



Managing heterogeneous knowledge: a theory of external knowledge integration

Jeroen Kraaijenbrink¹ and
Fons Wijnhoven¹

¹*School of Management and Governance,
University of Twente, Enschede, The Netherlands*

Correspondence: Jeroen Kraaijenbrink,
School of Management and Governance,
University of Twente, P.O. Box 217,
Enschede 7500AE, The Netherlands
Tel: +31 53 489 5443;
Fax: +31 53 489 2159

Abstract

Knowledge integration has been theorised at the levels of organisations and inter-organisational dyads. However, no theory exists yet of the integration of knowledge from an organisation's environment. This paper addresses this void in the literature by presenting a theory of external knowledge integration. It considers organisations as open systems confronted with intra-organisational, inter-organisational, and extra-organisational knowledge heterogeneity. It presents a prescriptive theory of how organisations should deal with these three levels of heterogeneity by three external knowledge integration capabilities: knowledge identification, knowledge acquisition, and knowledge utilisation. The paper develops propositions of how organisations should balance divergent and convergent external knowledge integration capabilities to achieve flexibility, efficiency, and scope. As such, the paper builds further on Grant's seminal work and provides a prescriptive theory of external knowledge integration.

Knowledge Management Research & Practice (2008) 6, 274–286.

doi:10.1057/kmrp.2008.26

Keywords: external knowledge integration; heterogeneous knowledge; changing knowledge; divergence; convergence

Introduction

In his seminal paper on knowledge integration, Robert Grant (1996) convincingly claimed that if a firm's most important resource is knowledge, and if knowledge resides in a specialised form among individual organisational members, then the essence of organisational capability is the integration of individuals' specialised knowledge. Grant was not the first who made this claim (e.g., Drucker, 1992). However, he was the first who developed it into a theory of knowledge integration. Meanwhile, Grant's theory is accepted and applied in a growing number of publications. These publications have predominantly increased the understanding of knowledge integration in groups (Huang *et al.*, 2001; Alavi & Tiwana, 2002; Huang & Newell, 2003) and within organisations (De Boer *et al.*, 1999; Ravasi & Verona, 2001; Becker & Zirpoli, 2003; Andreu & Sieber, 2005). When it concerns knowledge integration crossing organisational boundaries, however, the theory has been less developed. At the end of his article, Grant has expressed some thoughts on a knowledge integration theory at the inter-organisational level. These ideas have been further developed in Grant & Baden-Fuller's (2004) paper in the direction of a knowledge integration theory at the level of inter-organisational dyads. However, no theory exists yet that treats the integration of knowledge from an organisation's broader environment. This means that no theory of external knowledge integration has been developed that considers organisations as truly open systems interacting with their

environment. This is a substantial limitation since organisations use external knowledge in many situations, typically those where the need for knowledge is occasional or urgent. In such situations, developing knowledge internally or building long-term alliances to integrate the knowledge is too costly and inflexible. Yet, to be able to use such knowledge, organisations will have to integrate it with the knowledge present in the firm. This means that other ways must be found to integrate external knowledge. Hence, and here we paraphrase Grant, if external knowledge is a crucial resource for organisations, and if external knowledge resides in specialised forms outside the organisation, then external knowledge integration is an essential organisational capability. Yet, as argued above, it has been under-theorised so far.

The purpose of this article is to fill this void in the literature. It builds on Grant's work and extends it towards a prescriptive theory of external knowledge integration. The paper presents external knowledge integration as the capability to deal with three levels of knowledge heterogeneity. With knowledge heterogeneity we refer, in line with Grant, to the differences in knowledge that result from the increased specialisation of individuals. As Grant argued, advancements in knowledge come with increased specialisation, because the cognitive limitations of our brains do not allow us to acquire a wide set of in-depth knowledge. However, as Grant continued, the production of goods and services typically requires the integration of a wide set of in-depth knowledge. This means that organisations face the challenge of integrating a wide heterogeneous set of specialised knowledge. Grant's knowledge integration theory focused on knowledge heterogeneity within organisational boundaries. Since external knowledge integration involves the integration of external knowledge with internal knowledge, *intra-organisational* knowledge heterogeneity also is part of external knowledge integration. A theory of external knowledge integration, though, has to deal with two additional levels of knowledge heterogeneity. First, when organisations want to use external knowledge, they face a virtually unbounded and constantly changing set of heterogeneous knowledge. Organisations will have to find it and distinguish between relevant and irrelevant knowledge. This means that organisations have to deal with *extra-organisational* heterogeneity of knowledge. Second, relevant knowledge can be embedded in and owned by organisations and individuals operating in completely different contexts and at the other side of the world. To be able to use such knowledge, organisations will have to bridge many differences between their organisation and the source of knowledge. In other words, organisations have to deal with the *inter-organisational* heterogeneity of knowledge.

This paper develops a prescriptive theory of external knowledge integration. We propose that, to deal with the three levels of knowledge heterogeneity, organisations must develop the capabilities to balance divergence and

convergence in knowledge identification, knowledge acquisition, and knowledge utilisation. Based on the principles of requisite variety, dialectic, and evolutionary theory, we develop propositions on how organisations should balance these external knowledge integration activities. The paper makes two contributions to the knowledge integration literature. First, we extend knowledge integration theory such that also external knowledge is included. Given the importance of external knowledge for many firms, this extension provides a more comprehensive explanation of how firms can gain a competitive advantage from knowledge integration. The second contribution of the paper concerns its prescriptive character. At the end of his paper, Grant explicitly argues that knowledge integration theory so far '...offers little guidance as to the management actions needed...' (Grant, 1996, p. 384). This paper contributes by developing prescriptive propositions that do provide such guidance. The paper is organised as follows. In the next section, we elaborate on the challenge of external knowledge integration. Consequently, we define external knowledge integration and the capabilities of which it is comprised. Thereafter, we compare external knowledge integration to the related concepts of knowledge transfer, inter-organisational learning, information processing, and absorptive capacity. This helps to clarify the connections and distinctions between the various concepts. The subsequent section presents the external knowledge integration theory and propositions. The paper ends with a discussion and conclusion.

The challenge of external knowledge integration

Integrating external knowledge is a challenge for organisations. To understand this challenge and its differences from internal knowledge integration, we first need to answer the question as to what is meant by external knowledge. This is certainly not a trivial question given the numerous definitions and taxonomies of knowledge that are circulating (e.g., Nelson & Winter, 1982; Nonaka, 1994; Spender, 1996; Alavi & Leidner, 2001). Like Grant (1996), we adopt a broad definition of external knowledge. We define it here as *any intellectual entity that is created by or together with an external actor*. In this definition, the 'external actor' is not necessarily another organisation. It can also be an individual. With the rising importance of the Internet as a mechanism for knowledge sharing, organisations now have access to a virtually unlimited number set of experts. The addition 'or together with' in the definition of external knowledge is important because of the tacit nature of much knowledge. Tacit knowledge cannot be simply transferred from a source to a recipient (Polanyi, 1966; Nonaka, 1994). Rather, it needs to be reconstructed by the recipient, which often takes place in close cooperation with the source (Dhanaraj *et al.*, 2004). From the literature, three further characteristics of external knowledge can be derived.

First, it is not knowledge itself but the way this knowledge is integrated in the firm that leads to a firm's competitive advantage (Grant, 1996). Dependent on how it is integrated, external knowledge can range from being a valuable resource to being an inconvenient source of uncertainty and ambiguity. We find these different perspectives on knowledge represented in several streams of literature. For example, the literature on information processing and sensemaking (Tushman & Nadler, 1978; Weick, 1995) focuses on how organisations reduce uncertainty in the knowledge they receive from their environment. Articles on absorptive capacity, knowledge brokering, and knowledge valuation, stress the value of external knowledge as a crucial resource for organisations (Cohen & Levinthal, 1990; Hargadon & Sutton, 1997; Menon & Pfeffer, 2003). From these perspectives, it can be invoked that external knowledge can both be a valuable resource as well as a cause of uncertainty and ambiguity. Its effect on a firm's competitive advantage is mediated by the way and extent to which this knowledge is integrated.

The second relevant characteristic of external knowledge concerns its boundary conditions. As Carlile (2002, 2004) has argued, the transfer and integration of knowledge across specialised functions within an organisation asks for the bridging of syntactic, semantic, and pragmatic boundaries. As we can invoke from Grant's (1996) work, such boundaries make intra-organisational knowledge integration already challenging. With external knowledge integration, though, there are additional boundaries to be crossed. An important additional boundary concerns the ownership of knowledge. Where theory on intra-organisational knowledge integration assumes ownership to be in the hands of the organisation, this is not the case with external knowledge. External knowledge is either fully or partly owned by some other organisation or individual, or it is public knowledge that is also available to others. For several reasons, organisations and individuals might have an interest in protecting their knowledge. Hence, they will intentionally raise boundaries that prevent knowledge to flow to others by protecting legal ownership (i.e., patents and copyrights), but also by secrecy or by knowledge being integrated in another organisation. When knowledge is integrated in other organisations, this means that it is embedded in those organisations, which makes it hard to acquire for other organisations. Ownership thus creates an additional boundary for integrating external knowledge. When knowledge is public, this is not the case. Since it is available to everybody, though, its competitive value might also be substantially lower and will depend even more on how and to what extent it is integrated in the organisation.

A final characteristic of external knowledge concerns the borders of knowledge entities. Three views can be distinguished here: knowledge as a single object, knowledge as a closed set, and knowledge as an open set. The first view is present in theories of information seeking (Ellis & Haugan, 1997; Wilson, 1997) and in part of the

work on knowledge management (e.g., Zack, 1998). Such literature applies a resource-based logic stressing characteristics of single knowledge objects and the processes by which such knowledge objects are found, acquired, stored, distributed, and used. In the second view, knowledge is seen as a closed set. This view is adopted in literature on internal knowledge integration (Grant, 1996) and knowledge creation (Nonaka, 1994). The focus in such literature is on how to create competitive advantage from the heterogeneous set of knowledge that is available in an organisation. This view shifts attention from managing single characteristics of knowledge (e.g., how to handle tacit knowledge) to managing the heterogeneity of knowledge (e.g., how to create value from several types of specialised knowledge). We extend this view of a knowledge set into a third view. We move from a closed systems view to an open systems view in which the set of knowledge that organisations deal with is virtually unbounded and unmapped. In such view, knowledge is considered to be an open heterogeneous set that crosses organisational boundaries. This provides organisations with a nearly unlimited set of potentially valuable specialised knowledge. Yet, it also provides them with an unlimited source of uncertainty and ambiguity.

The heterogeneity of knowledge arising from specialisation within and between organisations is a crucial source of innovation (Hargadon, 2002). Yet, there are other differences between types of knowledge that increase the challenge of integrating external knowledge. For example, external knowledge integration involves the integration of tacit and explicit knowledge (Polanyi, 1966; Nonaka, 1994), individual and social knowledge (Spender, 1996), and procedural, declarative, causal, and relational knowledge (Zack, 2001). Moreover, the knowledge to be integrated can reside in different knowledge reservoirs, such as people, tasks, tools, information technology, culture, and structures (Walsh & Ungson, 1991; Argote & Ingram, 2000). This variety of types of knowledge and knowledge reservoirs asks for different approaches of external knowledge integration. For example, while the integration of knowledge residing in a database involves explicit procedures and appropriate technologies, the integration of knowledge residing in people involves close cooperation, trust, and mutual interests. These differences in approaches make external knowledge integration a complex challenge for organisations. Dealing with all these complexities would imply a further level of granularity in this paper, which would result in less focus and more size. Therefore, we leave this for further papers and restrict this paper to the complexity that arises from the three types of heterogeneity.

External knowledge integration: definition and capabilities

In the Introduction, we identified three levels of knowledge heterogeneity in external knowledge integration: within the organisation, within the environment, and between the organisation and its environment. As we will

argue below, the challenges imposed by these three levels of knowledge heterogeneity are different. This implies that external knowledge integration involves three different organisational capabilities. In line with these three levels of heterogeneity, Kraaijenbrink & Wijnhoven (2006) and Kraaijenbrink *et al.* (2007) have defined external knowledge integration as the identification, acquisition, and utilisation of external knowledge. We will further specify this definition and the three capabilities in this section.

When organisations want to use knowledge from their environment, they face a virtually unbounded set of heterogeneous knowledge. Rather than trying to integrate all this knowledge, organisations will have to distinguish relevant and beneficial knowledge from irrelevant and unbeneficial knowledge. This heterogeneity of knowledge in the environment asks for *knowledge identification* activities. Following Kraaijenbrink & Wijnhoven (2006) and Kraaijenbrink *et al.* (2007), we define the knowledge identification capability as the capability to locate specific external knowledge relevant for the organisation. External knowledge is often embedded and contextualised in individuals or organisations that differ on aspects such as location, language, culture, and technological platform. This means that the acquisition of knowledge from external sources requires substantial efforts to bridge these differences. The second external knowledge integration capability that we therefore distinguish is *knowledge acquisition*. We define this as the capability to bridge the differences between knowledge in the organisation and knowledge in the environment. Finally, as knowledge within the focal organisation is heterogeneous as well and new external knowledge should be integrated with what is present, external knowledge integration requires activities of *knowledge utilisation*. While direction and routinisation are important here (Grant, 1996), utilisation is broader. Grant focused on converging knowledge transformation activities. As we will elaborate upon below, we consider diverging activities so inseparably connected that they

should be included in a conceptualisation of knowledge integration as well. Hence, we define knowledge utilisation as the capability to make knowledge internally accessible and usable such that it can be applied or used otherwise. The addition 'or used otherwise' is important here since not all knowledge that is integrated will be applied in the organisation. For example, organisations may identify and acquire knowledge not to apply it themselves, but to prevent competitors from applying it.

As hinted above, the divergence–convergence dimension is relevant for a theory of external knowledge integration. This dimension is found throughout the management literature. Among others, it appears in inter-firm learning (Lubatkin *et al.*, 2001, divergence vs convergence) and organisational learning (March, 1991, exploration vs exploitation). In such publications, it is argued that both divergence and convergence are needed for successful development. Divergence triggers new ideas – and as such increases heterogeneity (Mitchell & Nicholas, 2006), convergence is needed to realise these ideas. The divergence–convergence dimension is a key dimension for external knowledge integration theory because it precisely concerns the two opposite forces that organisations can use in dealing with heterogeneity. By adopting this dimension, we develop a dualistic view on the external knowledge integration process (cf. Nonaka & Toyama, 2003). The three levels of heterogeneity in external knowledge integration can provide organisations with opportunities as well as problems. Heterogeneity stimulates the generation of new ideas. As such, it is a driver for innovation. However, too much heterogeneity hinders the communication needed to turn these ideas into real goods and services (Cohen & Levinthal, 1990; Grant, 1996). Consequently, knowledge heterogeneity should be carefully managed towards a level that is suitable for the organisation, that is, that each of the three external knowledge integration capabilities involves the balancing of heterogeneity increasing activities (divergence) and heterogeneity decreasing activities (convergence). This is depicted in Figure 1.

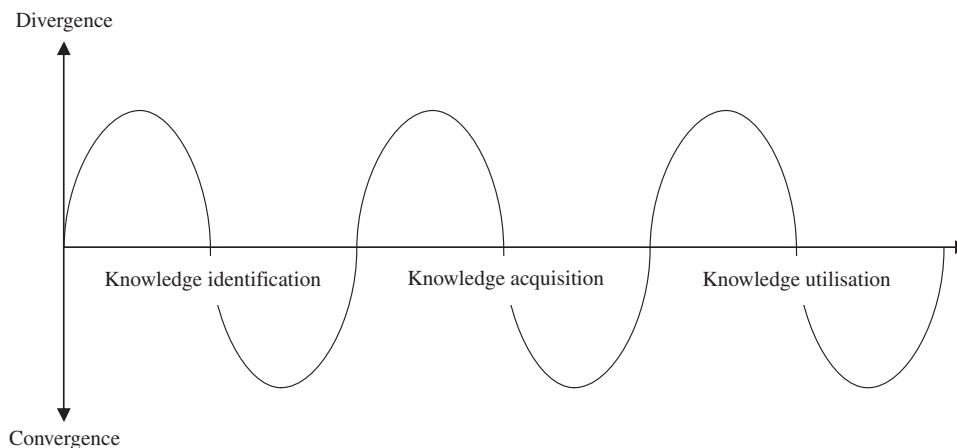


Figure 1 External knowledge integration capabilities.

In knowledge identification, divergence and convergence concern the span of attention. Diverging identification activities increase the span of attention and as such confront the organisation with more heterogeneity of knowledge. Illustrative activities are browsing (Marchionini, 1995), undirected viewing and enacting (Daft & Weick, 1984), and presentation by the source (Aguilar, 1967). Converging identification activities, on the other hand, decrease the span of attention and as such decrease heterogeneity. Examples of activities are seeking (Case, 2002), conditioned viewing and formal search (Daft & Weick, 1984), and filtering (Belkin & Croft, 1992).

In knowledge acquisition, the divergence–convergence dimension concerns the distinction between, on the one hand, activities that exploit or even increase the differences between the knowledge integrating organisation and a knowledge source, and, on the other hand, activities that decrease these differences (cf. Lubatkin *et al.*, 2001). Examples of diverging acquisition activities are knowledge accessing (Grant & Baden-Fuller, 2004) and inter-firm knowledge partitioning (Takeishi, 2002; Tiwana & Keil, 2007). In these activities, the differences between the organisation and the source are cherished and used to benefit from one another. Other diverging acquisition activities even increase the differences. Examples are inferencing (Ross Jr. & Creyer, 1992), and induction and deduction (Marchionini, 1995). By these types of activities, the integrating organisation obtains new knowledge on the basis of knowledge of the source. Since this new knowledge is different from the knowledge at the source, such activities increase the differences between the organisation and the source. Converging activities, on the other hand, decrease these differences. Examples are imitation (Rivkin, 2001), inter-organisational learning (Larsson *et al.*, 1998), and observation (Cooke, 1994). By such activities, the focal organisation's knowledge becomes more similar to that of the source because part of the source's knowledge is acquired.

Finally, in knowledge utilisation, the divergence–convergence dimension concerns the increase and decrease of heterogeneity of knowledge within the organisation. While diverging utilisation activities lead to new knowledge, converging utilisation activities facilitate the exploitation of existing knowledge. In the literature, this distinction is present in Nonaka's (1994) concept of knowledge creation and Grant's (1996) concept of knowledge integration. Examples of diverging utilisation activities are dispersion (Galunic & Rodan, 1998), brainstorming, and knowledge reuse (Majchrzak *et al.*, 2004). These activities increase the heterogeneity of knowledge in the organisation by giving different people different knowledge, by creating new knowledge, or by using knowledge in different ways than before. Converging utilisation activities, on the other hand, decrease heterogeneity of knowledge by spreading similar knowledge throughout the organisation, combining it, or disposing of it. Examples of activities are distribution

(Galunic & Rodan, 1998; as opposed to dispersion, see above), retention (Walsh & Ungson, 1991), and institutionalising (Crossan *et al.*, 1999).

Summarising the above, external knowledge integration is defined as the diverging and converging capabilities to identify, acquire, and utilise heterogeneous knowledge in the organisation, in the environment, and in the relation between the organisation and the environment. Going through an external knowledge integration process, organisations alternately increase and decrease their span of attention when identifying external knowledge. Once relevant knowledge is found, the differences between the organisation and the knowledge source are exploited by the organisation when perceived beneficial and reduced when detrimental. Consequently, the acquired knowledge is utilised in the organisation, leading to the creation of new knowledge and the integration with existing knowledge. As this conceptualisation of external knowledge integration demonstrates, external knowledge integration is a complex capability involving multiple activities performed by multiple actors. The complexity makes managing external knowledge integration to a real challenge. The crux of this challenge for managers is how to develop and match their organisation's external knowledge integration capabilities to the situation at hand. Moreover, the notion of external knowledge integration as a capability implies that organisations can learn to become better in external knowledge integration. By developing their external knowledge integration capabilities better than their competitors, organisations can gain a competitive advantage.

Related concepts

The concept of external knowledge integration is related to the concepts of knowledge transfer, inter-organisational learning, information processing, and absorptive capacity. Like external knowledge integration, each of these concepts concerns knowledge processes that cross organisational boundaries. While neither of the concepts is unambiguous or fully agreed-upon (Argote & Ingram, 2000; Lane *et al.*, 2006), they can be demarcated and distinguished. We compare them on three characteristics: (1) the key questions they address, (2) their focal unit of analysis, and (3) the main characteristic of knowledge they focus on (see Table 1).

While inter-organisational knowledge transfer is most relevant here, most theorising on knowledge transfer has been done on the intra-organisational level. Two key studies that characterise the work on knowledge transfer are Szulanski (2000) and Argote & Ingram (2000). Szulanski provided a model of the knowledge transfer process, which consists of four stages: initiation, implementation, ramp-up, and integration. Argote & Ingram, on the other hand, focused on the carriers on which knowledge is transferred: people, tasks, and tools. The key question that studies on knowledge transfer attempt to answer is the question of how one unit can benefit from

Table 1 External knowledge integration and related concepts

	<i>Knowledge transfer</i>	<i>Inter-organisational learning</i>	<i>Information processing</i>	<i>Absorptive capacity</i>	<i>External knowledge integration</i>
<i>Key question</i>	How to reuse knowledge from others	How to reuse knowledge from each other	How to deal with uncertainty in the environment	How to deploy external knowledge	How to deal with heterogeneity of knowledge
<i>Focal unit of analysis</i>	Dyad	Dyad	Single organisation	Single organisation	Single organisation
<i>Key characteristic of external knowledge</i>	Usefulness	Complementarity	Uncertainty	Newness	Heterogeneity
<i>Key publications</i>	Argote & Ingram (2000) and Szulanski (2000)	Lane & Lubatkin (1998) and Larsson <i>et al.</i> (1998)	Daft & Weick (1984) and Tushman & Nadler (1978)	Cohen & Levinthal (1990), Lane <i>et al.</i> (2006) and Zahra & George (2002)	Grant (1996) and Grant & Baden-Fuller (2004)

the knowledge of another unit. In answering that question, scholars typically focus on the dyad of source and recipient and the usefulness of knowledge of the source for the recipient.

A second relevant concept here is inter-organisational learning. Exemplar studies are Lane & Lubatkin's (1998) study on relative absorptive capacity and Larsson *et al.*'s (1998) study on collective knowledge development in alliances. Like the studies on knowledge transfer, studies on inter-organisational learning take the dyad as their unit of analysis. As an anonymous reviewer pointed out to us, this does not mean that scholars on inter-organisational learning limit their analysis exclusively to the level of dyads. Organisations may choose particular dyadic relationships to gain access to the partnering organisation's external networks and knowledge sources. Yet, the unit of analysis in such studies is the inter-organisational dyad. The key difference is that studies on inter-organisational learning focus on the mutual transfer and mutual complementarity of knowledge. The key question that is sought to answer is how two parties can learn from and with each other.

The third concept that is related to external knowledge integration is information processing. The key question in studies on information processing is how organisations can deal with uncertainty in the environment. Key contributions to the development of this concept are Daft & Weick (1984) and Tushman & Nadler (1978). Tushman & Nadler have elaborated the thesis that there should be a fit between the information processing requirements caused by environmental uncertainty and the information processing capacity of the organisation. Based on the work of Aguilar (1967), Daft & Weick have elaborated on the processes of scanning, interpretation, and learning. The concept of information processing differs from the concepts of knowledge transfer and inter-organisational learning in two important ways. Rather than taking the perspective of a dyad, the theory takes the perspective of a focal organisation and its environment. Also, rather than focusing on the usefulness of knowledge, information processing research focuses on knowledge as a source of uncertainty.

The final related concept here is absorptive capacity. While various definitions exist, absorptive capacity is generally seen as a firm's ability to recognise the value of new, external information, assimilate it, and apply it to commercial ends (Cohen & Levinthal, 1990; Zahra & George, 2002; Lane *et al.*, 2006). Absorptive capacity is argued to be a function of an organisation's prior knowledge. The key question that studies on absorptive capacity attempt to answer is how organisations obtain and use external knowledge to innovate. By its direct focus on commercial application of knowledge, absorptive capacity is more instrumental than the other concepts. Like the concept of information processing, absorptive capacity focuses on the receiving organisation. However, unlike information processing, the focus is not on the uncertainty caused by external knowledge but on the newness of knowledge as a source of innovation.

External knowledge integration has similarities with each of these four concepts. Yet, it is distinct. Similar to the concepts of information processing and absorptive capacity, external knowledge integration takes the perspective of a focal organisation. Different from information processing, however, it develops a view of organisations as integration systems dealing with heterogeneity of knowledge rather than as information processing systems dealing with uncertainty. Finally, and most crucially, the key question addressed by the concept of external knowledge integration is different: it concerns how organisations should deal with heterogeneity of knowledge in the organisation, its environment, and between the organisation and its environment.

External knowledge integration theory

As expressed in the first section, our aim is to develop a prescriptive external knowledge integration theory. Unlike positive theories, which intend to represent what is actually happening in practice, prescriptive theories express a norm or standard that ought to be followed. As such, prescriptive theories provide organisations with guidelines for how to act in particular situations. Different from prescriptions *per se*, a prescriptive theory includes an explanation of why the expressed

prescription should be followed and the assumptions under which it applies (March & Smith, 1995; Hevner *et al.*, 2004; Gregor, 2006). As outlined in the previous section, external knowledge integration covers the diverging and converging capabilities to deal with three types of knowledge heterogeneity. Given that resources are always limited in practice, we assume organisations cannot perform as many external knowledge integration activities as they like. This means, that managers have to choose which activities to perform in which situations. The prescriptive external knowledge integration theory is intended to support such decisions. It consists of prescriptive propositions as to how organisations should balance diverging and converging external knowledge integration activities. The basis for our theory is Grant's (1996) criteria of efficiency, scope, and flexibility. The basic proposition that we will develop in this section is that heterogeneity of knowledge should be compensated with scope, efficiency, and flexibility of external knowledge integration. We will construct our argument in several steps.

Knowledge heterogeneity and scope of external knowledge integration

For our first step, we go back to Grant & Baden-Fuller's article in which they remark '... as the range and diversity of knowledge increases, so integration mechanisms need to be increasingly differentiated...' (2004, p. 69). This remark is a specification of Ashby's (1956) principle of requisite variety, which says that the larger the variety of actions available to a control system, the larger the variety of perturbations it is able to compensate. When we translate this to external knowledge integration capabilities, it means that to be in control of situations in which knowledge is heterogeneous, an organisation should possess external knowledge integration capabilities with a scope that matches the amount of knowledge heterogeneity it faces. In other words, when organisations are confronted with an increase in knowledge heterogeneity, the scope of their external knowledge integration capabilities should increase as well. According to Grant, knowledge integration scope concerns the breadth of specialised knowledge that is drawn upon (Grant, 1996). It indicates how different the knowledge is that is integrated. It is assumed that the integration of a wider scope of knowledge is beneficial for the organisation, up to the point of diminishing relevance. As argued above, organisations increase external knowledge integration scope by means of divergent external knowledge integration activities. Hence, we propose that there should be a relation between knowledge heterogeneity and organisations' capabilities to perform divergent external knowledge integration activities. This relation is depicted in Figure 2. The diagonal represents a zone of external knowledge integration where heterogeneity of knowledge is matched with appropriate divergent external knowledge integration capabilities.

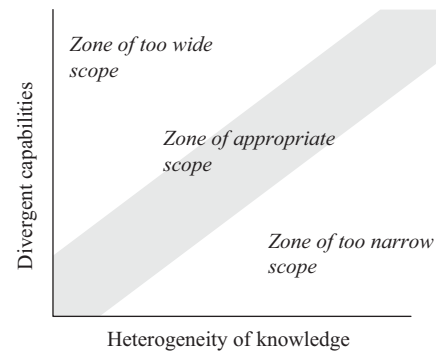


Figure 2 Knowledge heterogeneity and scope of external knowledge integration.

Proposing that heterogeneity of knowledge should be compensated with divergent external knowledge integration capabilities, raises the question of what happens if such compensation does not take place. We can identify two situations: (1) there is too much divergence in external knowledge integration capabilities and (2) there is not enough divergence in external knowledge integration capabilities. In the first case, the organisation has an excess capacity to compensate for heterogeneity that is not used. The organisation is able to deal with the heterogeneity that it is facing internally, in its relations, or in its environment, but there is a waste of resources. Moreover, as resources are limited, this takes resources away from other activities that the organisation could have performed. In the second case, the organisation does not compensate enough for the heterogeneity of knowledge. This means that the organisation loses its capability to deal with the heterogeneity of knowledge it faces. When competitors have better developed this capability, it is likely that the organisation will eventually be outperformed by a competitor. These considerations lead to our first proposition:

Proposition 1: *Heterogeneity of knowledge should be compensated with divergent external knowledge integration capabilities.*

Based on the three types of knowledge heterogeneity and the three external knowledge integration capabilities that have been discussed above, this proposition can be further specified. For knowledge identification, it implies that heterogeneity of knowledge in the environment should be compensated with a well-developed divergent knowledge identification capability. Heterogeneity of knowledge in the environment exists, for example, when an organisation has many different actual and potential suppliers, customers, or competitors. To stay knowledgeable about what these other players do, organisations need a wide span of attention – and thus a well-developed divergent knowledge identification capability. When too well-developed, resources are wasted that could have been deployed otherwise. Alternatively, when underdeveloped, the organisation runs the risk of not

being aware of important knowledge at a particular customer or supplier, and being less informed than its competitors.

For knowledge acquisition, the heterogeneity of knowledge in the relationship is relevant. When the differences between knowledge in the organisation and knowledge at the source are large, it will be difficult for the organisation to acquire knowledge from that source. In such situations, organisations must put great efforts in finding and bridging knowledge differences. For that, organisations need a well-developed divergent knowledge acquisition capability. For example, they must be able to effectively partition knowledge between their organisation and the source and effectively induce from knowledge at the source. While too much divergence here will lead to a waste of resources, too little divergence is likely to result in incomplete acquisition and under-usage of the source's knowledge.

For knowledge utilisation, Proposition 1 means that, if there is much knowledge heterogeneity in the organisation, this should be compensated with a well-developed divergent knowledge utilisation capability. Thus, we argue that high heterogeneity of knowledge in the organisation should not firstly be compensated by converging utilisation activities, but by diverging utilisation activities. The reason for this is that insufficient divergence leads to unused heterogeneity of knowledge in the organisation. Similar to what has been said above, overcompensation of heterogeneity of knowledge will result in a waste of resources on utilisation activities. Based on these considerations, the following three specifications of Proposition 1 are made:

Proposition 1a: *Heterogeneity of knowledge in the environment should be compensated with a divergent knowledge identification capability.*

Proposition 1b: *Heterogeneity of knowledge between an organisation and a knowledge source should be compensated with a divergent knowledge acquisition capability.*

Proposition 1c: *Heterogeneity of knowledge in the organisation should be compensated with a divergent knowledge utilisation capability.*

These propositions express the point that heterogeneity of knowledge should in first instance be compensated with divergence rather than convergence. This might sound counter-intuitive. When there is much heterogeneity, it seems appropriate to counteract this heterogeneity by converging external knowledge integration activities. However, when doing so, organisations fail to make use of the richness of the set of knowledge they face that results from its heterogeneity. Since it is exactly the effective usage of this heterogeneity that leads to innovations (Hargadon, 2002), organisations would destroy opportunities for innovation would they reduce heterogeneity too much or too early.

External knowledge integration scope and efficiency

As mentioned above, the criterion of knowledge integration scope concerns the breadth of specialised knowledge that is drawn upon (Grant, 1996), indicating how different the knowledge is that is integrated. Opposed to this, Grant's criterion of efficiency concerns the extent to which the specialist knowledge of organisational members is accessed and utilised (Grant, 1996). Knowledge integration would be maximally efficient when all knowledge of specialists is accessed and used in the organisation. According to Grant, such efficiency can be achieved when communication between specialists is unproblematic. This is the case, for example, when there is much common knowledge between individuals or when there is little need for communication. In such situations, highly specific knowledge can still be efficiently integrated.

All other things being equal, there is, in principle, a negative relationship between the two criteria, meaning that efficiency tends to decline when the knowledge scope increases. The wider the scope of external knowledge integration, the greater is the heterogeneity of knowledge involved. When heterogeneity is greater, the level of common knowledge will be lower, which makes external knowledge integration less efficient. This is not to say that the relation between scope and efficiency is fixed. As organisations develop their external knowledge integration capabilities, they can learn to increase their scope and efficiency at the same time. Yet, there always remains a tension between the two. This tension implies that organisations will have to find a balance between scope and efficiency. This does not mean that at every moment in time the two should be balanced. Rather, as external knowledge integration is a dynamic process that evolves over time, the two should be balanced over time. This means that it can be very useful for organisations to focus on scope at one moment and to focus on efficiency at another moment. For example, it seems likely that organisations entering a new market initially focus on divergent external knowledge integration to increase scope and later on focus on convergent external knowledge integration to increase efficiency.

The argument that divergent and convergent external knowledge integration activities should be balanced over time resembles evolutionary theories of organisation (Nelson & Winter, 1982; Weeks & Galunic, 2003). In analogy with biological evolution, such theories argue that progress is made through a process of variation, selection, and retention. While we sympathise with such theories, they are not fully applicable to a theory of external knowledge integration. Evolutionary theories assume blind variation followed by selection. In the case of external knowledge integration, we would not promote blind variation. Rather, based on their existing knowledge, organisations are capable of purposefully increasing variation in specific ways. Zollo & Winter (2002) have called this 'generative variation'. Also, external knowledge integration is not necessarily a

selection process. A selection process would assume that from a particular set of heterogeneous knowledge, certain knowledge is chosen. This means that the knowledge is created first and then selected. This is, however, not always the case. Rather than selected, knowledge is also created by combining several knowledge elements. In other words, rather than being selected, knowledge is sometimes synthesised. This focus on synthesis and generative variation is core to dialectic theories. Such theories assert that progress is made through a process of thesis, antithesis, and synthesis (Hegel, 1890; Popper, 1940). The focus of such theories on synthesis rather than selection is a useful extension of the evolutionary view. However, we would harm the richness and potential of external knowledge integration when we would reduce the variety increasing external knowledge integration activities towards a dichotomy. In the external knowledge integration process divergence is not restricted to confronting a thesis with an antithesis. Rather, variety can be increased in more ways, for example, by looking for complementary knowledge in addition to contradictions in knowledge.

This discussion on evolutionary and dialectic theories leads us to a view on external knowledge integration as a combined process of divergence by generative variance increasing activities and convergence by selective and synthesising activities. This view also suggests that, over time, divergent external knowledge integration should be compensated with convergent external knowledge integration, and vice versa. Too much divergence means that the scope of knowledge involved in external knowledge integration gets out of hand and that efficiency is lost. Alternatively, too much convergence means that external knowledge integration narrows down too much. This might lead the process to get stuck. Also, it can result in organisations to become vulnerable because they rely on a too narrow scope of knowledge. The balancing of divergent and convergent external knowledge integration capabilities is expressed in Proposition 2 and depicted in Figure 3. The diagonal in Figure 3 represents a zone where divergent and convergent external knowledge integration capabilities are in balance; that is, a zone in which external knowledge integration is efficient and

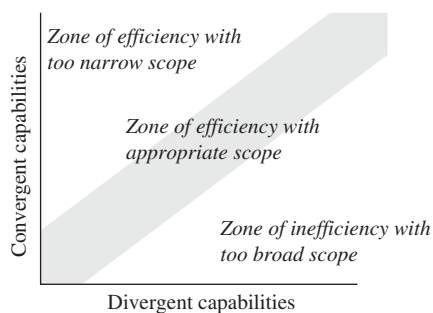


Figure 3 Scope and efficiency of external knowledge integration.

has sufficient scope. Off-diagonal we find the situations of too much divergence and too much convergence.

Proposition 2: *Divergent external knowledge integration capabilities should be compensated with convergent external knowledge integration capabilities, and vice versa.*

Again, we can specify this proposition for each of the three external knowledge integration capabilities. For knowledge identification, a balance between divergent and convergent activities means that the span of knowledge in the environment that the organisation considers is wide enough to cover the knowledge an organisation could need and narrow enough to remain manageable. Would there be too much divergence in knowledge identification, the organisation would lose its way in the breadth of knowledge available in the environment. Would there be too much convergence, the organisation would miss too much relevant knowledge in the environment.

In balanced knowledge acquisition, there are enough differences in knowledge between the organisation and a source to be beneficial for the organisation and enough similarities to be able to acquire knowledge from the source. When there is too much divergence in knowledge acquisition, and organisation is confronted with knowledge that is so different that it cannot efficiently acquire it anymore. Alternatively, if there is too much convergence between the organisation and the source, then the acquisition loses its relevance. While in such situations knowledge can be acquired very efficiently, knowledge is so similar to the knowledge the organisation already has, that it is not worth acquiring it anymore.

Finally, balanced knowledge utilisation means that the scope of knowledge in the organisation is sufficiently broad and heterogeneous to generate competitive advantage from and sufficiently narrow to do this efficiently. In a situation where there is too much divergence, the organisation will become incoherent and fragmented. Alternatively, in situations where there is too much convergence, the organisation is likely to be less innovative than it should be. This leads to the following three propositions:

Proposition 2a: *Divergent knowledge identification capabilities should be compensated with convergent knowledge identification capabilities, and vice versa.*

Proposition 2b: *Divergent knowledge acquisition capabilities should be compensated with convergent knowledge acquisition capabilities, and vice versa.*

Proposition 2c: *Divergent knowledge utilisation capabilities should be compensated with convergent knowledge utilisation capabilities, and vice versa.*

External knowledge integration efficiency and flexibility

The final criterion that Grant put forward is flexibility. It concerns an organisation's ability to extend existing organisational capabilities such that they encompass new types of knowledge and its ability to reconfigure existing knowledge into new types of organisational capabilities (Grant, 1996). The first type of flexibility relates to the extent to which an organisation is able to deal with new knowledge it has not faced before. There is a tight connection between this type of flexibility and external knowledge integration scope: being confronted with new knowledge means an increase in the scope of knowledge. The second type of flexibility is tightly connected to external knowledge integration scope as well, but in a different way. This type of flexibility concerns an organisation's ability to do new things with the knowledge it already has access to. This flexibility depends to a large extent on the scope of knowledge an organisation has access to: a greater scope of knowledge implies a greater number of new combinations that can be made. As this discussion demonstrates, external knowledge integration scope and flexibility are tightly connected in a way that causes no tensions between them. An increase in external knowledge integration scope is associated with an increase in external knowledge integration flexibility. For our prescriptive external knowledge integration theory this means that balancing between them is not an issue. Therefore, we leave the relation between external knowledge integration scope and flexibility out of our further discussions.

A tension, however, does exist between external knowledge integration efficiency and flexibility. External knowledge integration efficiency increases as a result of convergent external knowledge integration activities. At the same time, too much focus on efficiency can make an organisation lose its flexibility. When organisations strive for efficient external knowledge integration, this means that they focus on knowledge from only a few sources – internal or external – and attempt to integrate as much as possible of the knowledge from these sources. This makes them highly dependent on a few knowledge sources, which tend to reduce the organisation's flexibility. The other way around, an increase in external knowledge integration flexibility involves the risk of reduced efficiency. In line with what was remarked above about the relation between scope and efficiency, also the relation between efficiency and flexibility is not fixed. Rather, there is a tension between them that organisations can, and should learn to overcome. This is expressed in our final propositions, which are depicted in Figure 4.

Proposition 3: *Convergent external knowledge integration capabilities should be compensated with flexibility of external knowledge integration capabilities, and vice versa.*

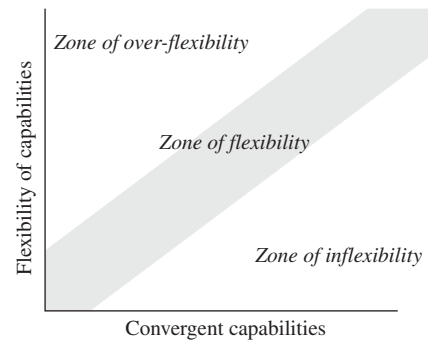


Figure 4 Efficiency and flexibility of external knowledge integration.

Proposition 3a: *Convergent knowledge identification capabilities should be compensated with flexibility of these knowledge identification capabilities, and vice versa.*

Proposition 3b: *Convergent knowledge acquisition capabilities should be compensated with flexibility of these knowledge acquisition capabilities, and vice versa.*

Proposition 3c: *Convergent knowledge utilisation capabilities should be compensated with flexibility of these knowledge utilisation capabilities, and vice versa.*

Discussion and conclusion

An important strength of organisations compared to individuals and markets is their ability to flexibly and efficiently integrate a wide scope of heterogeneous knowledge. Grant has made us aware of this strength and has provided the rudiments for a knowledge integration theory. In this paper, we have built further on the work done and proposed a prescriptive theory of external knowledge integration. We have presented a view of organisations as open knowledge integration systems that are confronted with heterogeneous knowledge in their environment, in their relations, and within their own boundaries. The paper has suggested that dealing with these three levels of heterogeneity requires three types of external knowledge integration capabilities: knowledge identification, knowledge acquisition, and knowledge utilisation. The paper has proposed how organisations should balance divergence and convergence in these three capabilities to achieve external knowledge integration scope, efficiency, and flexibility. These propositions and the consequences of unbalanced external knowledge integration are summarised in Table 2.

By providing a prescriptive theory of external knowledge integration, the paper makes two contributions to the literature. First, by its inclusion of external knowledge, it extends Grant's knowledge integration theory. Given the importance of external knowledge for many firms, this extension provides a more extensive explanation of how

Table 2 Consequences of unbalanced external knowledge integration

<i>Proposed balance</i>	<i>Consequences of undercompensation</i>	<i>Consequences of overcompensation</i>
<i>Heterogeneity of knowledge should be compensated with divergent capabilities</i>		
In knowledge identification	Not aware of important knowledge	Inefficient waste of resources
In knowledge acquisition	Incomplete acquisition	Inefficient waste of resources
In knowledge utilisation	Unused heterogeneity in the organisation	Inefficient waste of resources
<i>Divergent capabilities should be compensated with convergent capabilities</i>		
In knowledge identification	Losing way in the breadth of knowledge	Missing relevant knowledge
In knowledge acquisition	Too much difference to acquire knowledge	Acquisition of too similar knowledge
In knowledge utilisation	Incoherence and fragmentation	Lack of innovation
<i>Convergent capabilities should be compensated with flexibility</i>		
In knowledge identification	Inability to switch knowledge sources	Inefficient waste of resources
In knowledge acquisition	Inability to acquire new knowledge	Inefficient waste of resources
In knowledge utilisation	Inflexibility in using knowledge	Inefficient waste of resources

firms can gain a competitive advantage from knowledge integration. The second contribution concerns the prescriptive character of the proposed theory. So far, knowledge integration theory has provided little guidance for managers (Grant, 1996). By developing prescriptive propositions, this paper offers guidance for how to balance diverging and converging knowledge integration capabilities.

While external knowledge integration is related to the concepts of knowledge transfer, inter-organisational learning, information processing, and absorptive capacity, it is different in important ways (see Table 1). Most notably, it is different in the key question it addresses and the associated view on the nature of external knowledge. By focusing on knowledge as a heterogeneous set, the paper combines the views of knowledge as a potentially valuable resource and of knowledge as a disturbing factor. Following Grant's logic, it is assumed that the value of knowledge depends on what organisations do with it. Unlike resource-based theories, knowledge integration theory therefore does not draw attention to the valuing, transfer, and use of particular knowledge objects. Rather, it draws attention to how organisations cope with the heterogeneous sets of knowledge they are confronted with. By this different focus, the external knowledge integration concept complements the conceptual arena of organisational knowledge processes.

Focusing on knowledge as a set rather than as a single entity is helpful to tease out the differences between internal and external knowledge. So far, these differences have not received much attention in the literature. External knowledge is often characterised by the reasons that organisations use it. Such reasons include the rapid depreciation of internal knowledge (Argote *et al.*, 1990), the innovative nature of external knowledge (Von Hippel, 1988; Cohen & Levinthal, 1990), and the different status attributed to external knowledge (Menon & Pfeffer, 2003). While such reasons explain why organisations use external knowledge, they hardly char-

acterise the external knowledge itself and its differences with internal knowledge. With our discussion of ownership and openness, we have illuminated some of the important differences. We hope this will trigger further theorising on the nature of external knowledge.

While progress has been made in enhancing the understanding of external knowledge integration processes and their relationship with external knowledge integration scope, efficiency, and flexibility, much remains to be done. We have to find out whether there is indeed an optimal way of dealing with the three types of knowledge heterogeneity and whether the suggested consequences of sub-optimal external knowledge integration hold in practice. Even though based on a law-like principle such as that of Ashby's principle of requisite variety, we should be careful in accepting the propositions as they are. We might have overlooked important mediating or moderating factors that make that heterogeneity of knowledge should not always be compensated or that make that diverging external knowledge integration activities should not be compensated with converging external knowledge integration activities. When present, such factors should show up in empirical tests of the propositions. Putting the propositions to the test requires the operationalisation of the three types of heterogeneity and a further decomposition of external knowledge integration capabilities into a measurable set of diverging and converging capabilities.

When empirical studies provide support for the propositions, additional work remains to be done. The propositions provide managers with guidelines on how to balance divergence and convergence in knowledge integration. However, they do not inform managers yet on the concrete actions to be taken. This means that further recommendations are to be developed as to what actions and organisational changes managers should make to improve their organisation's external knowledge integration processes.

References

- AGUILAR FJ (1967) *Scanning the Business Environment*. The MacMillan Company, New York, London.
- ALAVI M and LEIDNER DE (2001) Review: knowledge management and knowledge management systems: conceptual foundations and research issues. *MIS Quarterly* **25**(1), 107–136.
- ALAVI M and TIWANA A (2002) Knowledge integration in virtual teams: the potential role of KMS. *Journal of the American Society for Information Science and Technology* **53**(12), 1029–1037.
- ANDREU R and SIEBER S (2005) Knowledge integration across organizations: how different types of knowledge suggest different 'integration trajectories'. *Knowledge and Process Management* **12**(3), 153–160.
- ARGOTE L, BECKMAN SL and EPPEL D (1990) The persistence and transfer of learning in industrial settings. *Management Science* **36**(2), 140–154.
- ARGOTE L and INGRAM P (2000) Knowledge transfer: a basis for competitive advantage in firms. *Organizational Behavior and Human Decision Processes* **82**(1), 150–169.
- ASHBY WR (1956) *An Introduction to Cybernetics*. [WWW document] (1999): <http://pcp.vub.ac.be/books/IntroCyb.pdf> ed. Chapman & Hall, London.
- BECKER MC and ZIRPOLI F (2003) Organizing new product development: knowledge hollowing-out and knowledge integration – the FIAT auto case. *International Journal of Operations & Production Management* **23**(9), 1033–1061.
- BELKIN NJ and CROFT WB (1992) Information filtering and information retrieval: two sides of the same coin? *Communications of the ACM* **35**(12), 29–38.
- CARLILE PR (2002) A pragmatic view of knowledge and boundaries: boundary objects in new product development. *Organization Science* **13**(4), 442–445.
- CARLILE PR (2004) Transferring, translating, and transforming: an integrative framework for managing knowledge across boundaries. *Organization Science* **15**(5), 555–568.
- CASE DO (2002) *Looking for Information: A Survey of Research on Information Seeking, Needs, and Behavior*. Academic Press, San Diego, CA.
- COHEN WM and LEVINTHAL DA (1990) Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly* **35**(1), 128–152.
- COOKE NJ (1994) Varieties of knowledge elicitation techniques. *International Journal of Human-Computer Studies* **41**, 801–849.
- CROSSAN MM, LANE HW and WHITE RE (1999) An organizational learning framework: from intuition to institution. *Academy of Management Review* **24**(3), 522–537.
- DAFT RL and WEICK KE (1984) Toward a model of organizations as interpretation systems. *Academy of Management Review* **9**(2), 284–295.
- DE BOER M, VAN DEN BOSCH FAJ and VOLBERDA HW (1999) Managing organizational knowledge integration in the emerging multimedia complex. *Journal of Management Studies* **36**(3), 379–398.
- DHANARAJ C, LYLES MA, STEENSMA HK and TIHANYI L (2004) Managing tacit and explicit knowledge transfer in IJVs: the role of relational embeddedness and the impact on performance. *Journal of International Business Studies* **35**(5), 428–444.
- DRUCKER PF (1992) The new society of organizations. *Harvard Business Review* **70**(September/October), 95–104.
- ELLIS D and HAUGAN M (1997) Modeling the information seeking patterns of engineers and research scientists in an industrial environment. *Journal of Documentation* **53**(4), 384–403.
- GALUNIC DC and RODAN S (1998) Resource combinations in the firm: knowledge structures and the potential for schumpeterian innovation. *Strategic Management Journal* **19**, 1193–1201.
- GRANT RM (1996) Prospering in dynamically-competitive environments: organizational capability as knowledge integration. *Organization Science* **7**(4), 375–387.
- GRANT RM and BADEN-FULLER C (2004) A knowledge accessing theory of strategic alliances. *Journal of Management Studies* **41**(1), 61–84.
- GREGOR S (2006) The nature of theory in information systems. *MIS Quarterly* **30**(3), 611–642.
- HARGADON AB (2002) Brokering knowledge: linking learning and innovation. *Research in Organizational Behavior* **24**, 41–85.
- HARGADON AB and SUTTON RI (1997) Technology brokering and innovation in a product development firm. *Administrative Science Quarterly* **42**(4), 716–749.
- HEGEL GWF (1890) *Lectures on the Philosophy of History*. Bell, London.
- HEVNER AR, MARCH ST and PARK J (2004) Design science in information systems research. *MIS Quarterly* **28**(1), 75–105.
- HUANG JC and NEWELL S (2003) Knowledge integration processes and dynamics within the context of cross-functional projects. *International Journal of Project Management* **21**, 167–176.
- HUANG JC, NEWELL S and PAN S-L (2001) The process of global knowledge integration: a case study of a multinational investment bank's Y2K program. *European Journal of Information Systems* **10**, 161–174.
- KRAAIJENBRINK J and WIJNHOFEN F (2006) External knowledge integration. In *Encyclopedia of Knowledge Management* (SCHWARTZ DG, Ed), pp 180–187, Idea Group Reference, Hershey, etc.
- KRAAIJENBRINK J, WIJNHOFEN F and GROEN AJ (2007) Towards a Kernel theory of external knowledge integration for high-tech firms: exploring a failed theory test. *Technological Forecasting and Social Change* **74**(8), 1215–1233.
- LANE PJ, KOKA BR and PATHAK S (2006) The reification of absorptive capacity: a critical review and rejuvenation of the construct. *Academy of Management Review* **31**(4), 833–863.
- LANE PJ and LUBATKIN M (1998) Relative absorptive capacity and interorganizational learning. *Strategic Management Journal* **19**, 461–477.
- LARSSON R, BENGTSOON L, HENRIKSSON K and SPARKS J (1998) The interorganizational learning dilemma: collective knowledge development in strategic alliances. *Organization Science* **9**(3), 285–305.
- LUBATKIN M, FLORIN J and LANE P (2001) Learning together and apart: a model of reciprocal interfirm learning. *Human Relations* **54**(10), 1353–1382.
- MAJCHRZAK A, COOPER LP and NEECE OE (2004) Knowledge reuse for innovation. *Management Science* **50**(2), 174–188.
- MARCHIONINI G (1995) *Information Seeking in Electronic Environments*. Cambridge University Press, Cambridge.
- MARCH JG (1991) Exploration and exploitation in organizational learning. *Organization Science* **2**(1), 71–87.
- MARCH ST and SMITH GF (1995) Design and natural science research on information technology. *Decision Support Systems* **15**, 251–266.
- MENON T and PFEFFER J (2003) Valuing internal vs external knowledge: explaining the preference for outsiders. *Management Science* **49**(4), 497–513.
- MITCHELL R and NICHOLAS S (2006) Knowledge creation through boundary-spanning. *Knowledge Management Research & Practice* **4**(4), 310–318.
- NELSON RR and WINTER SG (1982) *An Evolutionary Theory of Economic Change*. The Belknap Press of Harvard University Press, Cambridge, MA, London, England.
- NONAKA I (1994) A dynamic theory of organizational knowledge creation. *Organization Science* **5**(1), 14–37.
- NONAKA I and TOYAMA R (2003) The knowledge-creating theory revisited: knowledge creation as a synthesizing process. *Knowledge Management Research & Practice* **1**(1), 2–10.
- POLANYI M (1966) *The Tacit Dimension*. Cox & Wyman Ltd., London.
- POPPER KR (1940) What is dialectic? *Mind* **49**(196), 403–426.
- RAVASI D and VERONA G (2001) Organising the process of knowledge integration: the benefits of structural ambiguity. *Scandinavian Journal of Management* **17**, 41–66.
- RIVKIN JW (2001) Reproducing knowledge: replication without imitation at moderate complexity. *Organization Science* **12**(3), 274–293.
- ROSS Jr. WT and CREYER EH (1992) Making inferences about missing information: the effects of existing information. *Journal of Consumer Research* **19**(1), 14–25.
- SPENDER J-C (1996) Organizational knowledge, learning and memory: three concepts in search of a theory. *Journal of Organizational Change Management* **9**(1), 63–78.
- SZULANSKI G (2000) The process of knowledge transfer: a diachronic analysis of stickiness. *Organizational Behavior and Human Decision Processes* **82**(1), 9–27.
- TAKEISHI A (2002) Knowledge partitioning in the interfirm division of labor: the case of automotive product development. *Organization Science* **13**(3), 321–338.

- TIWANA A and KEIL M (2007) Does peripheral knowledge complement control? An empirical test in technology outsourcing relations. *Strategic Management Journal* **28**(6), 623–634.
- TUSHMAN ML and NADLER DA (1978) Information processing as an integrating concept in organizational design. *Academy of Management Review* **3**(3), 613–624.
- VON HIPPEL E (1988) *The Sources of Innovation*. Oxford University Press, New York, Oxford.
- WALSH JP and UNGSON GR (1991) Organizational memory. *Academy of Management Review* **16**(1), 57–91.
- WEEKS J and GALUNIC C (2003) A theory of the cultural evolution of the firm: the intra-organizational ecology of memes. *Organization Studies* **24**(8), 1309–1352.
- WEICK KE (1995) *Sensemaking in Organizations*. Sage Publications, London, New Delhi.
- WILSON TD (1997) Information behaviour: an interdisciplinary perspective. *Information Processing & Management* **33**(4), 551–572.
- ZACK MH (1998) Managing codified knowledge. *Sloan Management Review* **40**(4), 45–57.
- ZACK MH (2001) If managing knowledge is the solution, then what's the problem?. In *Knowledge Management and Business Model Innovation* (MALHOTRA Y, Ed), pp 16–36, Idea Group Publishing, U.S.A./U.K..
- ZAHRA SA and GEORGE G (2002) Absorptive capacity: a review, reconceptualization, and extension. *Academy of Management Review* **27**(2), 185–203.
- ZOLLO M and WINTER SG (2002) Deliberate learning and the evolution of dynamic capabilities. *Organization Science* **13**(3), 339–351.

About the authors

Jeroen Kraaijenbrink is assistant professor at NIKOS, the Dutch Institute for Knowledge Intensive Entrepreneurship at the University of Twente. His research focuses on high-tech entrepreneurship, knowledge management, and business development in networks. Next to papers published in several books and international journals, Jeroen has co-authored a book on knowledge integration in knowledge intensive small- and medium-sized enterprises.

Fons Wijnhoven is associate professor of Knowledge Management and Information Systems at the University of Twente. He researches the development and exploitation of information services and organisational memories in the University's Center of Telematics and IT. In the last decade, over 50 of his articles appeared in academic journals and peer reviewed conference proceedings. He published books on organisational learning, IT impact assessment, organisational memories, and knowledge integration.