be more effective than decisions which are aligned with neither of the two. Of the two possible combinations (i.e., of alignment with one type of knowledge but not the other), it is difficult to say which one is worse based on the method that was used in this study. However, this is an interesting question which the objective-driven mode helps to uncover.

Due to the admitted simplification, several disclaimers are warranted to clarify some of the assumptions which underpin this framework. First, this framework pre-supposes the prevalence of this type of knowledge, i.e., about how to and how not to integrate knowledge, relative to the objectives of a firm.[74] Second, the framework pre-supposes that individuals are capable of accumulating a satisficing representation of this knowledge (i.e., a version which is approximately right), given adequate time and effort.[75] If these two assumptions are not true, the proposed framework for effective management obviously becomes unintelligible. Third, the two extremes in the model are primarily illustrative, demarcating the space of possibility for the management of knowledge integration. In practice, perfect alignment of decisions with the business idea and industry recipe appears to be unlikely. First, due to the bounded rationality of individuals (see 2.4.1.1). Second, due to the difficulty of communicating a high-resolution representation of the business idea and industry recipe within a firm (see 4.5.5.3). Third, and part of the problem of communication, due to the continuous evolution and growth of this knowledge (see 4.5.6).

Interestingly, the feature that the business idea and industry recipe can be perceived as kinds of specializations (see 5.2.3.1), i.e., knowledge which can vary in depth and accuracy, amplifies the importance of efforts to communicate this knowledge within a firm, according to this framework for effective management. This since the

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[74] Referred to as the business idea and the industry recipe in this chapter, see 5.2.1.

[75] As was clarified in 5.2.1.4 regarding the recipe-metaphor, the knowledge underpinning the business idea and industry recipe are *not* truth claims about how economic benefit can be achieved. I.e., this knowledge can vary in depth and accuracy.

expected difference between the two extremes in the framework (i.e., the most effective and least effective management) then would increase as a function of an individual's depth of this knowledge (i.e., about the business idea and industry recipe). Accordingly, if there would be little or no variation in individuals' understanding of this knowledge, this would lead to small differences between better or worse management of knowledge integration in the proposed framework.

Lastly, the framework also explains why application of an erroneous or flawed understanding of this knowledge (see 4.5.5.2) does not lead to effective management, i.e., as this corresponds to decisions which are not aligned with the business idea and industry recipe. This is an additional argument for communication efforts, in that it then becomes beneficial to replace a poor understanding of the business idea and industry recipe with a less poor understanding of the business idea and industry recipe (cf. 5.2.1.4). This implication is quite logical and would explain the observed pattern in the study; see 4.5.5.3 in particular.

5.2.3.3 Comparison with the expected pattern

While this analysis of the empirical material may appear to be common sense for any practitioner of strategy and management, the resulting conception of effective management targets a gap which is not sufficiently addressed in the preliminary framework. In comparison with the expected pattern for how objectives may influence knowledge integration (see 2.5.7), this analysis advances our understanding in multiple ways.

Starting with integration of knowledge to solve problems which require multiple types of knowledge (see 2.5.7.2), the analysis in this section builds on previous research that suggest that a type of problem requires the corresponding type of knowledge (Burgers et al., 2008; Court, 1997; Frishammar et al., 2012; Ramesh & Tiwana, 1999; Tanriverdi & Venkatraman, 2005; Tiwana, 2004). The business idea and industry recipe were invoked (see 5.2.1) to capture the phenomenon that was observed to occur at the intersection of all three categories of knowledge (see 5.2.2). Consequently, I would argue that the resulting conception of effective management (alignment of decisions with the business idea and industry recipe) is grounded in a knowledge integration framework (i.e., in accordance with 2.5.7.2), i.e., and not just a 'raw' application of the original work on the business idea and industry recipe. This finding is, hence, significantly different from how most contributions on knowledge integration have framed the issue (cf. the characteristic-driven mode). In particular, the commercial dimension of knowledge integration and the purpose of economic benefit are much more emphasized in this proposed conception of effective management.

Another part of the expected pattern proposed that management is effective relative to a firm's objectives (see 2.5.7.1). Although grounded in the definition of knowledge integration as a 'purposeful combination' of knowledge (see 2.1.1), this proposition was not very substantiated by previous research (Berggren, Bergek, Bengtsson, & Söderlund, 2011; Simon, 1947; Tell et al., 2017a; Werr & Runsten, 2013; Willem et al., 2008). The findings in this section (5.2.3) develop this part of the preliminary framework by proposing that management, relative to the firm's objectives, can be described through the alignment of decisions with the knowledge underpinning the business idea and industry recipe. Also, the proposed interpretation corroborates the suggestion by Werr and Runsten (2013) that individuals' mental representation of a task may facilitate coordination and collaboration (cf. motivation). Similarly, Drucker (1954), introduced in 5.2.1.1, made a related argument about the importance of alignment between decisions and the objectives of a firm which supports this view:

> Each member of the enterprise contributes something different, but they must all contribute toward a common goal. Their efforts must all pull in the same direction, and their contributions must fit together to produce a whole – without gaps, without friction, without unnecessary duplication of effort. (Drucker, 2010, p. 125)

However, the finding in this study is significantly more specific than the preliminary framework. For example, by suggesting that the business idea and industry recipe are types of *knowledge* which individuals can mobilize (i.e., as a type of specialization) to integrate knowledge, relative to the objectives of a firm (Drucker, 1954; Hedman & Kalling, 2002, 2003; Magretta, 2002; Martins et al., 2015; Massa et al., 2017; Normann, 1975; Tikkanen et al., 2005). Neither of these concepts were salient in the preliminary framework.

The finding that the depth of this knowledge is not evenly (or randomly) distributed across the organization, however, is akin to the view presented in the expected pattern (Runsten & Werr, 2020; Werr & Runsten, 2013). In the study, it was observed that individuals in senior management generally appeared to have a deep understanding of this knowledge (see 4.5.2 and 4.5.5.3). This pattern is also echoed among contributions on business model schema, such as Sund et al. (2020), and in the work by Drucker (1954, 1988). Drucker, for example, suggested that:

> The second challenge that management faces is giving its organization of specialists a common vision, a view of the whole. […] It needs a view of the whole and a focus on the whole to be shared among a great many of its professional specialists, certainly among the senior ones. (Drucker, 1988, p. 51)

However, what was not emphasized in the preliminary framework (see 2.5.7.1 and 2.5.4.3) was that it was also observed that individuals at lower levels of the firm (middle-management or regular employees) could have a deep understanding of this knowledge if part of their responsibility was to solve the type of interdependent problems, which were described in 4.5.1. Accumulation of this knowledge about how the pieces of the puzzle were supposed to fit together, hence, was not merely a function of seniority, but also a matter of exposure to strategic problems.

Furthermore, the proposed framework also improves our understanding of the generic objectives, which require knowledge integration. This refers to the objectives which require integration of knowledge that were outlined in 2.3.1, such as to deliver an offering to the market and to complete this objective within certain time and resources constraints. In the preliminary framework, there were few references which substantiated these quite obvious influences on how firms approach problem-solving. The proposed conception of effective management of knowledge integration advances this part of the expected pattern in several ways. First, the literature on business models (e.g., Amit & Zott, 2001; Hedman & Kalling, 2003; Johnson et al., 2008) provides a more solid foundation for the *offering* in the context of knowledge integration (cf. Wikström & Normann (1994) in the preliminary framework). Second, Porter's competitive forces framework (Porter, 1980, 1991) provides a more solid foundation for constraints in terms of time and resources, i.e., which currently lack references to the obvious root cause (i.e., competition).

In terms of differences between problems related to natural versus social phenomena (see 2.5.7.3), the results in the study confirmed the expected pattern. In 4.5.5.3, it was, for example, discussed how a cost-benefit logic underpinned decisions about the degree of accuracy in efforts to communicate knowledge underpinning the business idea and industry recipe. Consistent with the preliminary framework, technological problems (see 4.3.1) were observed to not be malleable to social construction; rather, they had to be solved according to the laws of nature, i.e., those that govern how a car can be made to drive by itself. Correspondingly, organizational problems and commercial problems appeared to permit more individual discretion and involve multiple, potentially satisficing solutions.

An additional perspective (not mentioned in the preliminary framework), which was found useful to make sense of alignment or discrepancy between the business idea/industry recipe and individual decision-making, was Mintzberg's seminal work on strategy as *"a pattern in a stream of decisions"* (Mintzberg, 1978, p. 935). This view is referenced in several contributions which were introduced in 5.2.1 (e.g., Demil & Lecocq, 2010; Gibe & Kalling, 2019; Hedman & Kalling, 2003). In this work, Mintzberg (1978) makes a distinction between strategy as a plan (an *'intended strategy'*) and strategy in practice (a *'realized strategy'*) (Mintzberg, 1978, p. 945). Through this perspective, the decisions that were made by individuals at Omega can be perceived as a type of *de facto* enactment of Omega's business idea and the recipe for the industry in which Omega was competing. As will become clear in forthcoming 5.2.4 and 5.2.5, this view also illuminates the process by which the business idea and industry recipe evolves, e.g., the distinction between, 'unrealized,' 'deliberate,' and 'emergent' strategy in Mintzberg (1978, p. 945).

Lastly, the proposed framework contradicts part of Spender's (1989) assertion that a recipe *"is a rationality indicating how it is reasonable to think. It carries no message about how strategy should be implemented"* (Spender, 1989, p. 183). However, this claim by Spender was nested in a two-step model of the managerial process which was inspired by Thompson (1967): first choices about 'policy and strategy' and second, 'implementation' (Spender, 1989, p. 191). To be fair, Spender suggested that a recipe may guide the first step by stating that *"the recipe is crucial to the formation of strategy"* (Spender, 1989, p. 60). The observed pattern in this study, however, contradicts the proposition that a recipe does not carry a message about how a strategy should be implemented (i.e., the second step). In fact, this whole section (5.2.3) can be summarized by the opposite claim, namely that the business idea and industry recipe carry the message about how strategy should be implemented in a particular firm and industry. See, for example, 4.5.2 and literature, which was introduced in 5.2.1.1 (e.g., Doz & Kosonen, 2010; Drucker, 1954; Gibe & Kalling, 2019; Martins et al., 2015; Normann, 1975; Sund et al., 2020).

5.2.3.4 Normative implications for management of knowledge integration

The framework proposed in 5.2.3.2 is not only a novel theoretical explanation of the management of knowledge integration, but it carries several normative implications for practitioners of strategy and management. In summary, knowledge integration, which requires a *decentralized* organization structure, appears to benefit more from efforts to communicate the business idea and industry recipe.

This claim is grounded in the expectation that knowledge integration to solve difficult problems (cf. 2.5.1) might benefit from a decentralized organization structure (Enberg, 2007; Mintzberg, 1979; Ravasi & Verona, 2001; Takeuchi & Nonaka, 1986). For example, it was recognized at Omega that it was impractical to transfer all important knowledge to the top of a hierarchy (i.e., to enable a select few individuals to make all decisions of importance) when the knowledge in question was too deep, involved too many different specializations, and was predominantly tacit (M. T. Hansen, 1999; Szulanski, 1996; von Hippel, 1994). The conundrum, narrated by Eton, about when two specialists disagree, is illustrative of this point (see 4.8.2.3).

A ripple-effect from the employment of a decentralized structure is that it exposes more individuals to make decisions of strategic importance, i.e., relative to a centralized structure (see 4.5.5.3). At Omega, this was a result of the philosophy of allocating decision mandates to the individuals that are most endowed with the requisite knowledge (see, for example, 4.3.1.2). Consequently, however, it appears that more individuals need an understanding of the business idea and industry recipe of this type of decentralized structure than a centralized organization structure, i.e., to enable these individuals to make decisions that are aligned with the objectives of the firm (see 5.2.3.2). This quite basic relationship was not discussed in the preliminary framework but seems quite relevant to clarify for practitioners of strategy and management, since it indicates two rules-of-thumb. First, as was stated in the summary, more efforts to communicate (cf. 'transfer') the business idea and industry recipe appear to be warranted in settings with high problem difficulty. Second, efforts to communicate the business idea and industry recipe, accordingly, do not appear to be as justified in settings characterized by low problem difficulty, e.g., routine work (i.e., high frequency, low heterogeneity) or mundane tasks (i.e., low complexity, uncertainty, specialization, differentiation, and so forth), i.e., where a centralized organization structure, typically, is considered appropriate (Grandori, 2001; Grant, 1996b; Nickerson & Zenger, 2004; Ravasi & Verona, 2001; Zollo & Winter, 2002).

Several practical questions can be highlighted. The first question is *how much* effort should be invested in communication of the business idea and industry recipe? Generally, a higher level of effort by the sender seemed to yield a representation of the business idea and industry recipe with less room for interpretation for the receiver. This trade-off, cf. *cost-benefit* (L. Bengtsson et al., 2017; Grandori, 2001; Werr & Runsten, 2013), was described in 4.5.5.3 using the metaphors of 'low-resolution' and 'high-resolution.' To decide how much effort to invest, the specific recommendation to practitioners is to apply what is known about the characteristic-driven mode (see 5.1.1.1) to facilitate a better understanding of the problem in question.

A second question is which *methods* should be employed in communication (cf. transfer) of this kind of knowledge? Multiple methods (cf. mechanisms) were observed at Omega. For example, it was observed how this knowledge can be communicated top-down (from top management to employees), co-formulated between individuals from multiple layers in the organization, and shared peer-to-peer (see 4.5.5.3). In terms of which method to apply in a given situation, the results of this study indicated that this depends on the characteristics in play (i.e., the same recommendation as to how much effort to invest). For example, low trust between employees and the management team (cf. Bhandar et al., 2007; Newell et al., 2004; Zahra et al., 2020) appears to make it less likely that the top-down approach will be especially successful (see 4.6.1 and 4.6.3).

A third question is *who* should be involved? This question is relevant both concerning the formulation of content and the communication of this content. Importantly, decisions about whom to involve have implications for the scope of knowledge, which can be combined (given bounded rationality of individuals; see 2.4.1.1). For example, this means that top-down communication may be improved by involving certain individuals who are not part of the management team in the formulation process.

A different angle on how the findings in this section (5.2.3) can be applied by practitioners of strategy and management is to consider application of the business idea and industry recipe in various product development methodologies. For example, Burgers et al. (2008) argued that there are benefits from the integration of commercial knowledge early in such processes, and Eslami and Lakemond (2016) made a similar point regarding knowledge about customer's (technological) problems to solve. The implications from the framework in 5.2.3.2 is similar but slightly different. Rather than focusing on the timing of interventions (cf. Burgers et al., 2008; Eslami & Lakemond, 2016), the emphasis should be on choices related to the level of effort, method, and which individuals to involve (see above). Simply put, there is no checkpoint in either stage-gate (Cooper, 1990, 2008; Cooper & Sommer, 2016) and agile (Annosi et al., 2020; Beck et al., 2001; Bredin et al., 2017; Takeuchi & Nonaka, 1986), where it appears to be superior to only consider one or two of the three types of knowledge. As was outlined in 5.2.2, the business idea and industry recipe are produced by combining all three types of knowledge. This view hence builds on, rather than contradicts, the expected pattern in the preliminary framework, such as that it is productive to consider commercial knowledge early in technological development processes (Burgers et al., 2008; Eslami & Lakemond, 2016).

5.2.4 Business idea evolution

The former sections (5.2.1–5.2.3) have foremost concerned the *application* of firm-specific and industry-specific knowledge about how to benefit economically from knowledge integration. Of course, such knowledge does not appear out of thin air but have at some point been created by individuals (cf. 2.4.2.1). This growth of knowledge can be understood as a process of *evolution*, in which a new understanding is influenced by and builds on previous knowledge. Hence, akin to how 'natural selection' favors certain adaptations, one can imagine how evolution of knowledge is exposed to the circumstances in play (for example, its trajectory and rate of change). The term 'evolution' is, hence, a suitable choice to describe this process, although there are alternative terms with similar connotations that could have been used as well.[76]

This view is commensurate with the assumption in knowledge integration theory that the process of solving a problem is exposed to internal and external circumstances.[77] For example, regarding knowledge creation, Nonaka and Toyama (2003) argued that *"knowledge is created through the synthesis of the contradictions between the organization's internal resources and the environment"* and that strategy consequently *"can be conceptualized as a combination of internal resources as well as environmental adjustment"* (Nonaka & Toyama, 2003, p. 4).

[76] Such as 'development,' 'growth,' or 'innovation.' Especially the latter ('innovation') is, however, laden with a very distinctive theoretical baggage. This makes it pertinent to employ a more descriptive term, i.e., such as 'evolution,' which positions changes in this knowledge as products of a *process*.

[77] Compare with inspiration from contingency theory (e.g., Lawrence & Lorsch, 1967; Thompson, 1967; Woodward, 1958, 1965) in the preliminary framework (Brusoni et al., 2021; Enberg, 2007; Enberg et al., 2010; Grant, 1996b; M. T. Hansen, 1999; Tell, 2011).

The logic underpinning the analysis in forthcoming sections is quite conventional: as circumstances change, the knowledge about how to achieve a set of objectives, such as to benefit economically from knowledge integration, must be updated. Following this rationale, this section (5.2.4) will deal with the phenomenon of *business idea evolution*, and the next section (5.2.5) will deal with the phenomenon *industry recipe evolution*, which are two completely new concepts, relative to the preliminary framework.

5.2.4.1 Defining business idea evolution

There was substantial support in the empirical material for the evolution of Omega's business idea (see 4.5.6.1). Rather than a static phenomenon, the business idea of Omega appeared to be open to revision. However, it would not be accurate to depict this knowledge as fluid. Rather, certain parts of the business idea appeared to have crystallized during the process, such as when the decision was made to launch the joint venture (see 4.2.5). After this moment in time, there were parts of the business idea which did not appear to be subject to much change. For example, the decision to prioritize development of both ADAS and AD persisted throughout the case study-period (see 4.5.5.2).

Inspired by the definition of the business idea, which was proposed in 5.2.1.3, the concept of *business idea evolution* will be defined as *the development and integration of firm-specific knowledge about how to benefit economically from knowledge integration*. The emphasis on both 'development' and 'integration' is relevant to distinguish evolution of the business idea from a mere creation of new knowledge.[78] For example, 'innovation' is similarly often distinguished from 'invention' based on the same criteria (Damanpour, 1991; Schumpeter, 1939).

5.2.4.2 Review of literature on business idea evolution

Although the proposed concept is a novel term, phenomena which are akin to business idea evolution, at least partly, have been observed and discussed in prior research. For example, there is, on the surface, a clear resemblance between 'business idea evolution' and work on 'business model innovation.' Before outlining a framework for the process of business idea evolution (see upcoming 5.2.4.3), a review of literature which contribute to a foundation for this concept will thus be discussed.

First, there are some grounds for the concept of business idea evolution within the literature on the business idea (Gibe & Kalling, 2019; Hedman & Kalling, 2003, 2003; Normann, 1975). Normann (1975), for example, describes how a business idea may be subject to 'successive redefinition,' albeit it refrains from employing a

[78] The same distinction is made by Normann: *"The business idea does not exist until it has been realized; an untried idea about where or how money can be earned is no business idea; it may possibly be an idea about business idea"* (Normann, 1977, p. 38).

specific concept to describe this process. The longitudinal dimension of business models, i.e., in which a certain configuration may evolve over time, is also highlighted in the frameworks by Porter (1991) and Hedman and Kalling (2002, 2003). However, the development and integration of a business idea is not the focus of these contributions.

Second, the 'cognitive view' within business model-literature contains multiple references which may inform this concept (e.g., Doz & Kosonen, 2010; Martins et al., 2015; Massa et al., 2017; Sund et al., 2020; Tikkanen et al., 2005). In 5.2.1.1, the similarities between cognitive structures/representations of business models, such as the concept 'business model schema' (Martins et al., 2015; Sund et al., 2020), and the business idea was established. A quite dynamic view of this type of knowledge is clearly present within this literature, often discussed in the context of development and change of business models (cf. business model innovation). Even though the reviewed contributions do not propose a specific concept which is equivalent to the concept of 'business idea evolution,' the support for such a concept, however, is quite strong. Consider, for example, Martins et al. (2015), who discussed 'schema change' and how cognitive processes of individuals (such as analytical reasoning and conceptual combination) can be proactively leveraged to innovate business models. Similarly, Sund et al. (2020) argued that business model innovation is grounded in schema change and proposed that this involves several stages: awareness, exploration, and exploitation (cf. March, 1991).

Furthermore, there are parts of the evolutionary view on business model change which clearly support the concept of business idea evolution in the context of knowledge integration. Sosna et al. (2010), for example, applied an organizational learning perspective on business model innovation to argue that this process can be perceived as *"an initial experiment followed by constant fine tuning based on trial-and-error learning"* (Sosna et al., 2010, p. 384). Likewise, Tikkanen et al. (2005) discussed how the material and cognitive components of a business model *"changes through incremental mutations – whether intentional or purely evolutionary"* (Tikkanen et al., 2005, p. 802).

Demil and Lecocq (2010) argued that the business model of a firm is in a permanent state of disequilibrium and that change (cf. 'evolution') is the 'normal permanent state.' In this view, firms are constantly searching for better ways of utilizing its resources (cf. Penrose, 1959) and the components of a business model (cf. Osterwalder et al., 2005, 2010) are adjusted (foremost incrementally) as new insights emerge about the external environment or the firm's internal operations. Similar to Doz and Kosonen's (2010) concept of strategic agility, Demil and Lecocq (2010) used the term 'dynamic consistency' to describe *"the capability that allows a firm to change its BM while at the same time building and maintaining sustainable performance"* (Demil & Lecocq, 2010, p. 230). Similar to Sund et al. (2020), Winter and Szulanski (2001) invoke the terms 'exploration' and 'exploitation' (March, 1991) to explain the process of business model change. The notion of learning-by-doing was also reflected on by Chesbrough (2010) and McGrath (2010), on their respective discussions of 'experimentation' as a method for business model development. For example, regarding business model design, McGrath (2010) pointed out that *"it is nearly impossible to tell in advance which design will win"* (McGrath, 2010, p. 254). In addition to experimentation, Chesbrough (2010) also discussed 'effectuation' and how such activity may be important for the *"cognitive act of reframing the dominant logic of one's business model"* (Chesbrough, 2010, p. 361).[79] Similarly, Bland and Osterwalder (2020) positioned search for insights and testing of hypotheses (cf. 'discovery' and 'validation') as central to the reduction of uncertainty in the execution of nascent business ideas.

Third, there are parts of the literature on business model innovation (Amit & Zott, 2012, 2015; Foss & Saebi, 2017; Gambardella & McGahan, 2010; Schneider & Spieth, 2013; Spieth et al., 2014), which may inform the concept of business idea evolution. Note that several of the previously discussed references on the cognitive and the evolutionary view are simultaneously part of this category (e.g., Chesbrough, 2010; Demil & Lecocq, 2010; Martins et al., 2015; McGrath, 2010; Sosna et al., 2010; Sund et al., 2020). The similarity between business model innovation and business idea evolution (as defined in the context of knowledge integration) is, of course, tangible. For example, Spieth et al. (2014) position the cognitive agenda on business model research, relative to the micro-foundations of dynamic capabilities. Although this is a different mode of explanation than knowledge integration (see the scope of knowledge integration in 1.2.3 and its relationship to 'capabilities'), the resulting picture, for example, with its emphasis on individual decision-making, clearly resembles the notion of business idea evolution as proposed in 5.2.4.1. However, this literature generally takes on a larger and less specific scope than the intended meaning of business idea evolution. See the proposed distinction between the 'business idea' and an actual configuration of a 'business model,' which was discussed in 5.2.1.1. Hence, the concept of 'business idea evolution' is a necessary addition to capture this specific knowledge-dimension of the broader business model innovation-phenomenon, i.e., which also concerns other aspects such as the components and attributes of business models (Chesbrough, 2010; Johnson et al., 2008; Osterwalder et al., 2005; Zott et al., 2011, 2011; Zott & Amit, 2010).

Lastly, a search for literature was conducted to complement the review in 5.2.1.1[80]. The term 'business idea evolution' only appeared once in these contributions

[79] Chesbrough, for example, described that in effectuation processes: *"actors (such as firms or entrepreneurs that create new businesses - and associated business models) do not analyze their environment so much as take actions that create new information that reveals latent possibilities in that environment. In other words, they do not study the market so much as* enact *it"* (Chesbrough, 2010, pp. 360–361).

[80] Searching in databases (Google Scholar and EBSCO) for "business idea evolution" and *""business idea" innovation."*

(Burgers & Sawang, 2011), i.e., which is rather telling about the novelty of the concept in question.[81] Furthermore, this literature was found to foremost concern the early stages of entrepreneurship (Bland & Osterwalder, 2020; Burgers & Sawang, 2011; Grimaldi & Grandi, 2005; Heinonen et al., 2011; S. N. Kaplan et al., 2009; Littunen, 2000; Littunen & Niittykangas, 2010; Littunen & Tohmo, 2003; Obschonka et al., 2010) and/or the assessment of opportunities (Borchert & Rochford, 2017; Der Foo et al., 2005; Kim & Mauborgne, 2000; Maravilhas et al., 2018), which are quite different scopes compared with the phenomenon in question, as presented in 4.5.6 and defined in 5.2.4.1.

In summary, previous research lend some support to the novel concept of business idea evolution, but have previously not used this language nor applied this concept in the context of knowledge integration. Obviously, this concept is completely new, relative to the preliminary framework.

5.2.4.3 A framework for the process of business idea evolution

Based on the observations in the study (see 4.5.6) and using the literature outlined in 5.2.1.1 (introducing the business idea) and in 5.2.4.2 (review of literature on business idea evolution), a framework will be proposed for the process of business idea evolution. This framework will focus on two principal questions: *what* and *how*.

Starting with the question of 'what' is subject to change in business idea evolution, this can be clarified by revisiting the knowledge-foundation of the business idea that was proposed in 5.2.2.1. In this section, it was argued that the business idea represents a synthesis of technological, commercial, and organizational knowledge (see Figure J). Logically, this means that there are only two ways that a business idea can evolve: through development of *new knowledge* which can be synthesized, and through a *new synthesis* (cf. combination) of the three types of knowledge. This view is quite commensurate with the work by Normann (1975), who proposed that a firm's 'dominant ideas' are a *product* of the history of a firm and the personal development of its key individuals. A complementary perspective to the logical division is, hence, that a business idea also represents a combination of acquired wisdom and ongoing learning.

Notably, this description indicates *how* change of the first (new knowledge) or second type (new synthesis) can be achieved. Similar to the evolutionary perspective on business model change (Chesbrough, 2010; Demil & Lecocq, 2010; Magretta, 2002; Martins et al., 2015; McGrath, 2010; Sosna et al., 2010; Tikkanen et al., 2005), both Normann (1975) and Prahalad and Bettis (1986) proposed that

[81] (Bland & Osterwalder, 2020; Borchert & Rochford, 2017; Burgers & Sawang, 2011; Cantù, 2010; Casali et al., 2018; Cavalcante et al., 2011; Der Foo et al., 2005; Grimaldi & Grandi, 2005; Heinonen et al., 2011; S. N. Kaplan et al., 2009; Kim & Mauborgne, 2000; Littunen, 2000; Littunen & Niittykangas, 2010; Littunen & Tohmo, 2003; Maravilhas et al., 2018; Obschonka et al., 2010; Von Auken, 1999)

knowledge about how to benefit economically from circumstances (the 'business idea' and 'dominant logic,' respectively) progresses through *feedback*. Magretta (2002), for example, argued: *"When managers operate consciously from a model of how the entire business system will work, every decision, initiative, and measurement provides valuable feedback"* (Magretta, 2002, p. 88).

In reference to Buckley (1967), Normann (1975) separated 'feedback' into *positive* feedback (which reinforces a deviant pattern through co-measures) and *negative* feedback (which reinforces an established pattern through countermeasures). Prahalad and Bettis (1986) complement this view of feedback by proposing two principal sources for how a 'dominant logic' emerges: 'complex problem solving behavior' (cf. internal feedback) and 'operant conditioning' (cf. external feedback).[82]

Applied together, these two perspectives (positive/negative and internal/external) comprise a credible, albeit crude, framework for how a business idea may evolve through feedback (Demil & Lecocq, 2010; Magretta, 2002; McGrath, 2010; Normann, 1975; Prahalad & Bettis, 1986; Sosna et al., 2010; Tikkanen et al., 2005). This framework appears to explain many of the observations which were presented in Chapter 4 on this topic. For example, the re-organization at the beginning of 2018 was preceded by an analysis of how the current organization structure had not permitted the type of product development which was deemed necessary for Omega to be competitive in the nascent autonomous driving industry (see 4.3.2.2 and 4.5.6.2).

The purpose of this framework, however, is not to imply that all evolution of the business idea is reactive and tentative. In accordance with Martins et al. (2015), the evolution of a business idea can be a product of individual initiatives within the firm, i.e., it is not only a product of responses to external shocks (cf. Prahalad & Bettis, 1986). For example, individuals can focus their attention on certain issues (cf. Ocasio, 2011) and employ various cognitive mechanisms to produce a new understanding (Gavetti & Levinthal, 2000; Gavetti & Rivkin, 2007; Martins et al., 2015). In the study, this was, for example, observed when individuals tried to understand interdependencies (i.e., if-then) between types of problems (see, for example, 4.5.1.3) or determine the likelihood that an activity would produce the desired result (see, for example, 4.5.2). However, *a priori* initiatives do not exist in a vacuum but are, arguably, influenced by what is currently known about the state of play. Such pre-understanding is, in turn, influenced by prior events, i.e., which have provided feedback (Gavetti & Rivkin, 2007). Hence, a potential division between growth of knowledge *a priori* and *ex ante* is somewhat circular. The main point by Martins et al. (2015) is, however, relevant, namely that individuals have the capacity to act proactively.

[82] The term 'operant conditioning' was inspired by the seminal work by Skinner (1953), and here refers to *"reinforcement of a world view by market success"* (Prahalad & Bettis, 1986, p. 492).

In terms of how to apply this framework for business idea evolution in the context of knowledge integration, it may be worth re-iterating that bounded rationality still applies, i.e., as discussed in 2.4.1.1 regarding the nature of individuals. Hence, neither responses to feedback (positive/negative from internal/external sources) nor proactive efforts (e.g., analogical reasoning or deduction) should be understood as expressions of another kind of rationality. It may, thus, be more accurate to describe the evolution of a business idea as driven forward by individual *interpretation* of feedback, i.e., rather than a kind of rational and passive reception of cues. The human condition of bounded rationality, therefore, is a central part of an explanation for why the knowledge underpinning the business idea remains a 'recipe' for satisficing decision-making and not a perfect map of how firms can optimize profits. As the Enlightenment philosopher Immanuel Kant remarked: *"Nothing straight can be constructed from such warped wood as that which man is made of"* (Kant, 1991, p. 46).

Regarding evolution of nascent business ideas, Normann (1975) actually applied another term, namely the *'growth idea.'* The 'growth idea' seems to function as an 'initial experiment,' which then is subject to fine tuning (cf. Bland & Osterwalder, 2020; Sosna et al., 2010). A similar distinction was also detected in the literature on the early stages of entrepreneurship (Cavalcante et al., 2011; Littunen, 2000; Littunen & Niittykangas, 2010; Littunen & Tohmo, 2003) and appears to be relevant, since it highlights potential differences in how to manage business idea evolution in early versus mature stages. For example, Normann (1975) described that the early development stages are subject to other *effectiveness criteria*, namely 'learning' and 'vision development.' In later development stages of a business, where the 'business idea' is the primary conceptual instrument, return on investment/equity is typically the effectiveness criterion (Normann, 1975). A similar view was expressed in Bland and Osterwalder (2020), who argued that the most important problem to address in the early life of a business idea (cf. 'growth idea') is uncertainty-reduction (i.e., rather than return on investment/equity). Normann (1975) also outlined a typical developmental sequence that can be expected for the growth idea (cf. early-stage business idea evolution: the 'spearhead-stage,' the 'development-phase,' 'market penetration,' 'exploitation and stabilization,' and, finally, 'liquidation' or 'successive redefinition of the business idea'). Alternative sequences can also be found in Sosna et al. (2010), Cavalcante et al. (2011), and Spieth et al. (2014). For example, Cavalcante et al. (2011) argued for a lifecycle (consisting of business model creation, extension, revision, and termination) which is quite easy to apply to business idea evolution.

Lastly, there are reasons to differentiate between *incremental* and *radical* business idea evolution. This distinction is very established in the literature on innovation and technology management (Christensen & Rosenbloom, 1995; Dosi, 1982; Tushman & Anderson, 1986) and is also mentioned in some literature on business model innovation. For example, both Demil and Lecocq (2010) and Tikkanen et al. (2005) argue that incremental change is much more common despite more attention typically being directed toward examples of radical change. However, radical change is also part of the spectrum of business idea evolution. Normann, for example, proposed that when the basis of a firm's dominance is disrupted by structural changes (e.g., new technology) in its environment (cf. contingency theory), the firm can choose to *"either gradually wither away; or it will reorient itself radically, developing completely new lines of business; or it will have to try to redefine and reformulate the old, mature business idea"* (Normann, 1977, p. 63). Although the term 'evolution' may imply incremental change, the main point (see also 5.2.4.1) is the growth of this knowledge, not its rate of change.[83]

5.2.4.4 Normative implications for management of business idea evolution

The proposed framework for business idea evolution is only a first attempt to explain the phenomenon which was observed in the study. Nonetheless, a couple of recommendations for practitioners can be suggested based on this new understanding of business idea evolution. First, to manage the process of business idea, evolution appears to depend on *persuasion*. For example, Normann (1975) explained that 'dominant ideas' are the product of a struggle between subjects about which ideas should become accepted and directional for the firm (Normann, 1975, p. 30). Normann, thus, repeatedly emphasized that dominant ideas are also a product of power games and politics, not merely the result of intellectual processes and individual's values (Normann, 1975, p. 30). This view was also reflected in Velu and Stiles (2013). How this particular feature of business idea evolution can be managed will be discussed further in a forthcoming section on persuasion and rhetoric, in relation to relational characteristics (see 5.2.7.1).

Second, given the primacy of feedback (see 5.2.4.3), effective management of business idea evolution appears to involve cultivation of the firm's feedback processes. Normann (1975), for example, outlined several mechanisms: sensing-mechanisms; access to feedback sources with richness in variation (i.e., to enable novel insights);[84] selection mechanisms or criteria to judge which co-measures and countermeasures to employ; and mechanisms to preserve, maintain, and reinforce responses, which (*ex ante*) have proven effective, relative to the criteria for success. This is especially relevant, considering that the new knowledge or synthesis of that knowledge (cf. 5.2.4.3) is likely to be asymmetrically distributed within the firm (see 4.5.6.3). Accordingly, business idea evolution can be expected to be quite an interaction-intensive process, especially so in distributed organization structures (cf. 5.2.3.4).

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[83] However, other authors might be tempted to introduce an additional concept, such as 'business idea revolution,' to describe the complete overhaul of a firm's business idea. A simpler approach, however, is preferred due to the problems of demarcation, i.e., where does one draw the line between evolution and revolution?

[84] Compare with cross-functional collaboration within firms (Brusoni et al., 2021; De Luca & Atuahene-Gima, 2007; Ghoshal et al., 1994; M. T. Hansen, 1999; Nonaka, 1994; Nonaka et al., 2000).

Third, it appears important to manage the process of business idea evolution as a *system*. This feature was emphasized in literature on the business idea (e.g., Drucker, 1954; Hedman & Kalling, 2003; Normann, 1975) and the cognitive view on business models (e.g., Demil & Lecocq, 2010; Doz & Kosonen, 2010; Magretta, 2002; Martins et al., 2015; Tikkanen et al., 2005). For example, Normann (1975) stated: *"Knowledge of markets, technology, organization, the build-up of resources, and so on – all this must be integrated. Otherwise the growth idea may never lead to anything – it will be abortive"* (Normann, 1977, p. 109). Similarly, Tikkanen et al. (2005) emphasized that *"firm processes emerge from each other and their coordination is key to maintaining competitive advantage. The major implication to management is that strongly developing one component of the business model always has network effects to other components"* (Tikkanen et al., 2005, p. 805).

Fourth, Normann (1975) highlighted cultivation of resources. In a knowledge-intensive firm, such as Omega, this appears to foremost be accomplished through practices to develop/retain productive employees and to attract individuals who are deemed likely to become productive to join the firm. This is because individuals are both the main repositories and creators of the knowledge which can be combined (Grant, 1996b), as well as the subjects who act out the processes of persuasion and feedback that were previously outlined (Martins et al., 2015; McGrath, 2010; Normann, 1975; Prahalad & Bettis, 1986; Sosna et al., 2010; Tikkanen et al., 2005).

Fifth and related to the fourth point, management of business idea evolution is likely to differ, depending on the industry (Bettis & Prahalad, 1995; Johansson, 2008; Prahalad & Bettis, 1986; Spender, 1989), e.g., due to the archetypical orientations (market-orientation, production-orientation, and raw material-orientation) of various industries (Normann, 1975). For example, in market-oriented firms, the 'basis for dominance' is related to knowledge about customers and the ability to solve their needs (jobs-to-be-done); moreover, in production-oriented firms, the 'basis for dominance' is related to capital-intensive assets which enable production at scale and at low costs (Normann, 1975, pp. 87–88). Although a very broad proposition, this heuristic is arguably corroborated by the view that different types of knowledge are required to solve different types of problems, which was emphasized in the preliminary framework (see 2.5.7.2) and in the conception of the objective-driven mode (see 5.1.1.1).

5.2.5 Industry recipe evolution

5.2.5.1 Defining industry recipe evolution

As was outlined in 5.2.4, it is possible to conceive the evolution of industry-specific knowledge about how to benefit economically from knowledge integration as a process of *industry recipe evolution*. For example, it was illustrated in 4.5.6.2 how a new recipe was emerging for the nascent automotive driving-industry, which appeared to be a combination of industry-specific knowledge about how to integrate knowledge from various industries effectively (automotive and software in particular). The concept of industry recipe evolution will be defined in the same way as business idea evolution (see 5.2.4.1), i.e., as an extension of the definition of 'industry recipe' in 5.2.1.3. Therefore, industry recipe evolution will be defined as *the development and integration of industry-specific knowledge about how to benefit economically from knowledge integration*.

5.2.5.2 Review of literature on industry recipe evolution

As for business idea evolution (see 5.2.4), there are some similarities between industry recipe evolution and prior research on industry-level change. First, there is some support for the concept of industry recipe evolution in the literature introduced in 5.2.1.2 (Introducing the industry recipe). Spender (1989), who coined the concept of industry recipes, for example, discussed the dynamics of 'recipe change.' In accordance with observations in the study (see 4.5.6.2), Spender (1989) stated that the *"recipe is not a closed formula. It is a rationality which remains open and somewhat ambiguous"* (Spender, 1989, p. 179). In accordance with the conception of industry recipes as knowledge, which is common across participants in an industry (see 5.2.2.3), Spender (1989) also stated that when *"recipes change, they do so because some firm or firms adopt a new rationality which then spreads across the rest of the industry"* (Spender, 1989, p. 180).

Spender (1989) thus positioned the change of recipes as *externally* triggered, by changes in the circumstances of firms (cf. contingency theory (Lawrence & Lorsch, 1967a) and 'operant conditioning' in Prahalad and Bettis (1986)). Similarly, the work by Aspara et al. (2013) on 'inter-organizational cognition' referenced how such knowledge may be subject to external influence, e.g., due to changed expectations among institutional investors (such as from focus on diversification to focus on core-business).

Second, prior work on 'industry structure' and how such structures may be subject to change shares the industry-level of analysis with industry recipe evolution but focuses on the de-facto structure, i.e., not the *knowledge* about this industry structure (Brusoni et al., 2009; De Boer et al., 1999; Nadkarni & Narayanan, 2007; Utterback & Suárez, 1993). This distinction is analogous to the division between the business idea and the actual configuration of a business model (e.g., customer agreements, organizational structures, and the offering a firm brings to the market), which was outlined in 5.2.1.1 and was recycled in the discussion about business idea evolution in 5.2.4 (i.e., relative to business model innovation).

Third, there is literature on different types of innovations which seem to correspond to the different types of problems that were introduced in the preliminary framework (see 2.3.2), such as 'organizational innovation' (Damanpour, 1991; Damanpour & Evan, 1984; Hage, 1999; Lam, 2006b; Wolfe, 1994) and 'technological innovation'

(Abernathy & Clark, 1985; Christensen, 1997; Christensen & Rosenbloom, 1995; Dosi, 1982; Henderson & Clark, 1990; Tushman & Anderson, 1986; Tushman & O'Reilly, 1996). Such contributions may explain parts of the industry recipe evolution-concept but are clearly different in terms of scope. Where industry recipe evolution was observed to encompass all three types of problems (see 5.2.2.3), organizational innovation literature clearly focuses on changes in organizational/administrative arrangements (Damanpour, 1991; Damanpour & Evan, 1984), and technological innovation literature clearly focus on development of technology. Still, interdependencies between types of problems are present in some of this work, for example, implications of new technology in the organizational dimension (e.g., Tushman & Anderson, 1986; Tushman & O'Reilly, 1996) and commercial dimension (e.g., Abernathy & Clark, 1985; Christensen, 1997). Furthermore, there are additional innovation concepts that could be considered to make sense of industry recipe evolution, e.g., product innovation, process innovation, service innovation, marketing innovation, and so on.

Fourth, there are parts of the literature on 'business model innovation,' which inform the meaning of industry recipe evolution. As discussed in 5.2.1.1 (Introducing the business idea), some of the more sophisticated contributions on the business model concept (e.g., Chesbrough & Rosenbloom, 2002; Hedman & Kalling, 2003; Porter, 1991) incorporate linkages between the firm and the industry in which the firm participates. For example, through references to competitive forces (Porter, 1980) and PESTEL (Gibe & Kalling, 2019; Yüksel, 2012). Also, an industry is innately composed of different firms, i.e., a reductionist argument for how to understand industries. In this sense, literature on business models may, hence, enrich our understanding of industry recipe evolution. However, both the concept of business idea evolution (see 5.2.4) and business model innovation (e.g., Cavalcante et al., 2011; Chesbrough, 2010; Demil & Lecocq, 2010; Foss & Saebi, 2017; Gambardella & McGahan, 2010; Martins et al., 2015; Schneider & Spieth, 2013) foremost deal with the *firm-level* of analysis, i.e., versus the *industry-level* of analysis. Thus, neither literature on business model innovation nor the proposed concept of business idea evolution are sufficient to explain industry recipe evolution.

Fifth, a search for literature on 'industry recipe evolution' was conducted but produced no contributions to review. A search for the similar term 'industry recipe innovation' only resulted in a handful of contributions. Most of these contributions, however, do not match the observed phenomenon (see 4.5.6.2). Rather than explaining the process of industry recipe change (cf. Spender, 1989), several of these contributions instead examine how a firm's business model can be divergent (cf. radical innovation), relative to the established industry norm (E. Hansen et al., 2007; Matopoulos & Vlachopoulou, 2008; Matthyssens, 2019; Matthyssens et al., 2006, 2008).

Lastly, there was some support for the concept of industry recipe evolution in the work on 'industry belief systems' (Galvin et al., 2004; Porac et al., 2002; Sneddon et al., 2009; Tikkanen et al., 2005). This literature deals with industry-level knowledge about how an industry functions. For example, the proposition by Tikkanen et al. (2005), namely that the alternatives for structural change are more narrow in mature industries appears to be relevant. This may, for example, explain the urgency at Omega to influence the trajectory of the nascent recipe for AD (see 4.5.6.4). A major difference, however, is that the industry recipe is only one of four components of an industry belief system (the other components are 'product ontologies,' 'boundary beliefs,' and 'reputational rankings'). Consequently, the two concepts should not be applied as synonyms (Porac et al., 2002; Tikkanen et al., 2005).

5.2.5.3 A framework for the process of industry recipe evolution

To construct a framework for the process of industry recipe evolution, several propositions from 5.2.4.3 (A framework for the process of business idea evolution) will be recycled.

Starting with *what* is subject to change, the industry recipe was also proposed to be a synthesis of the three types of knowledge (see 5.2.2.3). Like business idea evolution, the industry recipe, hence, appears to evolve through the development of *new knowledge,* which can be synthesized or through a *new synthesis* (cf. combination) of the three types of knowledge. Like business idea evolution, I would submit that an industry recipe is also a product of history and ongoing learning (cf. Normann, 1975). Due to the method in this study, neither dimension was, however, examined in depth (see 4.5.6.2). It should, thus, be admitted that there is weaker support in the empirical material for this interpretation of industry recipe evolution, i.e., compared with business idea evolution.

In terms of *how* an industry recipe evolves, the same feedback-framework, which was presented in 5.2.4.3, can arguably be applied on the industry-level (Magretta, 2002; McGrath, 2010; Normann, 1975; Prahalad & Bettis, 1986; Sosna et al., 2010; Tikkanen et al., 2005). First, it was proposed that feedback could be *positive* and *negative* (Buckley, 1967; Normann, 1975). For example, Omega's adoption of a divergent product development method (see 4.3.2.2 and 4.5.6.2) provided a type of positive feedback for other participants in the emerging AD industry, i.e., that it may be possible to act against conventional wisdom in the automotive industry. Conversely, the skeptical response by potential OEM customers to Omega's attempt to introduce a subscription revenue model (see 4.3.3.2 and 4.5.6.2) can be interpreted as a kind of negative feedback, i.e., discouraging efforts to break norms and go against the logic of the current automotive industry.

Second, the source of feedback can be *internal* or *external* (Prahalad & Bettis, 1986). This proposition was also consistent with observations of industry recipe evolution in the study. For example, part of the change in the emerging recipe appeared to come from *within* firms, such as internally generated learnings from Omega's confrontation with various problems to be solved. Through interaction with the external environment (e.g., efforts to persuade other industry participants; see 4.5.6.4), such internally generated learnings were then diffused and could potentially alter the trajectory of the emerging industry recipe. Another example, in the opposite direction, was that Omega paid significant attention to competitors' results from real-world tests of AD (i.e., which were products of internal learning).[85]

Part of the feedback also appeared to originate in changes in the external environment (cf. Aspara et al., 2013; Spender, 1989), i.e., not as a product of internal problem-solving within Omega or its competitors. For example, there were changes in the regulatory situation for large-scale testing of AD during the study (cf. Yüksel, 2012). Another example of such feedback was the media attention that followed a traffic accident involving AD/ADAS technology, which appeared to put the question of social acceptance for AD technology in the spotlight (cf. Yüksel, 2012).

5.2.5.4 Normative implications for management of industry recipe evolution

Many of the implications for management of business idea evolution (see 5.2.4.4) appear to apply to industry recipe evolution. For example, how to cultivate feedback processes (Buckley, 1967; Normann, 1975) appears to be as relevant to the industry recipe evolution as the business idea evolution. The synthesis-conception of the industry recipe (see 5.2.2.3) also makes it important to relate to this type of knowledge growth as a *system*, rather than to focus on individual types of problems (i.e., technological, organizational, and commercial; see 5.2.2.4).

Persuasion also appears to be central for industry recipe evolution, albeit in another way than for business idea evolution (see 5.2.4.4). Specifically, industry recipe evolution foremost requires *external* persuasion efforts, since the industry recipe represents knowledge which is distributed across participants in an industry (see 4.5.6.4 and 5.2.2.3). In instances where a firm is deemed to benefit from a certain trajectory, the findings suggest that this firm should then invest efforts to influence other industry participants. The mechanisms which were employed by Omega for this end (see 4.5.6.4) may provide some practical guidance. Regarding the cost-benefit trade-off of such mechanisms, efforts to influence the trajectory of an industry recipe appear to have a higher pay-off in nascent rather than mature industries. This was both indicated in the empirical material (see 4.5.6.2) and in the literature (Bettis & Prahalad, 1995; Prahalad & Bettis, 1986; Tikkanen et al., 2005).

The point about cultivation of resources (see 5.2.4.4) is also applicable to industry recipe evolution. First, grounded in logic (if-then) rather than empirical data, if the previously outlined recommendations are pertinent (persuasion, cultivation of feedback processes, and to manage knowledge growth as a system), then cultivation

[85] For example, the Californian DMV published ‘disengagement reports’ for all firms that were registered to test self-driving vehicles in California. These reports disclosed how frequently human operators were forced to intervene to take control of the vehicle (i.e., that the system was ‘disengaged’ from autonomous mode) and the distance driven by all registered firms

of resources that are significant for such responses would facilitate management of industry recipe evolution. For example, one can imagine that persuasion efforts could be facilitated by hiring a renowned expert or senior executive.

A second perspective on cultivation of resources is that it might be possible to leverage *spillover* from active participation in industry recipe evolution. Insights about an emerging industry recipe, i.e., which are acquired through active participation, for example, may indicate which resources are likely to appreciate or depreciate in importance within a certain industry. For example, at Omega, judgments about the trajectory of industries (i.e., that the automotive industry likely would become more influenced by a software development-logic) appeared to support the decision to recruit individuals with specific competences, such as specialists in artificial intelligence (see 4.5.1.2). Thus, efforts to be at the forefront of industry recipe evolution appear to be conducive to business idea evolution, hence the notion of 'spillover.'

5.2.6 Toward a more strategic perspective on knowledge integration: a two-way street

Taking a step back and analyzing the findings that have been presented thus far in this chapter (5.2.1–5.2.5), a new pattern emerges which was not expected at the outset of this study. These findings also appear to say something profound about the fit between knowledge integration theory and the strategy concepts, which were introduced in 5.2.1. In this section, I propose that this relationship may be a two-way street, of mutual benefit for the respective domain of literature. First, how knowledge integration theory benefits from application of the strategic management theory, which was introduced, will be discussed. Second, there will be a discussion on how the findings about knowledge integration theory in this study, in turn, may contribute to the domain of strategy, with a particular emphasis on business model literature.

5.2.6.1 How the additional strategy literature contributes to knowledge integration theory

Starting with how the additional strategy literature contributes to knowledge integration theory, the findings in this study address several of the theoretical problems which were highlighted in the introduction chapter (see 1.4.3). To invoke additional literature on strategy (see 5.2.1) was central to the development of the findings in this chapter (see 5.2.2–5.2.5). It was through iteration between the empirical material and further reading of strategy literature (cf. 3.2) that it was discovered how some of these contributions (i.e., on the business idea and industry recipe) could be applied in combination with knowledge integration theory. Because of this abductive approach, there is arguably some basis for analytical generalization of these findings (Alvesson & Sköldberg, 2009; Eisenhardt, 1989b; Gioia et al., 2013; Yin, 2009).

The additional strategy literature contributed to the findings in this study in three main ways. First, a more comprehensive understanding of the *commercial* dimension of knowledge integration (see 1.4.3.1) has arguably been presented through the application of theory about firm-specific knowledge and industry-specific knowledge about how to achieve the objectives of a firm (i.e., as introduced in 5.2.1). For example, the influence of initial conditions (Barney, 1991; Hedman & Kalling, 2003; Peteraf, 1993; Porter, 1991) and the dynamics of competition (Hedman & Kalling, 2003; Porter, 1980, 1991; Spender, 1989) are difficult to explain through the preliminary framework (e.g., 2.3.1 and 2.5.6.4) but have become more intelligible through the approach in this chapter.

Second, the issue of *interdependencies* between different types of problems (see 1.4.3.2) also appears to have been resolved by the introduction of theory about the business idea and the industry recipe. Through an analysis of degrees of overlap between different types of problems (see 5.2.2), it was demonstrated how the simultaneous application (cf. 'synthesis') of all three categories of knowledge was a mechanism which individuals could mobilize to make decisions that were aligned with the objectives of Omega (see 5.2.3). This is arguably a more satisfying explanation for the question of whether or not there is a systemic interplay between the categories of problems (see 1.4.3.2). Specifically, several authors in the additional literature (e.g., Chesbrough & Rosenbloom, 2002; Demil & Lecocq, 2010; Drucker, 1954; Gibe & Kalling, 2019; Hedman & Kalling, 2002, 2003; Magretta, 2002; Martins et al., 2015; Normann, 1975; Porter, 1991; Spender, 2014; Tikkanen et al., 2005) provided an explanation for the root cause of systems of problems, which the preliminary framework (see e.g., 2.3.2.9) did not sufficiently address (e.g., Burgers et al., 2008; De Luca & Atuahene-Gima, 2007; Salunke et al., 2019; Sanchez & Mahoney, 1996; Tanriverdi & Venkatraman, 2005; Tiwana, 2004; Tsoukas, 1996; Wikström & Normann, 1994).

Third, the introduced strategy literature also contributed to our understanding of the management of knowledge integration through its emphasis on the strategic context of firms (see 5.1.2.2), i.e., the objectives and the circumstances for achieving those objectives. In contrast, the pre-understanding of management of knowledge integration, in the preliminary framework, was foremost derived from work on the characteristic-driven mode (cf. 5.1.1.1). This type of literature (see 2.5.1–2.5.6) (e.g., Grandori, 2001; Grant, 1996; Tell, 2011) generally does not invoke theory regarding the commercial dimension (e.g., competition) nor interdependencies between categories of problems in its explanation. Hence, they are the two theoretical problems which were discussed previously in this section.

In summary, and in the language of the purpose of this study (see 1.5), which is how knowledge integration is influenced by the objectives of a firm, becomes more intelligible by applying certain strategy theory (see 5.2.1) within a knowledge integration framework (see 2.7). The resulting combination is a more strategic perspective on knowledge integration, which arguably improves our understanding of the management of knowledge integration.

5.2.6.2 How knowledge integration theory may contribute to the business model literature

To develop the literature on the business model-concept was *not* part of the purpose of this study. Nonetheless, the analysis in this chapter appears to say something about how knowledge integration theory may contribute to our understanding of the business model-concept (i.e., the converse relationship, relative to 5.2.6.1). Although unintended, it is still relevant to examine this suspicion. For example, it is an important quality of abductive methods to be sensitive about unexpected findings (cf. 3.2). Also, logically, a better understanding of the strategy theories in question (see 5.2.1) would be beneficial for our understanding of knowledge integration theory, i.e., due to the arguments presented in 5.2.6.1 (how this additional strategy theory contributes to knowledge integration theory).

Specifically, the business model-concept (Hedman & Kalling, 2003, 2003; Johnson et al., 2008; Chesbrough & Rosenbloom, 2002; Amit & Zott, 2001; Osterwalder et al., 2005, 2010; Massa et al., 2017) appears to have a soft spot which could be addressed through knowledge integration theory. A fitting starting point for this discussion is the division between the cross-sectional problem and the longitudinal problem, which is central to Porter (1991) and the subsequent work by Hedman and Kalling (2003). According to Hedman and Kalling (2003), to highlight the *longitudinal problem* enables the strategy-process perspective (e.g., Chakravarthy & Doz, 1992; Mintzberg, 1978) to be integrated into a business model framework, *"to cover the dynamics of the business model over time and the cognitive and cultural constraints that managers have to cope with"* (Hedman & Kalling, 2003, p. 53).

However, this development toward a more complete framework also prompts new questions about the *nature* of that longitudinal dimension. Hence, how should the process by which the business model is enacted and evolves be conceptualized and explained? Through iteration between the business model literature and the empirical material, an alternative understanding of this question emerged, which, to my knowledge, has not been discussed in business model literature: the longitudinal process by which the business model is acted out and evolves can be interpreted as *a process of knowledge integration*.

Arguably, there is support for this view in the literature on business models as cognitive or linguistic representations of how a business functions (Baden-Fuller & Morgan, 2010; Chesbrough & Rosenbloom, 2002; Doz & Kosonen, 2010; Magretta, 2002; Martins et al., 2015; Massa et al., 2017; Sosna et al., 2010; Spender, 2014c; Sund et al., 2020). For example, several authors acknowledge that business models change as a consequence of changes in cognitive structures, representations, or schema (Demil & Lecocq, 2010; Martins et al., 2015; Sosna et al., 2010; Sund et al., 2020). A business model, thus, can be perceived as a product of knowledge combination, if one accepts the proposition that individual knowledge underpins a specific cognitive schema or representation, which is one of the ontological assumptions that is distinctive for knowledge integration theory (outlined in 1.2.3).

Neither the general literature on business models nor the more specific literature on business models as cognitive representations, structures, or schema, however, explicitly reference or apply knowledge integration theory to explain this process. In terms of fit, I would argue that the business model concept is very compatible with knowledge integration theory. The feature of conceiving process outputs as products of knowledge integration (see 1.2.3 and 2.1), for example, is also present in the work by Porter (1991), who argued that 'initial conditions' are products of earlier 'managerial choices':

> Lying behind all initial conditions internal to the firm were earlier managerial choices. The skills and market position a firm has built today are the result of past choices about how to configure activities and what skills to create or acquire. (Porter, 1991, p. 106)

The quote by Hedman and Kalling (2002, p. 95) in 5.2.1.1 that knowledge is the 'vehicle' by which business models and firms evolve displays a similar logic, i.e., that a business model might be a product of a purposeful combination of knowledge, to paraphrase Tell et al. (2017a) and Berggren, Bergek, Bengtsson, & Söderlund (2011). Furthermore, there are multiple references in 5.2.1 (Chesbrough & Rosenbloom, 2002; Demil & Lecocq, 2010; Magretta, 2002; Martins et al., 2015; McGrath, 2010; Sosna et al., 2010; Tikkanen et al., 2005) which describe how business models evolve through various types of feedback processes. This view also implies the ontological feature of knowledge integration theory, namely that process outputs represent an integration of knowledge (Grant, 1996b; Simon, 1973; Tell et al., 2017a). For example, the 'Learning and Business Model Innovation Process' model in Sosna et al. (2010) includes an output for each process stage (cf. 'What?') which is clearly impregnated by knowledge, e.g., references to 'cognitive maps' (cf. Calori et al., 1994; Fiol & Huff, 1992; Gavetti & Levinthal, 2000) and 'congenital learning' (cf. Huber, 1991). In terms of compatibility, there appears to be few obstacles to an application of knowledge integration theory within a business model framework, i.e., to make the 'longitudinal' dimension of business models more intelligible (Gibe & Kalling, 2019; Hedman & Kalling, 2003; Porter, 1991).

It can also be interpreted that there is some support for this view in the preliminary framework. Specifically, Wikström and Normann (1994) hinted at a similar relationship between knowledge integration and a firm's offering: *"the offering to the customer (the product and/or the service) will be a manifestation of the information,* *the skill and the theoretical knowledge which the company possesses in order to be able to supply that offering"* (Wikström & Normann, 1994, p. 102). Accordingly, if the offering which a firm brings to the market is a manifestation (cf. an 'integration') of the knowledge residing in the firm, then the process of combining that knowledge could be considered the 'longitudinal' problem/dimension (cf. Hedman & Kalling, 2003; Porter, 1991). Another relevant suggestion may be detected in Cestino and Matthews (2016), in their contribution on path dependence of business models. In this work (Cestino & Matthews, 2016), knowledge integration is positioned as a kind of explanation of path dependence of knowledge (cf. Berggren et al., 2017) and organizational persistence (cf. Sydow et al., 2009).

Beyond Wikström and Normann (1994) and Cestino and Matthews (2016), the reviewed knowledge integration theory is however quite void of consequential references that would support the proposed conception of the 'longitudinal' dimension of business models as a process of knowledge integration. For example, Bashir and Farooq (2019), one of the few contributions which explicitly references the business model concept, is merely a literature review that suggests hypotheses about a relationship between knowledge management, business model innovation and firm competence. In Demarest (1997), the term 'business model' is used twice but only in reference to the degree of re-use of knowledge in a firm's offering (cf. Tanriverdi & Venkatraman, 2005). In Burgers et al. (2008), the term 'business model' is used fleetingly, on the one hand, as a type of market knowledge, and, on the other hand, as a revenue model (cf. Johnson et al., 2008). In Brusoni et al. (2021), to develop and implement alternative 'business models' is mentioned only once, as a means *"to profit from a given technology or product portfolio"* (Brusoni et al., 2021, p. 1522). Relative to the preliminary framework, the view which is proposed in this section of how knowledge integration theory may develop business model literature is, hence, completely new.

As a last comment, the rationale in this section has similarities with the work by Teece (2010, 2018), who applies literature on 'dynamic capabilities' (Di Stefano et al., 2014; Eisenhardt & Martin, 2000; Teece, 2007; Teece et al., 1997), i.e., instead of knowledge integration theory, to discuss the longitudinal dimension of business models. However, the literature on capabilities is a rival explanation of the phenomenon which knowledge integration theory tries to address, which deviates from the three features that make knowledge integration theory distinct (see 1.2.3). Hence, the main point of this reference to Teece is to further illustrate how there appears to be a demand for an explanation of the longitudinal process within the business model concept.

5.2.6.3 A new relationship

Summarizing both 5.2.6.1 (what the additional strategy literature says about knowledge integration) and 5.2.6.2 (what knowledge integration says about the business model concept), the discovery of the business idea and industry recipe as knowledge-impregnated mechanisms (see 5.2.2 and 5.2.3) connects these domains of strategy literature in a novel way. Knowledge integration theory appears to become more intelligible by applying certain strategy theories (see 5.2.1) within a knowledge integration framework. Conversely, the business model-framework (part of the literature introduced in 5.2.1) appears to become more intelligible by applying knowledge integration theory to explain the longitudinal process through which a business model is acted out and evolves over time.

Due to the single-case design and limited review of strategy literature outside of knowledge integration theory, more research is however needed to further explore these two propositions. This is especially the case for the application of knowledge integration theory in a business model-framework, which was not part of the purpose of this study. Notwithstanding that more work is needed, I would maintain that this finding improves our understanding of the purpose of this study, of how knowledge integration is influenced by the objectives of a firm. Most notably, there appears to be a fit on an ontological-level and epistemological-level between the features of knowledge integration theory (see 1.2.3) and the additional strategy literature which was introduced in 5.2.1. This fit suggests that the approach (i.e., in this study) of integrating these concepts into the revised framework is not a problematic move.

5.2.7 Relational characteristics

The analysis will now focus on findings related to the characteristic-driven mode (see 5.1.1). In summary, it was demonstrated throughout Chapter 4 how the empirical material largely confirmed previous work on relationships between difficulty with integration and problem characteristics (see 4.6–4.8). This was especially the case for task characteristics (see 4.8), such as complexity and uncertainty, and partly the case regarding knowledge characteristics (see 4.7), such as depth of specialization and tacitness. The largest discrepancy, relative to the preliminary framework, was detected in the observed pattern regarding relational characteristics (4.6), which thus will be the starting point for this part of analysis (i.e., related to the characteristic-driven mode).

5.2.7.1 A new interpretation of relational characteristics as factors which influence the process of persuasion

The finding on how the interplay between subjects is characterized by *persuasion* (see 4.4.1.2) will be discussed in depth in the forthcoming 5.3.2. Interestingly, this interpretation of the empirical material also has implications for how to perceive the category of relational characteristics (see 2.5.4), i.e., which essentially describe sources of problem difficulty related to the interplay between individual and group-level subjects (see 2.4).

To summarize the finding that will be discussed in this section, this conception (i.e., of knowledge integration as a process which is driven forward by persuasion of subjects) supports a new interpretation of relational characteristics as underlying factors which influence the process of persuasion between subjects (see Figure L). Interestingly, the empirical material also displayed how the *rhetorical framework* and relational characteristics are compatible and lead to a more satisfying explanation when applied simultaneously.

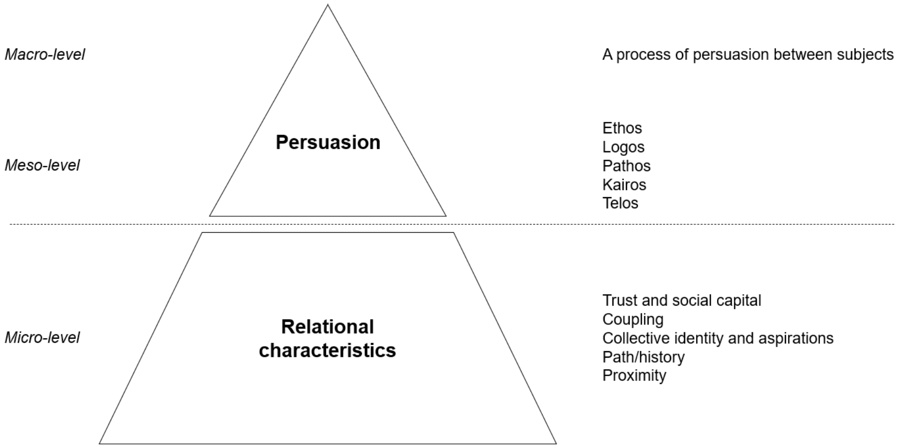

Figure L. Relational characteristics as factors which influence the process of persuasion.

In this proposed conception of persuasion (Spender, 2014a) and relational characteristics (Alavi & Tiwana, 2002; Berggren et al., 2017; Inkpen & Tsang, 2005; Newell et al., 2004; Tell, 2011; Tsai & Ghoshal, 1998), the categories of rhetoric appeals (ethos, logos, pathos, kairos, and telos) occupy somewhat of a 'meso-level' (Kinneavy & Eskin, 2000; Purdue Online Writing Lab, 2022; Rapp, 2022). Hence, they manifest as factors which explain the process of persuasion ('macro-level'), and which can be understood through consideration of relational characteristics ('micro-level'). For example, appeals to *ethos* appeared to be influenced by trust and history (see 4.4.1.2).

Furthermore, *kairos* and *telos* were two types of rhetoric appeals, which the data indicated to be important (Kinneavy & Eskin, 2000; Purdue Online Writing Lab, 2022). *Kairos* supports an interpretation of how temporal and spatial boundaries (Tell, 2017) influence the interplay between subjects. The concept of *telos* notably fits the objective-driven mode of explanation (see 5.1.1) and the definition of knowledge integration (as the *purposeful* combination of knowledge) that is applied in this study (see 2.1.1). Telos also appears to be influenced by the relational characteristic 'collective identity and aspiration' (Bhandar et al., 2007; Newell et al., 2004; Tsai & Ghoshal, 1998; Willem et al., 2008).

Thus, relational characteristics are still valid in this conception but positioned as a 'micro-level' explanation of variation in problem difficulty and subsequent costs for persuasion efforts. An illustrative example was how the hurdle for persuasion appeared to be influenced by the degree of trust between subjects (see 4.6.1). This pattern also appeared to apply to the other relational characteristics. For example, the fluidity of individual responsibility displayed this quality (see 4.6.2), as the organizational arrangements at Omega made individual roles open for interpretation and, in turn, negotiation. The depiction of collective identity and aspiration clearly referenced this feature, i.e., in that individual motivation to act in alignment with Omega's objectives was observed to vary (see 4.6.3). The influence of history and path dependence was likewise observed to have the potential to make persuasion more difficult or simple (see 4.6.4). Lastly, proximity (see 4.6.5) was observed to influence persuasion efforts by facilitating collaboration between individuals (for example, by enabling ad-hoc interactions).

5.2.7.2 Compatibility between the two modes: Collective identity and aspirations as an illustrative example

As was indicated in 4.6.3, a new relationship was detected between the relational characteristic 'collective identity and aspirations' (Bhandar et al., 2007; Newell et al., 2004; Tsai & Ghoshal, 1998; Werr & Runsten, 2013; Willem et al., 2008) and the mechanism of employing the business idea and industry recipe to solve problems, relative to the objectives of Omega (see 5.2.3.2). This observed fit appears to be quite logical, i.e., that coordination and motivation of individuals appear to vary in difficulty, depending on the degree of collective identity and aspiration among subjects (see 4.6.3). Moreover, this is a good illustration of the compatibility of the characteristic-driven and objective-driven mode (see 5.1.1.4). Hence, the characteristic-driven mode helps us understand how the difficulty of solving a problem varies depending on the degree of collective identity and aspiration, and the objective-driven mode helps us understand the mechanism which was employed in response.

5.2.8 Knowledge characteristics

5.2.8.1 A division of knowledge locus into two distinct knowledge characteristics: absence/existence of knowledge and internal/external knowledge

The empirical material (see 4.7.6) was unequivocally in favor of dividing the 'locus' of knowledge into two separate knowledge characteristics:

- *absence/existence* of knowledge and
- internal/external *locus* of knowledge

This distinction was identified in the literature review (see 2.5.3.6). However, more attention has previously been directed toward implications of internal/external locus of knowledge (e.g., Becker & Zirpoli, 2003; Grant & Baden-Fuller, 2004; Mitchell, 2006; Tell, 2011) than that of absence of knowledge (Kraaijenbrink et al., 2010; Spender, 2008, 2014a). In fact, one might even argue that it was a stretch to include knowledge absence in the preliminary framework in the first place, given the lack of references to this characteristic in the reviewed literature. In any case, the empirical material clearly demonstrated how these two aspects can be considered as separate knowledge characteristics with their own expected implications for problem difficulty. This is a development, relative to the preliminary framework (Bacon et al., 2020; Becker & Zirpoli, 2003; L. Bengtsson et al., 2017; Dibiaggio, 2007; Mitchell, 2006; Takeishi, 2002; Tell, 2011, 2017).

Moreover, a major difference between the two is that knowledge locus is *subordinated* to the characteristic of absence/existence of knowledge, i.e., the knowledge must exist prior to that, so it can vary in accessibility (i.e., depending on locus). This should not be a contentious proposal. A second difference is that absence/existence is a binary characteristic, whereas the internal/external locus is best conceptualized as a spectrum, e.g., from within a team to outside a firm's boundaries or scope of influence (cf. Tell, 2011). A third and final difference is the relevance of knowledge absence for the conception of the nature of subjects (see 2.4). Absence of knowledge was arguably a key factor in understanding why judgment (see 4.4.1.1) was observed to be a common mechanism in response to problems with considerable uncertainty (see 4.8.2). This relationship, of course, is not novel, considering the work by Spender and other researchers who position judgment and imagination as central to individuals' confrontation with knowledge absences and 'Knightian uncertainty' (Knight, 1921; Kraaijenbrink et al., 2010; Spender, 2008, 2014a).

5.2.8.2 Knowledge dysergy as the opposite of knowledge synergy

The observed pattern regarding complementarity confirmed the expected pattern in terms of implications for integration costs (4.7.4). However, the data also revealed that the spectrum in the preliminary framework should be extended beyond *a lack* of complementarity to also encompass the *opposite* of knowledge complementarity.

Synergies can be thought of as instances where the product of integration exceeds the sum of its parts (i.e., 2+2=5). This phenomenon is central to the rationale of investing effort in the combination of different specializations to solve problems (Enberg, 2007; Salunke et al., 2019; Tell, 2011). Also, Velu and Stiles (2013) discussed synergies in the context of business model innovation (see 5.2.1), specifically in terms of how to manage cannibalization when a firm runs different business models in parallel. Furthermore, potential synergies are a common rationale in inter-organizational efforts to integrate knowledge, such as joint-ventures and acquisitions (Harrison et al., 2001).

Interestingly, the empirical material illustrated that there is a potential for the opposite of ‘synergy’ to occur. Instead of being productive, an additional combination of knowledge may be destructive for the output. In 4.7.4.2, it was, for example, shown how the mechanism of joint problem-solving not only may have diminishing returns of involving additional individuals beyond a certain point, but that involving further individuals had the potential to make the effort by the other individuals less valuable. In such instances, the product of integration could be *smaller* than the sum of its parts (i.e., 2+2=3). This observation is, hence, different from the mere lack of synergies (i.e., 2+2=4). For example, cannibalization (Velu & Stiles, 2013) can be a zero-sum game during a transition period from one business model to another.

To describe when the product of integration is smaller than the sum of its parts, I propose that the term *dysergy* can capture this minimum potential on the complementarity-spectrum[86]. Notably, the observations in the study and this proposed finding about *dysergy* also confirm the relevance of trans-specialists as a *substitute* to integration efforts (Postrel, 2002, 2017; Tell, 2011). However, it appears that a similar observation led Tell (2011) to conceive this knowledge characteristic as a spectrum between ‘complementary’ and ‘substitution.’ The new conception of this knowledge characteristic is, instead, proposed to be a spectrum between *synergy* and *dysergy*.

5.2.9 Task characteristics

5.2.9.1 Confirming the expected pattern

Of the three types of characteristics in the characteristic-driven mode, task characteristics was the category in the preliminary framework which the empirical material confirmed the most. However, this replication of previous findings should not be seen as a failure. Rather, it can be interpreted as a demonstration of the progress made in our understanding of task characteristics, tracing all the way back to Simon (1947, 1962) regarding complexity, and Knight (1921) regarding uncertainty.

5.2.9.2 A paradox: response-certainty in the face of problem-uncertainty

An interesting paradox regarding uncertainty was highlighted in 4.8.2.4, which has not been discussed in prior literature. In line with the expected pattern, increasing levels of uncertainty encouraged the use of more costly responses (see 2.5.2.2), such as investments in very flexible organizational arrangements (see 4.3.2 and 4.8.2.2). However, in instances of extreme uncertainty (cf. Enberg, 2007; Grandori, 2001),

[86] Based on searches, e.g., on Google Scholar, for antonyms to ‘synergy’ that have been applied to capture a similar phenomenon, e.g., Frick (2007).

the empirical material also showed that one of the few *certainties* that individuals in the study could rely on was the high level of uncertainty that their responses would have to consider. The preliminary framework did not outline this peculiar aspect, namely that the uncertainty of a problem can become so tangible that it presents individuals with a type of certainty in terms of how to respond to the problem. Note that it is not the uncertainty of the problem itself that this paradox points out, but how certain it is that a *response* will be appropriate as the uncertainty of a problem increases. Other known responses to uncertainty, such as to postpone a decision pending further developments (i.e., to expend time as a resource, see 4.8.2.1), can arguably be understood through this paradox of response-certainty in the face of problem-uncertainty.

5.3 Subjects involved in the knowledge integration process

In summary, most of the expected pattern regarding individual and group-level subjects were observed in the study without major inconsistencies. For example, the influence of bounded rationality of individuals (Grandori, 2001; Simon, 1947) and implications of group-level structures (Johansson et al., 2011; Postrel, 2017; Tsai & Ghoshal, 1998; Zahra et al., 2020). Two extensions of the preliminary framework, however, can be proposed based on the interpretation of the empirical material.

5.3.1 Judgment and satisficing in advanced knowledge integration

Judgment was observed to be a central response to difficult problems, such as high degrees of uncertainty (see 4.8.2), complexity (see 4.8.1), and absence of knowledge (see 4.7.6 and 5.2.8.1). The role of judgment in uncertain situations with incomplete information is not a new finding, but it follows the adoption of bounded rationality of individual subjects (Grandori, 2001; Grant, 1996b; Simon, 1947; Spender, 2014a; Tversky & Kahneman, 1974). However, while the preliminary framework acknowledges judgment as one of many mechanisms for decision-making, the empirical material suggested that the role and efficacy of judgment in advanced knowledge integration should be emphasized further. For example, observations of how difficult problems were often solved in a *satisficing* manner (Demarest, 1997; Simon, 2018; Winter, 2000) support this interpretation (see 4.4.1.1 and 4.7.6.2). Notably, the need for individuals to rely on judgment and satisficing was influenced by an awareness about exogenous aspects, such as time-pressure based on estimations about the intensity of competition which Omega was facing. This relationship is not emphasized enough in the preliminary framework, but was abundantly clear in the empirical material.

5.3.2 The rhetorical framework

The empirical material suggested that the description of the interplay between subjects can be improved by further emphasis on the rhetorical framework (i.e., relative to the preliminary framework). The rhetorical framework, as outlined in the preliminary framework, was applied in 4.4.1.2 to describe the dynamics through which a subject is both influenced by other subjects and has the capacity to influence other subjects (i.e., in the process of persuasion). To my knowledge, this is the first time that this ubiquitous framework has been applied in the context of knowledge integration. The result was quite convincingly in favor of further integrating rhetoric into a framework for knowledge integration. In addition to advancing our understanding of this module in the preliminary framework (2.4), this finding also had implications for how to perceive relational characteristics. This was discussed at length in 5.2.7.1.

5.4 Revised theoretical framework

5.4.1 Summary of findings from the analysis

Table H summarizes the findings that have been discussed in this chapter. Based on the distinction between the characteristic-driven mode and the objective-driven mode that was introduced in 5.1.1, two columns are used in Table H to illustrate which mode each finding in this chapter relates to foremost.

Table H. Summary of findings from the analysis.

Framework module	***Findings related to the characteristic-driven mode***	***Findings related to the objective-driven mode***
*An **objective** requiring integration of knowledge*		• Toward an objective-driven mode of explaining knowledge integration • The building blocks of the objective-driven mode
***Subjects** involved in the knowledge integration process*	• Judgment and satisficing in advanced knowledge integration • The rhetorical framework	
***Management** of knowledge integration*	• Relational characteristics as factors which influence the process of persuasion • Compatibility between the two modes: Collective identity and aspirations as an illustrative example • A division of knowledge locus into two distinct knowledge characteristics: absence/existence of knowledge and internal/external knowledge • Knowledge dysergy as the opposite of knowledge synergy • A paradox: response-certainty in the face of problem-uncertainty	• Introducing the business idea and industry recipe in a knowledge integration context • The knowledge-foundation of the business idea and industry recipe • Effective management of knowledge integration – a framework for the objective-driven mode • Business idea evolution • Industry recipe evolution • Toward a more strategic perspective on knowledge integration: a two-way street

Starting with 'An objective requiring knowledge integration,' a main finding in this study was the discovery of the objective-driven mode and how this is different from the characteristic-driven mode of explaining knowledge integration (see 5.1.1). The two modes, however, were not found to be mutually exclusive but appear to lead to a more satisfying explanation of how to manage knowledge integration when applied together (see 5.1.1.4). To facilitate the application of the objective-driven mode in future research on knowledge integration, the building-blocks within this mode were clarified in 5.1.2.

The objective-driven mode prompted multiple findings about the 'Management of knowledge integration' module in the preliminary framework. First, two strategy concepts (the business idea and the industry recipe) were introduced in a knowledge integration context to explain observations in the study of a kind of knowledge about how to benefit economically from knowledge integration. Second, a knowledge-foundation for the business idea (5.2.2.1–5.2.2.2) and industry recipe (5.2.2.3–5.2.2.4) was proposed, based on the types of problems and knowledge which were discussed in the preliminary framework (see 2.3.2 and 2.5.7.2). Third, a framework for effective management of knowledge integration was constructed based on the application of the business idea and industry recipe as a mechanism in decision-making (5.2.3). Fourth, two new concepts were proposed, namely business idea evolution (5.2.4) and industry recipe evolution (5.2.5), to explain the observation in the empirical material that knowledge about how to benefit economically is subject to growth. Fifth, it was then discussed how the objective-driven mode enables a more strategic perspective on knowledge integration (5.2.6). In one direction (5.2.6.1), it was clearly the case that our understanding of knowledge integration can be improved by introducing literature on certain strategy concepts (i.e., the business idea, the business model, and the industry recipe) in a knowledge integration framework. In the other direction (5.2.6.2), knowledge integration theory appears to have a potential role in explaining the longitudinal dimension of the business model concept. This second question (5.2.6.2) was not part of the purpose of this study but is interesting nonetheless, given the mentioned role of business model literature in our understanding of the strategic perspective of knowledge integration (i.e., 5.2.6.1).

Several findings were also proposed, related to the characteristic-driven mode. First, the meaning of relational characteristics was repositioned based on the observed importance of persuasion in the knowledge integration process (see 4.4.1.2). In the new conception of relational characteristics (5.2.7.1), the process of persuasion is understood through a rhetorical framework, which, in turn, is explained through relational characteristics. Second, collective identity and aspiration were discussed as illustrations of the claim in 5.1.1.4 that the objective-driven mode and the characteristic-driven mode are two sides of the same coin, which enable a richer explanation when applied in combination (5.2.7.2). Third, it was proposed that the knowledge characteristic of 'locus' (2.5.3.6) ought to be split into two characteristics: knowledge absence/existence and internal/external locus (5.2.8.1). Fourth, the spectrum for the knowledge characteristic 'complementarity' was refined (5.2.8.2) to include the natural opposite of 'synergies' (i.e., when the product of integration is larger than the sum of its parts), namely: 'dysergy' (i.e., when the product of integration is *smaller* than the sum of its parts). Fifth and last, a paradox was highlighted regarding the certainty of how to respond to extreme task uncertainty (5.2.9.2).

Regarding the module 'Subjects involved in the knowledge integration process,' two findings were proposed about the need to emphasize certain aspects further than is the case in the preliminary framework. First, the importance of judgment and satisficing in advanced knowledge integration (5.3.1). Second, the suitability of the rhetorical framework in a knowledge integration framework (5.3.2), which also influenced the new interpretation of relational characteristics that was discussed in 5.2.7.1. Other than these two clarifications, the expected pattern, which was outlined in 2.4, was largely replicated in the study.

No major change was proposed to the meaning of the effect-module, i.e., how the output of a process to solve a problem represents an integration of knowledge (cf. 2.1 and 2.6).

5.4.2 The revised framework for the purpose of this study

Based on the findings in this chapter, a revised framework was constructed which represents our new understanding of the purpose of this study, i.e., how knowledge integration is influenced by the objectives of a firm (see Figure M). In terms of structure, the revised framework mirrors the structure and modules which were used in the preliminary framework (see Figure B in 2.7). Hence, the revised framework is not complete on its own. Rather, Figure M highlights the new findings which should be incorporated into a revised framework (see Table H in 5.4.1), i.e., in addition to the theory in the preliminary framework (see 2.7).

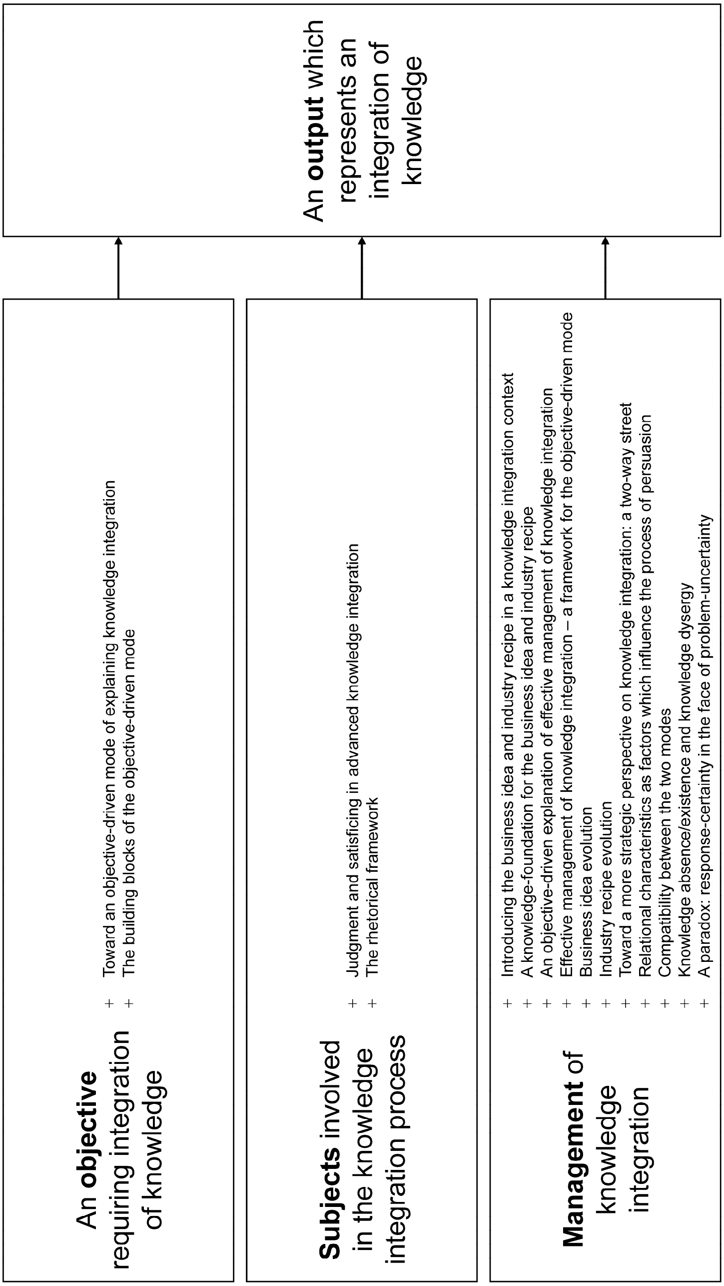

Figure M. A revised framework for the purpose of this study.

6 Conclusion and further research

The purpose of this study is *to contribute to the understanding of how knowledge integration is influenced by the objectives of a firm*. In Chapter 5, findings were presented which advance our understanding of this problem, summarized in a revised framework for the purpose of this study (see Figure M in 5.4.2). This chapter will discuss the meaning of these findings in terms of theoretical contributions, managerial implications, limitations, and suggestions for future research.

6.1 Theoretical contributions

6.1.1 Toward a more strategic perspective on knowledge integration

The purpose of this study was based on a problematization of previous literature, which argued for a more strategic perspective on knowledge integration. Following this line of inquiry, iterations between the empirical material and theory resulted in the conception of the objective-driven mode (see 5.1.1). The term 'characteristic-driven mode' was also introduced to describe the mainstream approach of explaining the management of knowledge integration through various problem characteristics (Carlile, 2004; Grandori, 2001; Grant, 1996b; Postrel, 2017; Szulanski, 1996; Tell, 2011).

The definition of knowledge integration by Tell et al. (2017a) as the 'purposeful combination' of knowledge to achieve specific tasks provided a foundation for this new orientation (Berggren, Bergek, Bengtsson, & Söderlund, 2011; Tell et al., 2017a). The satisficing principle (Demarest, 1997; Simon, 1947, 2018) further supported an interest in the influence of firms' objectives (i.e., satisficing in relation to *what*?). There were also grounds within the knowledge integration literature to tether problem-solving to the objectives of the firm (e.g., Demarest, 1997; Grandori, 2001; Nickerson & Zenger, 2004; Wikström & Normann, 1994). This prompted an interest in the different types of problems (technological, organizational, and commercial) which individuals in firms may encounter, and which require integration of the corresponding type of knowledge to be resolved (Burgers et al., 2008; Carlile, 2002; Ceci & Prencipe, 2017; Dabhilkar & Bengtsson, 2011; De Luca & Atuahene-Gima, 2007; Demarest, 1997; Enberg, 2007; Eslami & Lakemond, 2016; Frishammar et al., 2012; Lane & Lubatkin, 1998; Ravasi & Verona, 2001; Sanchez & Mahoney, 1996; Szulanski, 1996; Takeuchi & Nonaka, 1986; Tanriverdi & Venkatraman, 2005; Tiwana, 2004; Tsoukas & Vladimirou, 2001). The evidence for the occurrence of these thematic categories of problems and knowledge was quite substantial in the empirical material (see 4.3). The proposed approach is, hence, both logical (i.e., to derive problems from the objectives of a firm), indicated by prior research, and consistent with the empirical material (see also 5.1.1.2). Thus, a conclusion from this study is that the objective-driven mode is a valid alternative to the characteristic-driven mode of explaining the management of knowledge integration (see 5.1.1).

A key benefit of this development is that it directly addresses the critique regarding myopia of prior research (see 1.4.1), i.e., which do not sufficiently consider the strategic context in which a knowledge integration process is embedded (see 5.1.1.1 and 5.1.2.2). An important clarification, however, is that the objective-driven mode is complementary to the characteristic-driven mode (see 5.1.1.4). This means that future research which aims to contribute to a strategic perspective on knowledge integration ought to include literature on *both* modes into their theoretical frameworks.

Another conclusion from this study is that the prior research on the characteristic-driven mode have made impressive progress to expand our understanding of how various categories of problem characteristics (i.e., task, knowledge, and relational) influence the management of knowledge integration (e.g., Carlile, 2002; Carlile & Rebentisch, 2003; Enberg, 2007; Grandori, 2001; Grant, 1996a, 1996b; Huang & Newell, 2003; Tell, 2011; Zollo & Winter, 2002). Arguably, the quality of such prior work was demonstrated through the high degree of replication in this study. This was especially the case for the influence of task characteristics (e.g., complexity and uncertainty), which appears to have a very robust foundation (Beckman et al., 2004; Carlile, 2002; Enberg, 2007; J. R. Galbraith, 1974; Grandori, 2001; Grant, 1996b; Hall et al., 2011; Knight, 1921; Melander & Tell, 2014; Simon, 1962; Spender, 1996; Takeishi, 2002; Tell, 2011; Zollo & Winter, 2002). The practical value of the characteristic-driven mode of explaining the management of knowledge integration is also considerable. For example, in terms of how we can understand why certain responses (cf. 'mechanisms') are more or less effective, the heuristic relationship between problem difficulty and integration costs is a very strong contribution of this literature (L. Bengtsson et al., 2017; Berggren, Bergek, Bengtsson, & Söderlund, 2011; Grandori, 2001; Grant, 1996b; Nickerson & Zenger, 2004; Okhuysen & Eisenhardt, 2002; Tell, 2011; Van de Ven & Zahra, 2017; Werr & Runsten, 2013; Zahra et al., 2020).

6.1.2 Concept development

The application of the objective-driven mode in this study produced multiple developments of our understanding of the management of knowledge integration. Two concepts from the domain of strategy and management were introduced to make sense of the empirical material. First, the *business idea* was introduced to capture firm-specific knowledge about how to benefit economically from knowledge integration. Second, the *industry recipe* was introduced to capture industry-specific knowledge about how to benefit economically from knowledge integration. To apply these two concepts within a knowledge integration-context is quite a novel approach. The business idea has not been applied at all within knowledge integration literature, and there are only a few examples of references to business models (Bashir & Farooq, 2019; Brusoni et al., 2021; Burgers et al., 2008; Cestino & Matthews, 2016; Demarest, 1997) and industry recipes (Spender, 1996, 2002; Tsoukas, 1996; Tsoukas & Vladimirou, 2001) within a knowledge integration context. Also, the proposed meaning of these two concepts in the context of knowledge integration theory (see 5.2.1.3) is arguably a novel development, e.g., relative to prior work on the purpose of efforts to solve problems (e.g., Burgers et al., 2008; Demarest, 1997; Nickerson & Zenger, 2004; Tell et al., 2017a; Werr & Runsten, 2013; Willem et al., 2008).

Through incorporation of these concepts into a knowledge integration framework (discussed at length in 5.2.6.1), several of the theoretical problems which were highlighted in the introduction chapter could be resolved, such as the under-emphasized commercial dimension of knowledge integration (see 1.4.3.1) and interdependencies between categories of problems (see 1.4.3.2). A more surprising consequence of introducing the business idea and industry recipe in a knowledge integration-context was that it appeared to uncover a potential role for knowledge integration theory in the development of these strategy-concepts (see 5.2.6.3). This, especially related to 5.2.6.2, will be discussed in the forthcoming 6.1.4.1.

The additional strategy literature that was introduced (see 5.2.1) was also central to the conceptualization of observations in 4.5.6 as instances of *business idea evolution* and *industry recipe evolution*. These two concepts are completely novel in the context of knowledge integration theory. Within mainstream strategic management literature, there are similarities between the proposed concept business idea evolution and previous work on business model innovation (Cavalcante et al., 2011; Chesbrough, 2010; Foss & Saebi, 2017; Schneider & Spieth, 2013, 2013). However, as was highlighted in 5.2.4.2, a key difference between the 'business idea' and 'business model' was proposed in 5.2.1.1. This proposed difference (knowledge about a business versus the actual, objective or material configuration of a business) is quite consequential, since it means that the business idea is a more specific and narrow concept, which rather resembles the cognitive view on business models (such as 'business model schema') than the broader business model concept, i.e., which also encompasses other meanings (Demil & Lecocq, 2010; Doz & Kosonen, 2010; Martins et al., 2015; Massa et al., 2017; Sund et al., 2020; Tikkanen et al., 2005; Zott et al., 2011). Thus, the developed concept of business idea evolution involves a degree of novelty also within the broader domain of strategy and management. A similar argument can be made for industry recipe evolution.

A contribution of this study, hence, was to identify these phenomena in the empirical material and to position them in a theoretical landscape which is compatible with the features of knowledge integration theory (see 1.2.3). A key benefit of knowledge integration theory is that it allows these phenomena to be examined through the ontological position of knowledge impregnation. This is arguably a powerful tool which enables new perspectives to emerge, similar to how the adoption of bounded rationality leads to different perspectives, relative to the view of individuals as rational agents (Simon, 1947, 1956; Tversky & Kahneman, 1974). One of the ways in which this enabled a novel depiction to emerge was the analysis of the *knowledge-foundation* of the business idea and industry recipe (see 5.2.2). Through iteration between the empirical material and theory (including the additional theory which was introduced in 5.2.1), a new conception emerged of the business idea and the industry recipe as a synthesis of technological, organizational, and commercial knowledge (see Figure J). This combination-conception was both deemed to be a convincing explanation of the empirical material and a development of our understanding of these strategy concepts in the context of knowledge integration, i.e., beyond their original meaning (cf. Normann, 1975; Spender, 1989). Likewise, the proposition that the business idea and industry recipe are two parts of a whole body of knowledge about how to benefit economically from knowledge integration, on the firm-level and industry-level respectively, is a new proposition relative to prior theory (see 5.2.2.3). Furthermore, the analysis suggested that the business idea and industry recipe can be considered to be types of knowledge specializations, about which individuals can know more or less (Drucker, 1954, 1988; Normann, 1975). This is a consequential distinction, since it enables new perspectives on how knowledge integration may be managed (as proposed in 5.2.3).

6.1.3 Framework development

Equipped with this new understanding of the two concepts (i.e., the knowledge-foundation of the business idea and industry recipe), several frameworks (Edmondson & Mcmanus, 2007; Porter, 1991) were then constructed (see 5.2.3–5.2.5). These frameworks can be thought of as underlying explanations, that are part and parcel of the revised framework which was summarized in 5.4.

The new understanding of effective management of knowledge integration from the perspective of the objective-driven mode (see 5.2.3) was based on two findings. First, that the business idea and industry recipe can be leveraged as a mechanism by individuals (see 5.2.3.1). The empirical material (see 4.5) suggested that this mechanism was especially important when confronting problems with interdependencies across multiple categories (cf. systems of problems). Second, it was proposed that the alignment between individual decision-making and the business idea and industry is central to the prospect of effective management (see 5.2.3.2). Note that the knowledge which underpins the business idea and industry recipe abides by the meaning of the recipe-metaphor, which was outlined in 5.2.1.4, i.e., it could be applied in a satisficing sense, not as truth claims about universal relationships between causes and effects (Demarest, 1997; Kogut & Zander, 1992; Normann, 1975; Porter, 1991; Simon, 2018; Spender, 1989).

Frameworks were also constructed for the new concepts of business idea evolution (see 5.2.4.3) and industry recipe evolution (see 5.2.5.3). The previously mentioned knowledge-foundation of the business idea and industry recipe was central to the proposed interpretation of how this knowledge evolves. For example, in terms of *what* is subject to change in these processes (i.e., the underlying knowledge and how it is synthesized) and *how* such knowledge growth comes about (i.e., through positive and negative feedback, from internal and external sources).

Within the characteristic-driven mode, several developments were also proposed as part of the revised framework. First, regarding relational characteristics, the work by (Spender, 2014a, 2014d) was influential for the proposed view of knowledge integration as a process of persuasion, which can be interpreted through a rhetorical framework. Second, two clarifications were proposed regarding our understanding of knowledge characteristics (see 5.2.8). Third, a minor addition was proposed regarding the expected pattern for task uncertainty. The main conclusion about this part of the revised framework, however, was that previous research have been both productive and quite accurate, i.e., as illustrated by the high degree of replication which was mentioned in 6.1.1.

Finally, considering these developments altogether, the revised framework (see 5.4) has further encouraged my confidence about the benefits of adopting the features of knowledge integration theory (see 1.2.3) when exploring matters of strategy and management (Grant, 1996a, 1996b; Okhuysen & Eisenhardt, 2002; Spender, 1996; Tell, 2011; Tell et al., 2017a; Wikström & Normann, 1994). This is relevant to highlight, since there are alternative theoretical approaches that also attempt to explain how a firm can achieve its objectives through problem-solving, such as literature on capabilities/dynamic capabilities (Eisenhardt & Martin, 2000; Teece, 2018; Winter, 2003), literature that attempts to reconcile the capability-approach with knowledge integration theory (Bergek et al., 2008; Berggren, Bergek, Bengtsson, & Söderlund, 2011; De Boer et al., 1999; Grant, 1996a; Henderson, 1994; Kogut & Zander, 1992; Mitchell, 2006; Salunke et al., 2019; Zahra et al., 2020; Zollo & Winter, 2002), and literature within the micro-foundations movement (Felin et al., 2015; Foss & Linder, 2019; Helfat & Peteraf, 2015; Teece, 2007). A conclusion from this study is that such alternative approaches should *not* bargain with the key feature of knowledge integration theory: to conceive process outputs as an integration of knowledge (Grant, 1996b; Simon, 1973). This ontological position, i.e., which emerged in the wake of the seminal 1996 special issue of Strategic Management Journal (Spender & Grant, 1996b), is the bedrock upon which the findings in this study build.

6.1.4 Implications beyond knowledge integration theory

While outside the purpose of this study, it may also be relevant to reflect on how the findings from this study can be positioned, relative to other theories in the strategy domain, i.e., beyond the scope of knowledge integration theory.

6.1.4.1 Business models

First and foremost, this study can be positioned relative to the literature on business models. This is quite logical, given the application of parts of this literature throughout Chapter 5. In 5.2.6, it was discussed in depth how the findings in the study connect knowledge integration theory and the domain of business model literature in new and interesting ways. Foremost (see 5.2.6.1), literature on business models was applied to make sense of the business idea and industry recipe, which were two central concepts in the revised framework for the purpose of this study (Amit & Zott, 2001; Hedman & Kalling, 2003; Johnson et al., 2008; Osterwalder et al., 2005). The reverse relationship was also discussed in 5.2.6.2, in which it was proposed that knowledge integration theory can be applied to explain the 'longitudinal problem' (Porter, 1991) of the business model concept. There is support for this claim in previous literature on business models, not least in the cognitive and evolutionary views (e.g., Chesbrough & Rosenbloom, 2002; Demil & Lecocq, 2010; Martins et al., 2015; Massa et al., 2017; McGrath, 2010; Sosna et al., 2010; Sund et al., 2020; Tikkanen et al., 2005). This proposition could hence be an opportunity for future research within the domain of business model literature.

Another implication for the domain of business model research is how this study has demonstrated the benefits of making a distinction between knowledge about a business and the actual configuration of a business (see 5.2.1.1). The relevance of making such a distinction is reflected in the ongoing debate within the field and is hence not an original approach (Martins et al., 2015; Massa et al., 2017; Schneider & Spieth, 2013; Spieth et al., 2014; Zott et al., 2011). A new development, proposed by this study, however, was to anchor the former type (knowledge about a business) to the concept of the 'business idea,' and to subsequently sort business model-contributions which adopt a similar meaning (i.e., as cognitive or linguistic schema, structures, and representations) as part of this concept. Surely, there might be other ways of ensuring that this specific meaning is separated from other views on business models. Either way, the findings in this study certainly encourage attempts to draw a box around the knowledge-dimension of this concept, and to make this feature a more distinct part of the research agenda within the domain of business model research.

6.1.4.2 Capabilities

Arguably, the findings in this study further strengthened the standing of knowledge integration theory versus the theory of organizational capabilities and dynamic capabilities in explaining the phenomenon of interest. The overlap between knowledge integration and capabilities was addressed in the introduction chapter (see 1.2.3). What was not problematized in the introduction, but became increasingly clear during the study, however, is the lack of emphasis on individuals and, consequently, the lack of emphasis on bounded rationality of individuals (i.e., in the depiction of subjects) in literature on organizational capabilities and dynamic capabilities (Eisenhardt & Martin, 2000; Teece et al., 1997; Winter, 2003). The lack of emphasis on individuals in capabilities literature, i.e., the subjects which act out an organizational process, is a known critique that has been problematized in, for example, Felin and Foss (2005) and Foss (2005). For example, the work involving Teece (e.g., Teece, 2007, 2014; Teece et al., 1997) depicts dynamic capabilities as only partly residing in individuals (the 'managers' and the 'leadership team' of a firm) in favor of emphasizing how capabilities reside in organizational-level constructs (i.e., beyond individuals) such as processes, structures, routines, and rules. Using Coleman (1990), Felin and Foss (2005) point out that this approach to organizational capabilities (i.e., as a macro-level concept) is problematic, and argued that capabilities ultimately need to be grounded in the nature and behavior of individuals (i.e., as a micro-level explanation) (Felin & Foss, 2005; Foss & Linder, 2019).

To recognize individual agency naturally leads to questions about the nature of individual subjects who participate in the process. Knowledge integration theory draws its inspiration from a framework of psychology. This is especially clear in how bounded rationality is positioned as the basis for the need to integrate multiple individuals' knowledge, i.e., due to limits for what each individual may know (Felin & Foss, 2005; Simon, 1947, 1956; Tversky & Kahneman, 1974). In contrast, the literature on organizational capabilities and dynamic capabilities generally appear to be nested in a framework of neoclassical economics (Teece, 2014; Teece et al., 1997; Winter, 2003). While this view has been applied in combination with bounded rationality in the past, e.g., as demonstrated by Williamson (1981), the capabilities-literature generally adopts other ontological and epistemological positions than the Carnegie Mellon-tradition, i.e., which have influenced knowledge integration theory.[87]

Hiding in plain sight, there is an obvious opportunity to reconcile this problem: to apply knowledge integration theory as the individual-level explanation of organizational-level capabilities (Coleman, 1990; Felin & Foss, 2005; Foss &

[87] Generally, this is more the case for proponents of Teece and Winter than proponents of Eisenhardt and Martin (Di Stefano et al., 2014; Teece, 2014). For reference, Eisenhardt and Martin (2000, p. 1107) defined 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"* (Eisenhardt & Martin, 2000, p. 1107).

Linder, 2019). Hence, to perceive the combined ability of (individuals and group-level) subjects in firms to integrate knowledge as a firm's capability. This approach would be consistent with the findings in this study, and has been indicated previously by multiple authors (Berggren, Bergek, Bengtsson, & Söderlund, 2011; De Boer et al., 1999; Grant, 1996a, 1996b; Henderson, 1994; Kogut & Zander, 1992; Mitchell, 2006; Verona, 1999; Zahra et al., 2020). However, for various reasons, this type of convergence between capabilities literature and knowledge integration theory is currently not happening. Rather, the literature on organizational capabilities appear to pursue other explanations for its microfoundations (Di Stefano et al., 2014; Helfat & Peteraf, 2015; Teece, 2007, 2014, 2018). This trajectory is unfortunate, not least considering the findings of this study. Arguably, it would have been very difficult to produce the findings in this study without a commitment to a) the individual level of analysis, b) a dynamic perspective on knowledge, and c) the framing of outputs of processes to solve problems as the purposeful combination of individual knowledge (see 1.2.2 and 1.2.3). For example, the proposed conception of the business idea as a synthesis of the three different kinds of knowledge *directly* invoke this ontological foundation (see 5.2.2.1).

6.1.4.3 Organizational learning

The findings of this study notably conform with central thinking within the domain of organizational learning (Argyris & Schön, 1978; J. S. Brown & Duguid, 1991; Cohen & Levinthal, 1990; Huber, 1991; Levitt & March, 1988; March, 1991). For starters, the study appears to confirm the relevance of the dichotomy between single-/double-loop learning (Argyris & Schön, 1978) and exploration/exploitation (March, 1991). For example, the division between the application of the business idea and the evolution of the business idea (see 5.2.4) follows the same logic as these ubiquitous concepts (e.g., Sosna et al., 2010; Sund et al., 2020; Winter & Szulanski, 2001). Organizational learning, however, does not conform with the three features which makes knowledge integration theory distinct (see 1.2.3). This is why this domain of research was not treated as part of the scope for knowledge integration. However, if these differences remain clear, there are good reasons to keep applying these two concepts from the organizational learning literature. Of course, this kinship between knowledge integration theory and organizational learning is rather unsurprising, considering that several key authors on organizational learning are central figures in the Carnegie Mellon-tradition of studying organizations through the lens of individual decision-making (e.g., March, Levitt, Cohen, and Levinthal).

6.1.4.4 Microfoundations

Fourth and lastly, it may be relevant to comment on how this study relates to the microfoundations-movement, which was referenced in the previous discussion about capabilities (see 6.1.4.2) but is also its own orientation, which this study can be positioned against. Although this study did not intend to contribute to this movement, some of the findings from this study can be regarded as the result of a reductionist approach (Foss & Linder, 2019). For example, the knowledge-foundation for the business idea and industry recipe (see 5.2.2) is an attempt to develop these concepts by diving deeper and considering individual-level (cf. micro-level) application and development of knowledge (Coleman, 1990; Felin et al., 2015; Foss & Linder, 2019).

This study, however, is not committed to only explain phenomena on the micro-level (cf. microfoundations). Macro-level concepts (i.e., on the collective-level, such as the firm and industry) were also invoked (e.g., the business idea and industry recipe) and developed (e.g., 'business idea evolution' and 'industry recipe evolution') to explain observations in the study. Gibe and Kalling (2019), for example, discussed the business idea as a potential *"model for the 'macro-foundations' of strategy"* (Gibe & Kalling, 2019, p. 19), i.e., the opposite of a molecular approach to strategy. Another example of macro-level concepts in the study was the proposed explanation of the interplay between subjects (see 5.2.7.1). Here, the analysis in this study focused on developing a macro-level (cf. persuasion) and meso-level (cf. rhetoric) understanding on top of the already existing micro-level explanation of relational characteristics within knowledge integration theory.

In summary, this study has attempted to develop both macro-level and micro-level explanations. With that being said, there is certainly a level of conformance between some findings in this study (e.g., the knowledge-foundation of the business idea and industry recipe) and several core ideas in the work on microfoundations, e.g., Colemans's 'bathtub' (Coleman, 1990; Felin et al., 2015; Felin & Foss, 2005; Foss & Linder, 2019). One conclusion, therefore, might be that knowledge integration theory is compatible with the microfoundations-orientation, and thus might be a viable mode of producing micro-level explanation of macro-level phenomena (cf. discussion in 6.1.4.2).

6.2 Managerial implications

In addition to the development of concepts and frameworks, there were multiple insights which surfaced during the study that may be useful as rules-of-thumb for practitioners of strategy and management.

First, this study has shown how the management of knowledge integration depends on the objectives of a firm (see 5.1.1), such as commercial targets or innovation.[88] A practical application of this finding is that different objectives (such as the generic objectives in 2.3.1) are associated with different effectiveness criteria (Bland & Osterwalder, 2020; Burgers et al., 2008; Normann, 1975). Notably, this rationale is also reflected in performance management tools such as Key Performance

[88] Compare with the notion of strategic intent in Hamel and Prahalad (1989).

Indicators (Parmenter, 2010) and the Balanced Scorecard (R. S. Kaplan, 2009), as well as in the increasingly popular goal-setting framework 'OKR' (Doerr, 2018; Grove, 1995; Wodtke, 2016).[89] This may be useful to clarify since the overall purpose of firms to generate shareholder returns (see 2.3.1) is not very informative about what firms ought to prioritize, i.e., in comparison with more specific objectives (Hamel & Prahalad, 1989). The objective-driven mode brings another dimension to this discussion, by tethering the achievement of different objectives to the resolution of various thematic kinds of problems (see 5.1.1).

Second, knowledge integration efforts to solve difficult problems appear to typically motivate *more* investments communication of the business idea and industry recipe, compared with efforts to solve easier problems. This was discussed in 5.2.3.4 and was grounded in that solutions to difficult problems tend to require deeper knowledge specialization. Since transfer of deeply specialized knowledge is difficult for both the sender and the receiver (cf. Szulanski, 1996), and thus may fail the cost-benefit test, the resolution of difficult problems tends to benefit from a distributed organization structure, i.e., a structure in which other individuals than upper and middle management (namely, those endowed with the specialized knowledge in question) are empowered to make strategic decisions (Drucker, 1988). A consequence of difficult problem characteristics, hence, may be an organizational arrangement in which more individuals are exposed to strategic decision-making. This is what motivates more investments in communication of the business idea and recipe. The relevance of this rule-of-thumb was discussed in depth in 5.2.3.2, to enable individuals in a firm to make decisions aligned with the business idea of the firm and the industry recipe of the industry in which the firm operates.

Note, however, that this recommendation hinges on a distributed organization structure being employed in response to the problem characteristics in play. If a hierarchical structure instead is employed, then the need to communicate the business idea and industry recipe likewise decreases. This is because such structural arrangements expose fewer individuals to strategic decision-making. Consider, for example, an empirical setting that has a very simple form of production that relies on routines, such as a fast-food restaurant. In such settings, to exert costly efforts to communicate a high-resolution representation of a firm's business idea to all employees would likely not pass the cost-benefit criteria.

Third, the study points out that investments (time and effort) in communication of the business idea and industry recipe are not a one-dimensional spectrum (low to high) but involve decisions about which methods to employ and which individuals to involve in this process. Several recommendations can be shared about such investment-decisions. For starters, how high or low 'resolution' does the communication effort require? Generally, the higher resolution of the business idea

[89] 'OKR' is short for 'Objectives' and 'Key Results.' Notably, the work by Drucker (1954) on 'management by objectives' is sometimes credited as an antecedent of OKR (cf. Grove, 1995).

and industry recipe that can be communicated, the better in terms of accuracy and alignment. Whether efforts to communicate the business idea and industry recipe with high resolution is worth it or not is, however, subject to cost-benefit considerations. As a rule of thumb, the 'business case' for high resolution communication weakens if the external environment is very dynamic or the internal learning curve is very rapid. This proposition should be quite intuitive, i.e., the shelf-life of efforts to articulate advanced knowledge decreases if the circumstances are such that new learnings continuously emerge that render the previous understanding insufficient. Conversely, the rationale for low resolution communication (i.e., one which requires less effort but leaves more discretion for individual interpretation) becomes stronger in dynamic settings for knowledge integration.

In addition, as was alluded to, communication of a business idea and industry recipe pre-supposes a process or method for formulation and articulation/codification. The formulation process can be undertaken in many ways, such as top-down, bottom-up, or through co-creation (e.g., across multiple hierarchical layers or functional boundaries). There are also multiple methods for communication (cf. 'transfer') of this knowledge, such as one-to-many, peer-to-peer, dialogue within and between groups, and so on. There is no one-size-fits-all mechanism that should be employed for formulation and transfer of the business idea and industry recipe. Rather, the findings in the study suggest that practitioners would benefit from an analysis of which problem characteristics are salient (such as trust, complexity, and relatedness) when deciding between mechanisms for communication.[90] Furthermore, learning-by-doing is likely to be an important complement (or substitute) to communication efforts.

Fourth, the perspective of strategy as a *"a pattern in a stream of decisions"* (Mintzberg, 1978, p. 935) is quite illuminating to make sense of alignment/discrepancy between individual decision-making and the intended business idea and industry recipe. Through this view, what a practitioner observes in peers' decision-making is the *de facto* business idea and industry recipe, i.e., how this knowledge is applied to the best of these individuals' abilities. Since individuals' abilities are limited (cf. 'bounded rationality), this perspective is a powerful diagnosis-tool to identify where and why ineffective decisions, relative to the objectives of the firm, have been made (cf. 5.2.3.2). For example, was this caused by a failure to understand the industry in which the firm is acting? Or was it caused by a failure to understand how the focal firm is attempting to achieve its objectives? Furthermore, the proposed knowledge-foundation of the business idea and industry recipe can be applied to examine the root cause of this misunderstanding (cf. 5.2.2). For example, did the error depend on a shortage of one of the three types of knowledge, or a lack of comprehension about how the pieces of the puzzle are intended to fit together?

[90] Compare with the complementarity of the characteristic-driven and objective-driven modes (see 5.1.1.4).

Fifth, it may benefit a practitioner to contemplate how to manage the process of business idea evolution. Several potential responses were highlighted in 5.2.4.4. For example, to not merely perceive business idea evolution as an intellectual process but also a process of persuasion between subjects. Again, the rhetorical framework is instructive about how to navigate such interplay (Spender, 2014c). It also appears central to cultivate feedback processes which allow information from external and internal sources to develop the underlying knowledge or the way that the three types of knowledge are synthesized (i.e., as a system). Furthermore, if a decentralized organization structure is employed, more individuals will be part of the business idea evolution-process than in a centralized hierarchy. If so, it is crucial to foster motivation and to align the direction of that motivation with the objectives of the firm. For example, to ensure that learnings from individuals' own confrontation with problems are shared and can be considered in the evolution of the business idea.

Sixth, the same recommendation applies for industry recipe evolution (see 5.2.5.4). Furthermore, many of the prescriptions for business idea evolution apply for how to manage the process of industry recipe evolution. However, two differences may be highlighted, which may inform judgements about how to manage the process of industry recipe evolution. First, industry recipe evolution foremost requires persuasion of individuals *outside* the firm, since the industry recipe is a body of knowledge that is shared among all participants in an industry (cf. 5.2.2.3). Second, to be at the forefront of industry recipe evolution may benefit business idea evolution, since the former type of activity may generate *spillover* that can be integrated in the evolution of the firm's business idea.

6.3 Empirical contributions

As a side-effect of conducting this study with the chosen research design and selecting the specific case (Omega), this study may have contributed descriptions of several empirical themes which may be of interest to researchers and practitioners.

In particular, the Omega-case can be read as an example of technological development in the automotive industry. Specifically, the case depicts development of active safety systems, i.e., as one of the multiple domains of technology in the automotive industry. This empirical theme is even reflected in the subtitle of the book (cf. 'development of self-driving cars'). The dynamics of the automotive industry was a discernible theme in the empirical presentation, for example, in the depictions of the intent to enable end-to-end integration and deployment of software in end-customers' vehicles (see 4.5.1.1) and to introduce a subscription revenue model (see 4.3.3.2). For some readers, the technical jargon in Chapter 4 (e.g., 'ADAS,' 'hardware reference architecture,' 'control unit,' 'sensors,' 'machine learning,' and 'continuous integration') may have been a distraction from the purpose of the study.

For other readers, the same descriptions may have been a welcome insight into the intricacies of developing the kind of technology in question. Albeit separate from the purpose of the study, this text may contribute to an understanding of the development and commercialization of technology for 'self-driving cars.

Additionally, the Omega-case can also be read as an illustration of the challenges and benefits which are typical in joint ventures and similar interorganizational arrangements (cf. Das & Teng, 1998; Grant & Baden-Fuller, 2004; Harrison et al., 2001; Mowery et al., 1996). For example, the conception of Omega enabled its owners (Alpha and Beta/Gamma) to consolidate their efforts to develop active safety technology, i.e., compared with running this development effort as minor parts of the respective owners' larger operations. However, when this plan was put into practice, there were also challenges in the Omega-case which appeared to have their root-cause in the joint venture arrangement. Of particular interest for this study were implications of the joint venture setup for the business idea of Omega and its evolution throughout the study (see 4.5.5.2). As was described in 4.9, this may also have been a contributing factor to the termination of Omega and the subsequent organizational arrangements by Alpha (to start the new company Kappa) and Gamma (to continue as a spin-off from Beta).

6.4 Limitations and robustness

Clearly, the single-case design imposes certain limitations for how the findings of this study ought to be interpreted. Care has been taken throughout the study (when writing the analysis-chapter in particular) to ensure that claims and propositions are not exaggerated beyond the boundaries of analytical generalization (Yin, 2009). Through iteration between empirical data and previous theory, there should however be grounds for transferability (cf. Guba, 1981) of the concepts and frameworks developed in this study, i.e., to other settings than the specific case (Omega) in this study (Eisenhardt, 1989b; Guba, 1981; Yin, 2009). Measures taken to maintain a chain of evidence (Yin, 2009) and the description of the analytical process (Alvesson & Sköldberg, 2009; Eisenhardt, 1989b, 2021; Gioia et al., 2013; Yin, 2009) arguably support this claim.

In terms of theory, it can be clarified that this study is exposed to similar limitations as the overall field of knowledge integration theory. For example, there is a tension between the view of bounded rationality and the idea that individuals may improve their practices by acting more rationally (through discovery and application of knowledge). This issue was partly brought up in 5.2.4.3, namely that individuals are merely imperfect interpreters, not perfect arbiters, of knowledge (cf. reference to Kant). Care has thus been taken to balance the resulting picture, for example, by emphasizing metaphors such as 'recipes' (Spender, 1989) and the grounding of knowledge integration in bounded rationality (Simon, 1947, 1956; Tversky & Kahneman, 1974). As a second example, there may be more to the relationship between power and knowledge than this study has explored (Alvesson & Sköldberg, 2009; Engstrand & Enberg, 2020). For example, which individuals' and which groups' knowledge are featured or not in the resulting product of combination? Which problems are deemed a priority to be solved, and by whom? While this kind of interplay between subjects was somewhat addressed by the introduction of the rhetorical framework in a knowledge integration-context, this dimension of knowledge integration can likely be explored further (cf. Grant, 1996b; Kalling, 2003a; Malik et al., 2020; Melander & Tell, 2014; Spender, 2014d). A third limitation is the elusive character of 'knowledge' (Carlile, 2002; Grant, 1996b; Spender, 1998; Zahra et al., 2020). This aspect of knowledge integration theory was addressed in 2.1.2 and is relevant to highlight as a limitation since it may lead to methodological issues. For example, tacit knowledge may be difficult to measure through conventional quantitative tools, such as surveys (Nonaka & von Krogh, 2009; Spender, 1996; Szulanski, 1996).

6.5 Future research

To begin with, the theoretical contributions from this study ought to be examined further (see 6.1). Importantly, further inquiries to refute or confirm the theoretical contributions from this study would benefit from another research design than the single-case design (Edmondson & Mcmanus, 2007). Going forward, two paths appear to be suitable. First, a multiple-case study design would be beneficial to investigate if observations in other settings would replicate the new expected pattern (see 5.4). Note that the theoretical contributions which were proposed in this study were not purely based on induction but are products of abductive reasoning and consultation of prior theory (Alvesson & Sköldberg, 2009; Dubois & Gadde, 2002; Timmermans & Tavory, 2012). Thus, a refutation of the new expected pattern (see 5.4) would, to some degree, also question prior theory, i.e., not merely the interpretation of data from this unusual and critical case (see 3.3). Accordingly, such a result would be interesting for multiple reasons.

A second path to enhance external validity would be a hybrid approach involving both qualitative and quantitative data (Edmondson & Mcmanus, 2007). For example, it would be interesting to devise instruments that measure alignment/discrepancies between the intended business idea/industry recipe, e.g., as formulated by the top management in a firm, and how this knowledge is applied in practice, e.g., explained by individuals and observed to be enacted (cf. Runsten & Werr, 2020; Wageman et al., 2005). If there are demonstrable differences, it would be interesting to explore what these differences depend on, e.g., choices related to communication of this knowledge and how long individuals have worked at the firm and/or in the particular industry.

A third path would be the orientation of examining how various performance measures (e.g., ROI/ROE, profit, revenue, costs, time-to-market, and so on) are influenced by different practices for knowledge integration (e.g., Appleyard, 1996; Baxter et al., 2013; Bergek et al., 2008; Bierly & Chakrabarti, 1996; Boone & Ganeshan, 2008; De Luca & Atuahene-Gima, 2007; Subramanian & Soh, 2017; Tell, 2011; Tsai & Ghoshal, 1998; von Hippel & Tyre, 1995). It is, for example, possible to argue that the construction of models (cf. Porter, 1991), which establishes or even predicts effects from various types of interventions, is ultimately where the knowledge integration field needs to be headed.

However, the difficulty of devising instruments that enable us to sort out the false positives and false negatives is a problem for this third path (cf. 2.6.3). Simply put, there are other variables than management of knowledge integration, which also influence performance measures. Admittedly, this is a common issue for the whole strategic management domain, such as the aspiration to create a 'theory of profit' (Spender, 2014b). A conclusion from this study, however, is that the design of instruments for studies with this orientation (i.e., to study implications of knowledge integration on performance measures) should leverage both the characteristic-driven mode and the objective-driven mode. Several findings from this study could, for example, be applied to construct new 'independent' variables compared with previous studies, for example, related to the knowledge-foundation of the business idea or industry recipe.

In summary, our understanding of the purpose of this study is entering an 'intermediate' rather than 'mature' state (cf. Edmondson & Mcmanus, 2007). Thus, the first two paths are arguably more promising than the third path, in terms of contributing to a more rigorous explanation of how the objectives of a firm influence knowledge integration.

If the previous discussion of paths for research design answered *how* future research could be undertaken, the next question is *what* might be of interest to study further. For starters, the phenomena of business idea evolution and industry recipe evolution would be interesting to examine more closely. Potential normative implications for how these processes of business idea evolution and industry recipe evolution can be managed by practitioners are especially interesting. My suspicion is that there likely are more insights about this issue among practitioners than there are in academia. If so, a new understanding could emerge, i.e., by combining insights from practice with theory from academia, which is currently known by none. This kind of cycle, in which practice may inform theoretical research and theoretical research may inform practice, is an exciting prospect. The 'business model canvas' (Osterwalder et al., 2005, 2010) and later 'lean canvas' (Maurya, 2012, 2022) are illustrative examples of how this cycle may produce outputs which find their way into the practice of strategy and management.

Further research on knowledge integration also appear to benefit from applying the retrofitted notions of the business idea and industry recipe, as firm-specific and industry-specific knowledge about how and how not to manage a process, relative to the objectives of a firm. Specifically, this may lead to a greater appreciation of the commercial dynamics, which arguably permeate all firm activity, not least knowledge integration. More broadly, these two concepts are very useful to make sense of the strategic context (see 5.1.2.2), in which a focal knowledge integration process is embedded (see 5.2.6.1).

As was argued in Chapter 5 and earlier in this chapter (see 6.1.4.1), there are also good reasons to revisit the business model concept (see 5.2.6.2). To my understanding, the outlined approach of invoking knowledge integration theory to explain the longitudinal dimension of business models has not been applied in prior work on business models (e.g., Baden-Fuller & Morgan, 2010; Chesbrough & Rosenbloom, 2002; Demil & Lecocq, 2010; Hedman & Kalling, 2003; Johnson et al., 2008; Magretta, 2002; McGrath, 2010; Osterwalder et al., 2005; Sosna et al., 2010; Sund et al., 2020; Teece, 2018; Tikkanen et al., 2005; Zott et al., 2011) nor in prior work on business model innovation (Foss & Saebi, 2017; Martins et al., 2015; Massa et al., 2017; Schneider & Spieth, 2013; Spieth et al., 2014). This circumstance presents researchers with an exciting opportunity to develop the business model concept even further (Foss & Saebi, 2017, 2018; Schneider & Spieth, 2013; Zott et al., 2011). Given the amount of attention on the business model concept among both practitioners (e.g., the mentioned business model canvas and lean canvas) and researchers, such a development would likely be of interest to a large audience.

Finally, I hope that this study may inspire other researchers to further investigate the questions which the seminal 1996 special issue of Strategic Management Journal (re-)introduced into the domain of strategy and management theory (Grant, 1996b; Spender, 1996; Spender & Grant, 1996a, 1996b). The subsequent research agenda, which this study has aimed to contribute to, can hopefully advance the cause of producing theory about strategy and management which is more realistic (e.g., compared with neoclassical economics), actionable (e.g., through frameworks), and read, appreciated, and consulted among practitioners of management and strategy. Such further work may find utility in the work by or involving Richard Normann (Normann, 1971, 1975, 1977; Normann & Ramirez, 1993; Wikström & Normann, 1994), which during this study emerged as a central author concerning how knowledge integration is influenced by the objectives of a firm (cf. Casali et al., 2018; Demarest, 1997; Gibe & Kalling, 2019; Grimaldi & Grandi, 2005; Hedman & Kalling, 2003; Johansson, 2008; Massa et al., 2017; Nonaka & Toyama, 2003; Sanchez, 1999; Sanchez & Mahoney, 1996; Spender, 1989, 2014a). For example, Normann is not referenced in most contributions on the cognitive and evolutionary views on business models (e.g., Chesbrough, 2010; Chesbrough & Rosenbloom, 2002; Demil & Lecocq, 2010; Doz & Kosonen, 2010; Martins et al., 2015; Sund et al., 2020; Tikkanen et al., 2005).

7 References

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8 Appendix

8.1 Appendix A – Main interview guide for semi-structured interviews

General interview guide – first round 20180315

Presentation

Presentation of the PhD project

- High-level purpose

Presentation of the interviewee

- When did you start at Omega?
- What did you do before?
- What is your role today?

Tasks and interdependencies

Follow-up questions from the perspective of

Task characteristics

- Complexity and decomposability
- Uncertainty
- Novelty
- Frequency
- Heterogeneity

Knowledge characteristics

- Internal vs External
- Tacit vs Explicit
- Shared vs differentiated
- Related vs unrelated
- Complement vs substitute

Relational characteristics

- Social capital
- Normative social structures
- Level of interaction
- Collective identity and aspirations
- History

8.2 Appendix B – Private notes which were used alongside the main interview guide

Notes:

Do I have too many variables, should I impose some limitations already now?

In practice I ask questions within two categories:

- Tasks & interdependencies
- Process mapping (historical description)

I will try to sort every answer into one of three dimensions

- Firm level
- Org level
- Indiv level

Within each dimension (firm, org, indiv) replies can be interpreted in multiple ways, where I focus primarily on A) and b) in my preliminary framework:

a) Task characteristics (complexity, uncertainty, novelty)
   Relational characteristics (history, collective identity and aspirations, level of interaction)
   Knowledge characteristics (tacit/explicit, internal/external, shared/differentiated)

b) Coordination (even when there are no conflicts of interest)
   Collaboration (conflicts of interest)

The data I collect will include several types of components:

- Objectives
- Decisions
- Challenges (boundaries for knowledge integration)
- Solutions (mechanisms to cope with knowledge integration, e.g., types of learning activities)
- Outcomes (within the process, i.e., not in total for Alpha/Omega)

Somewhere here it becomes cumbersome. It feels like I am open for too many variables, it leads to many layers!

To meet this challenge I thus must consider: What are the answers I am ultimately seeking?

I find that the following is needed to make a meaningful analysis of the knowledge integration process:

a) A well described process in multiple dimensions. Since I point to that the context for the process matter (radical innovation, multi-level context) it is reasonable to map it, and I think the time-dimension is a good instrument to capture it. An overview of the following dimensions:
    a. Organization and decisions
    b. Technological development
    c. Business/competition/market
b) Objectives which are attempted to be accomplished: for something to be a challenge it reasonably needs to be in relation to something. It feels relatively uncomplex to capture this at the different levels
    a. Firm level (for Alpha, Beta and Omega)
    b. Org level (the purpose of functions: business development /sales, SW developers, Architects, Process, HR, and so on)
    c. Individual (the objectives and motivation of employees: salary, exciting challenge, social cohesion)
c) With a) and b) in place I can then present finding: which boundaries and mechanisms appear to be important for the management of the knowledge integration process?
    a. Present findings
        i. Boundaries
        ii. Mechanisms
    b. Sorting
        i. Firm level
        ii. Org level
        iii. Individual level
    c. Interpretation: based on theoretical framework, for example, knowledge integration characteristics
        i. Task characteristics
        ii. Relational characteristics
        iii. Knowledge characteristics

8.3 Appendix C – Refined interview guide for semi-structured interviews

David:

Hierarchy

Decision making

- Analysis paralysis
- Power/authority distribution among the parties (Omega, Beta, Alpha, OEM)

Mechanism: flexibility. In what dimensions? (roles, backlog, team belonging,)

Initial client meetings

The challenge of going from products to systems (cognitive, organizational inside/outside)

Knowledge transfer to OEMs…knowledge or persuasion?

BAPO learnings

Normative social structures:

What has highest status in Omega? Being a developer, a PAO, CPAO, strategy team, CEO

Alexander:

Revenue models – what is the latest on sub?

Beta spinoff status

Incremental emphasis → does that make it more or less clear?

Period of disruption → difficult to drive two models at the same time

Leo, based on interview with Eton:

- Who can one trust? When different opinions about the same problem among two experts
- How much of your coordination-role is ’information’ and ’intervention’?
- Alpha frustration, that you do not have the milestones they desire. How do you manage that?
- Assimilation/motivation of experts (research versus application)
- Zara (in Germany)?

Hugo:

- Decisions under uncertainty
    - For example, in Omega’s or the OEM’s cloud
    - For example, Felix ability to update the software in the car over air, continuously
- Knowledge transfer against other teams – how do you handle that?
    - Sitting next to, pedagogical material, etcetera
- Spatial dimensions
    - Detroit
    - Floor 2 with Sigma (pro and con)
- Design thinking → need or nice to have?
- ‘I could talk about innovation for more than 4 minutes’

8.4 Appendix D – Interview guide for Omega project on revenue models and offering

1 hour meeting

Alexander Intro (15 min):

Purpose of work. Scope of work.

Go through various ways one can earn money on software. Show the many alternative customer groups we could have and the value they see in our product. Definitions.

Questions (45 min): 20 TODAY & 80 FUTURE

1. Understanding of the industry and end value for the customer, where are we heading (check problems to solve list)
    a. How does the instability in the market effect the way we do business?
    b. How does the competitive outlook effect the way we do business?
    c. How does the fact that we are selling to an OEM effect the way we design our offer?
    d. How do you think users will use autonomous vehicles in the future?
    e. What are the biggest question marks in the industry according to you?
2. Understanding our product (IP, packaging, skill, org)
    a. Where are our strengths?
    b. Where are our weaknesses?
    c. What are the question marks in PD?
    d. How could we package what we have?
3. Understanding of who we could sell this to
    a. OEMs
    b. What industries do you think, after OEMs will be hit by AD?
    c. What specific customers could be interesting to talk to?
4. Understanding alternative revenue models within product fit segments
5. Ability to engage more in the process?

8.5 Appendix E – OEM customer interview guide for Omega project on revenue models and offering

External OEM customer interview guide 2017

Hi/welcome and orientation

1. Describe your role and responsibility

Problem to solve (high-level questions for orientation and get the ball rolling)

2. How would you describe your main challenges at the moment? (including electrification etc.)
3. More specifically concerning autonomous drive technology, how would you describe your main challenges at the moment?
4. What is your market outlook for autonomous drive, in terms of
    a. Customer demand
    b. Competition
    c. Regulatory/legal

Technological challenges

Would you like to describe your technological challenges in terms of

5. Hardware (architecture, processing power, memory, etc.)
6. Software (process, white spaces, areas of proficiency etc.)
7. Connectivity (i.e., hardware to enable software releases)

Organizational challenges

Would you like to describe organizational challenges related to autonomous drive, in terms of

8. Internally
    a. Structure and alignment
    b. Culture
    c. Resources and capabilities
9. Externally
    a. firm boundaries, partnerships, both legacy and going forward

Business case for autonomous drive

10. How would you describe to income side of the business case?
    a. Avoided cost for development
    b. Increased revenue (premium/differentiation, additional revenue streams)
11. How would you describe the cost side of the business case?
    a. Preferred model for paying for autonomous drive technology (subscription, licensing, etc.)
    b. Why?
    c. Which are the main obstacles given the preferred models?
    d. What kind of help is needed from Omega to make them viable?

8.6 Appendix F – Initial data collection needs before starting the case study

(From mail to Alexander (20170622), Bastian, David, and other individuals at Omega.)

Executive summary – the PhD project

The purpose of the PhD project is to advance our understanding of the process of how business models change and are developed due to the introduction of autonomous drive technology.

The focus is on business and organizational challenges rather than technological obstacles, but the evolution of the technology and influence of the external environment is of course important aspects which contribute to our understanding this phenomenon of autonomous vehicles.

The PhD project is finalized during the end of 2018, with publication during 2019.

Questions

Regarding the process of creating autonomous drive solutions, the following aspects would be interesting to learn more about through interviews:

Technical

How does the timeline look for the evolution of technology?

How have you approached issues related to data generation and application (for example, security, management, analysis)?

How has the development process changed to fit the challenges of autonomous drive/active safety?

Organizational

When and how did management attention for autonomous drive emerge? How did the journey look from exciting R&D prospect to actively pursuing investments in active safety/autonomous drive technology?

What are the challenges concerning collaboration? Both a) internally within Alpha as well as b) together with stakeholders outside your organization (public organizations, suppliers, other)

What were the main challenges in the decision-making process leading up to where we are today in Alpha autonomous drive ambitions?

Market-related

How have you approached consumer insights in the area of autonomous drive?

How has your external communication changed and what have been the main objectives and challenges?

How do you approach and analyze the competitive landscape? And how is that inferred into your internal decision making?

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