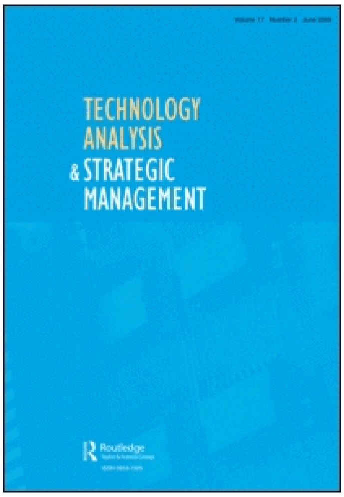

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Strategic Alliance Networks and Innovation: A Deterministic and Voluntaristic View Combined

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ABSTRACT *Over the past decades we have witnessed a tremendous growth in the number of strategic technology alliances and a growing importance of interfirm collaboration in the high-tech sectors. The literature on these topics has grown accordingly. In this respect, our paper serves two aims. One is to provide an overview of the consensus on key issues in this vast body of literature. Second is to identify some major gaps in this literature that may inform future research. In serving these aims, we first discuss the dominant structuralist perspective that stresses the role of embeddedness, but which also reflects a deterministic stance as if firms are subject to an exogenous structure. In contrast, we also explore a more voluntaristic view of how firms may possibly shape their network in view of achieving their strategic aims. This view also seems better able to capture change and network dynamics, an issue that has been largely ignored by the structuralist view.*

1. Introduction

Over the past decades we have witnessed a tremendous growth in the number of strategic technology alliances in the high-tech sectors. Especially, the number of alliances aimed at technological learning and knowledge creation, has grown rapidly since the mid 1980s (see Figure 1). We define strategic technology alliances as 'cooperative agreements for reciprocal technology sharing and joint undertaking of research between independent actors that keep their own corporate identity during the collaboration'.[1] They are strategic in the sense that they affect the long-term goals of the companies such as knowledge acquisition and technology development. To obtain these goals, strategic alliances and interfirm networks are an effective organizational form that allows firms to combine and integrate complementary knowledge and capabilities from a diversity of actors.[2]

Firms tend to use these technology alliances to reduce costs of R&D, to transfer technology in order to improve innovative performance, to reduce time-to-market or to search

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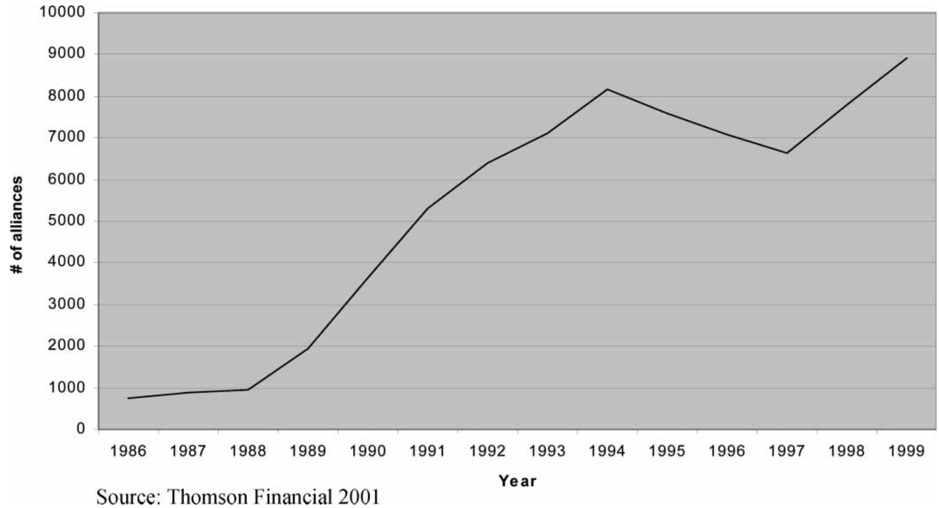

Figure 1. Growth in the number of alliances

for new technological opportunities.[3] In addition, they are also considered to be efficient vehicles for external knowledge acquisition.[4] In the last decade, research on alliances has primarily focused on the question of *why and when* alliances are formed.[5] In other words, the focus has been on the so-called exogenous factors that cause alliance formation. Interdependence and complementarities have been addressed here as the most common explanation for firms forming inter-organizational ties.[6] These resource dependency perspectives[7] posit that external resource scarcity is the most important reason for engaging in collaborative agreements.[8] As a consequence, networks increasingly provide an alternative to a more self-contained form of organization or to 'standard' market transactions.[9]

More recently, the strategic alliance literature has made progress in advancing our understanding of *how* inter-alliance dynamics—the so-called endogenous factors—affect the intent of creating, building and sustaining collaborative advantage through alliance formation.[10] This endogenous dynamic refers *to with whom specifically* alliances are formed.[11] This reflects the embeddedness perspective which views alliance networks as networks of social relations. Embeddedness refers to the structure of a network of social relations that can affect the firm's economic action, outcomes and behaviour and that of its partners to whom it is directly or indirectly linked.[12]

The combined body of research on both exogenous and endogenous reasons of alliance formation has shown that a firm's embeddedness in networks matters for its economic and innovative action, and that it positively affects corporate performance in terms of growth,[13] speed of innovation,[14] organizational learning[15] and reputation.[16] So, the literature has arrived at consensus concerning the reasons why and how alliance networks are formed, and their associated positive effects on firms. However, two major shortcomings can be observed here. One is that the received wisdom in the literature reflects a rather deterministic stance as if firms are subject to an exogenous network structure that unilaterally directs their behaviour and performance. Another shortcoming is that it reflects a static view and ignores change in alliances networks and the antecedents and consequences of this change.

To address these shortcomings, this paper aims to provide an overview of the most recent literature on interfirm networks and innovation by the following two steps. One is to provide an overview of agreement on key issues as advanced by the literature. Second is to identify some major gaps in this literature that may inform future research. A central theme in our analysis is formed by the debate in the literature on what constitutes an optimal network structure, once it has been formed. As we will show, there are two opposed views here: the social capital view of Coleman *vs* the structural hole view of Burt.[17] Our key argument is that each view contains validity under specific conditions. We will explore this role of conditions, on the one hand, by building on the existing literature that considers how alliance networks constrain and shape firm action and, on the other hand, by examining how firms may shape these alliance network structures. Given the vast body of literature dealing with networks, an important limitation is that we confine ourselves to the academic literature that deals with strategic technology alliances from the perspective of *learning and innovation*.

This paper is structured as follows. In Section 2 we discuss the central debate in the literature between two opposed views on how firms may optimally benefit from network embeddedness. This debate forms the basis for the subsequent sections in which we explore the role of conditions regarding their implications for optimal network embeddedness. To differentiate between conditions, we distinguish between three levels of analysis, namely the group-, the network- and industry-level (see Figure 2).

Based on this differentiation, we analyse how each level may inform us on the validity of two views *vis-à-vis* one another. Therefore, we focus in Section 3 on the group level by discussing group-based competition and cooperation. In Section 4, we discuss the role of the industry level by differentiating between exploration and exploitation. In this respect, Sections 3 and 4 reflect a more deterministic stance as if firms are subject to an exogenous structure that unilaterally shapes possibilities for learning and innovation. To counter this, Section 5 then takes the reverse perspective by considering the dynamics of networks, where we consider how network characteristics and industry conditions may change through acts of firms. Here we discuss how exploration and exploitation build on each other and how this may be induced by firm action. In this respect, Section 5 reflects a more voluntaristic perspective and we will explore how far it sheds new light on the validity of the two opposed views on network

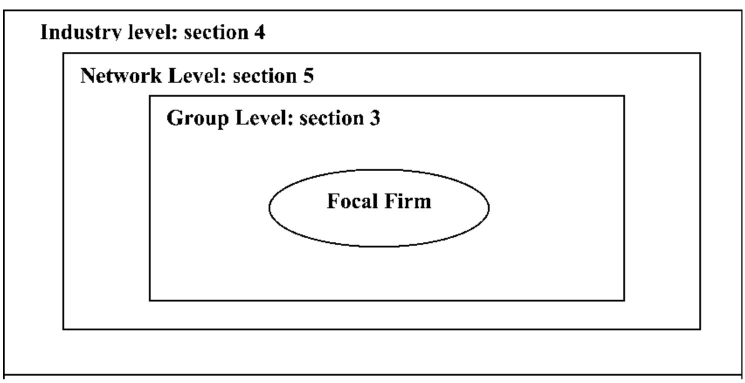

Figure 2. Conceptual model for differentiating between various levels of analysis

optimality. Finally, in Section 6, we come up with our main findings and draw a number of conclusions.

2. Two Views on Optimality of Network Embeddedness

A central debate in the network literature is on how network structures, once formed, facilitate the attainment of desired outcomes for their members. The key question here is whether networks should be sparse or dense, or put differently, whether ties should be redundant or non-redundant. On the one hand, we find the *structural hole theory* of Burt[18] which claims that firms can reap rents from the absence of ties among its contacts. According to Burt, there are costs associated with maintaining contacts and therefore efficiency can be created in the network by shedding off redundant ties and selectively maintaining only a limited set of ties that bridge 'structural holes'. This view is at odds with the *social capital theory* of Coleman[19] who claims that firms benefit from cohesive (or redundant) ties with their alliance partners. According to Coleman, density (or 'closure') facilitates the role of social capital that allows for reputation effects, trust, social norms and social control.

In both claims, and in their normative implications, we can observe a strong universalistic tone, which abstracts from any kind of context. As we consider network embeddedness from a perspective of learning and innovation, the universal nature of these claims is in contrast with arguments as advanced by evolutionary economics. Here it is argued that processes of learning and innovation are subject to selection forces by the institutional environment and that selection is assumed to take place in relation to the distinctive structure of this institutional environment, reflecting the assumption of local optimality instead of universal optimality.[20] As a consequence, it may not come as a surprise that in this debate between Burt's view and Coleman's view, the empirical evidence is mixed. McEvily and Zaheer found evidence against redundancy in an advice network, for the acquisition of capabilities.[21] Ahuja on the other hand found evidence against structural holes, for innovation in collaboration.[22] Walker, Kogut and Shan in their study found evidence in favour of cohesion, for innovation in biotechnology.[23] In view of these apparently inconsistent findings, subsequent studies have taken a 'contingency' approach,[24] investigating environmental conditions that would favour one view over the other.[25] In other words, the two views on optimality may well both be true as their value seems to vary in different settings or in the context of different tasks or purposes.[26] In other words, the question is not so much 'who is right', but 'who is right under which conditions'? Unfortunately, systematic insights in which type of condition is relevant and how they influence network optimality have remained absent in the literature until now. Therefore, we will explore the question of what kind of condition is relevant and how they may inform us on the validity of each view. Based on that we will formulate a number of propositions that may serve as suggestions for future research.[27]

3. Introduction to Group-based Competition

The embeddedness perspective has especially focused on cooperation but has largely ignored the competitive tension among alliances. In this section we focus on such competitive aspects. More specifically, we focus on groups of partners that compete with other groups within the same industry. We therefore take on a group level perspective and we will abstract from the industry- and network level (see Figure 3).

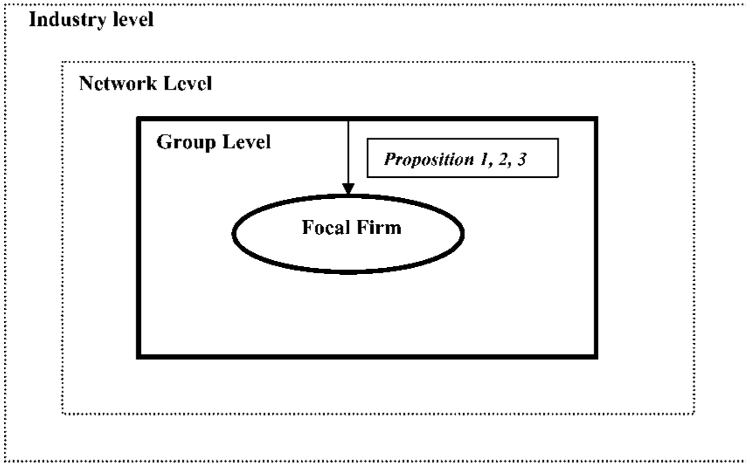

Figure 3. Focus on group-level

3.1. General Background and Converging Insights

The rapid increase of strategic technology alliances has set in a new era of external technology competition among networks of *multiple* alliances. It is now commonplace to observe technological competition between firms in a group, linked via alliances, against another alliance group. Research by Gomes-Casseres and by Doz and Hamel is among the first to have explored the increasing frequency of technology collaboration as a reflection of a fundamental shift from the traditional form of competition of dyadic alliances (firm *vs* firm) to a new form of multiple alliances (group *vs* group).[28] In this way, these scholars have provided a base for this largely unexplored field of study. However, as global competition continues to intensify, a more comprehensive understanding of this new form of group-based technological rivalry is necessary.[29] Research so far has largely focused on the mixed motives of ‘competition plus cooperation (co-opetition)’ in alliances and its implications for dependence, trust and mutual benefit, or has examined the implications of trust, opportunism, partner rivalry and sustained cooperation as a means of achieving competitive benefits.[30] Despite its insightful focus on the alliance as a vehicle for ‘co-opetition’, this line of research has not yet begun to incorporate the external competitive environment in which alliances compete.

Today, ‘competition through cooperation’ has become the foundation of a firm’s attempt to gain innovation and learning advantages through technology competition among networks of *multiple* alliances, especially in high tech sectors. By establishing multiple collaborative agreements, firms tend to compete intensely with each other in several areas they are active in, resulting in ‘co-opetition’ behaviour.[31] Thus, a firm’s alliances can be instruments to withstand competition—by making enemies partners—but can also impose stronger competition on others, as winning the alliance race entails access to better partners, resources or patents.[32] As these cooperative technology agreements among competitors proliferate,[33] technology competition becomes an indispensable part of a firm’s strategy. This actual explosion of collaborative agreements has led to a new form of competition: group *vs* group rather than company *vs* company.[34] See also Figure 4, which provides an illustration of the microelectronics industry.

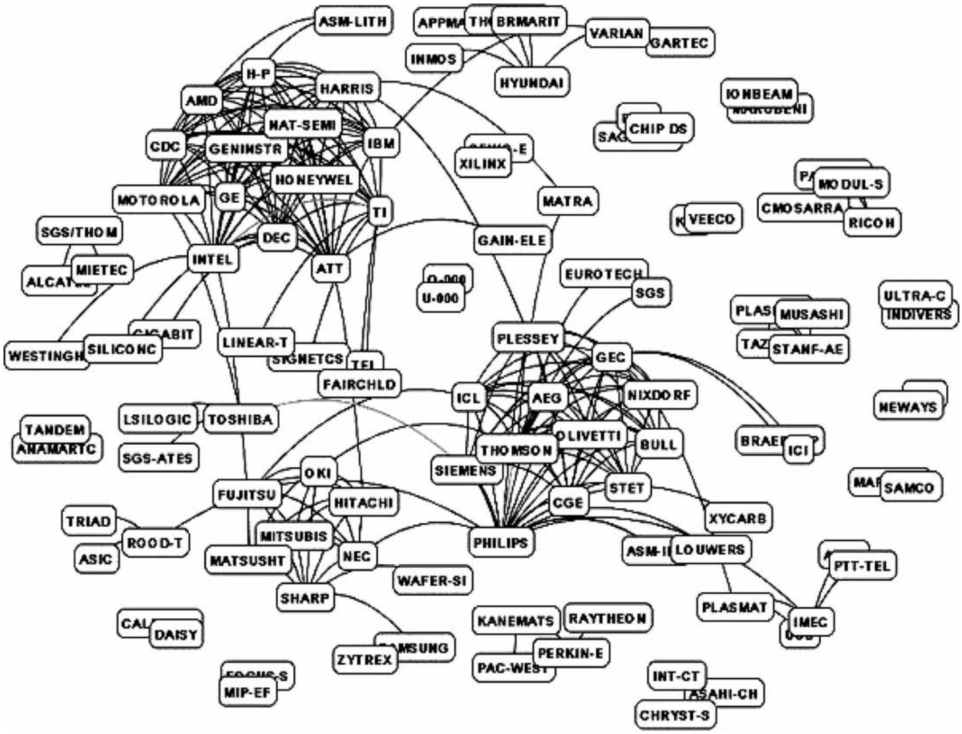

Figure 4. Alliance blocks in the microelectronics industry

An important reason behind the formation of these technology-driven constellations is typically related to technology competition. Technology competition takes the form of multiple partners, i.e. firms linked with each other through strategic alliances in groups or constellations[35] 'competing against other groups and against traditional independent firms'.[36] Through multiple R&D collaboration in alliance blocks, innovators can capture the full benefit of their innovative activity through spillovers and externalities, as they now are able to share the costs and revenues of R&D projects, which can serve as an incentive to conduct further R&D.[37] Other reasons that lead to group formation entail establishing industry standards, as a result of standard battles between firms, as well as (re)positioning strategies of companies.[38] A common theme behind these motivations is taking advantage of economies of scale and scope.[39] However, as global competition continues to intensify, a more thorough understanding of this new form of group-based technological rivalry is required.[40]

The force underlying such group formation can best be understood in terms of the social capital view as endorsed by Coleman. His argument suggests that being part of a dense and redundant network is advantageous for innovative performance, because it involves trust and cooperation among its members in view of joint innovative efforts. Relying on other players in the group gives better chances for innovative renewal as a result of spillover effects, which enables block members to tap into each other's knowledge base. In this way block members exploit and deepen their existing capabilities by linking up with firms in their own technology cluster to improve their innovative performance. At the same time, however, such strong coherence within groups may lead to competition between groups. This leads to the question what are such competitive effects of these processes of group formation?

3.2. Unsettled Issues

A relatively understudied phenomenon in the embeddedness perspective is that alliance formation is not only driven by cooperation between firms, but also by the internal competitive tension among alliances. Here the academic literature has generally focused on bilateral (dyadic) alliances. In examining this relationship between competition and cooperation, research has largely focused upon the characteristics of the individual alliance, arguing that it is important to acknowledge the mixed-motive nature of 'competition plus cooperation' (co-opetition) of alliances and its implications for dependence, trust, and mutual benefit. Here, research has either focused on the performance/financial benefits of alliance formation[41] or examined the implications of trust, opportunism, partner rivalry, and sustained cooperation as a means of achieving competitive benefits.[42] Although this approach has served to advance our understanding of such *internal* competitive implications considerably, it ignores the *external* competitive implications of alliance relationships. In other words, despite its insightful focus on the alliance itself, this line of research has been primarily introspective. It has not yet begun to incorporate the external competitive environment in which alliances compete, namely the competitive effects of alliance network formation processes on partners and competitors at the group level. Understanding these issues is important as they have substantial implications for the competitive dynamics of technology-based industries. This means we have to include the external competitive environment in which alliances compete by investigating the competitive effects of alliance network formation at the group level.

To address how alliance group formation induces a competitive effect on rival groups, we differentiate between a competitive effect in terms of the degree to which rival's opportunities to form alliances are foreclosed and in terms of the degree to which the resource base available to industry participants decreases.[43] Following the two opposed views as endorsed by Burt and Coleman, we distinguish between two types of strategies and will analyse the implications of each strategy for both types of competitive effects.

When following Burt's recommendations, firms should create access to non-redundant ties. In other words, they should invest in contacts *beyond* the group. There may be two possibilities here, namely to engage in downstream or in upstream alliances. Downstream alliances link firms in technology-based industries to sources of complementary assets downwards in the value chain, often in view of commercialization of technology. An example is the pharmaceutical biotechnology industry in which small, technology-oriented biotech firms cooperate with large pharmaceutical companies that 'own' distribution channels and/or marketing expertise. Here, these types of alliances typically do not pose a high foreclosure risk to their rivals, as large pharmaceutical firms often maintain alliances with lots of different biotech firms simultaneously. Moreover, these marketing and distribution activities are very scale- and scope intensive, which forms an economic argument why these downstream firms have to work together with multiple and different players in the industry. Hence, as a result of spillovers, these alliances increase the resources available to partners and rivals in the industry. In other words, extending the alliance portfolio with downstream alliances is likely to have a limited effect on the competitive intensity in the industry. We therefore suggest the following proposition:

> **Proposition 1:** *If an alliance block extends its alliance portfolio with downstream alliances in order to commercialize technology or increase accessibility to distribution channels, this is likely to have a limited effect on the competitive intensity in the industry.*

Upstream vertical alliances can be formed by allying with universities or other research institutions to create access to novel sources of state-of-the-art technological expertise. This results in an infusion of scientific input into the industry, which expands the resource base and lowers the competitive intensity. However, because of lack of scale and scope economies in research projects, universities generally do not collaborate with more than one biotech firm at a time. In this way, it is unlikely that spillovers will occur to the rivals of the allying firms and as a consequence, partners of the allying firms cannot benefit from the knowledge available. In the case of biotechnology, biotech firms' exclusive alliances with upstream partners, such as universities and research institutes, foreclose that their rivals can access those partners, which has an increasing effect on the competitive intensity in the industry.[44] Thus, if an alliance block extends its alliance portfolio with upstream alliances (to research institutions) in order to get access to leading edge technology, this is likely to have a more moderate effect on the competitive intensity in the industry, when compared with downstream alliances. Our second proposition therefore reads as follows:

> **Proposition 2:** *If an alliance block extends its alliance portfolio with upstream alliances (e.g. research institutions) in order to get access to leading-edge technology, this is likely to have a moderate effect on the competitive intensity in the industry*

In contrast, following Coleman's view, it is argued that firms should replicate ties *within* their group in view of the build up of social capital. This entails the creation of alliances that link firms to others in the industry, horizontally across value chains. In comparison to the up- or downstream (vertical) alliances as mentioned above, these alliances do not tap into resources outside of the focal industry. Horizontal alliances thus have no productive effect on the resources available to the industry.[45] Moreover, as the number of horizontal alliances with the same partner type increases, this may lead to a situation of strategic gridlock[46] where the number of eligible partner diminishes as a result of overcrowding in this field.[47] Rivals thus face a rapidly shrinking pool of eligible and desirable partners, which increases the competitive dynamics in the industry.[48] Therefore, we suggest our third proposition:

> **Proposition 3:** *If an alliance block extends its alliance portfolio with horizontal alliances (competitors), this is likely to have a major effect on the competitive intensity in the industry*

4. Role of Context: Exploration and Exploitation

In this section we focus on the industry level and discuss its role by differentiating between exploration and exploitation, cf. March's distinction.[49] More specifically we are interested

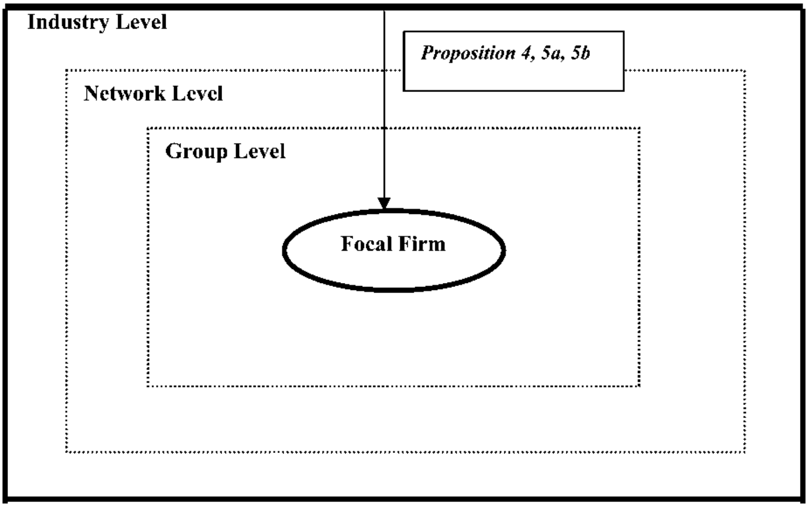

Figure 5. Focus on the industry level

in how these conditions affect the possibilities for learning and innovation for firms, and which view on the role of network embeddedness (Burt *vs* Coleman) has most relevance here (see Figure 5).

4.1. General Background and Converging Insights

In the literature, there is mounting empirical evidence that the specific relationship between embeddedness and innovation can be found in industries as diverse as chemicals,[50] biotechnology,[51] telecommunications, semiconductors,[52] textile,[53] personal computers[54] and banking.[55] More recently, some studies have started to unravel this notion of embeddedness in order to understand in what specific ways it contributes to a firm's innovation performance. Here, characteristics of partners have been studied such as their innovativeness[56] as well as the properties of alliances such as the role of formal governance mechanisms, equity *vs* non-equity alliances[57] or the role of repeated contacts.[58] Beyond the dyad level, studies at the network level have shown that the properties of an alliance network also affect innovation. Here it has been shown that apart from the number of direct ties[59] also a firm's indirect ties[60] and the redundancy among these ties[61] affect its innovation performance.

Following these studies, the prevailing 'embeddedness logic' entails the insight that alliance formation is based on building preferential relationships characterized by trust, stability and rich exchange of information between partners.[62] It is asserted that network formation proceeds through the formation of new relationships, building on the experience with existing firm ties. By investing in these social relations through the replication of their existing ties, firms build up social capital.[63] So, embeddedness and the social capital derived from that are thus by their very nature dependent on history.[64] Social capital generates returns as it enables firms to access and capture the embedded resources in their social relations.[65] In this way the network becomes a growing repository of information on the availability, reputation, competencies and reliability of prospective partners.[66] In most of these studies, alliances are characterized as channels for the diffusion and sharing of technological knowledge. Alliances are considered as a mechanism that enables knowledge sharing,[67] information exchange,[68] information-gathering[69] or information-processing and screening.[70] In other words, an important function of alliances is that they function as 'pipelines' through which information and knowledge flows between firms.[71]

This focus on the diffusion potential of alliances may not be surprising, as implicit in most studies on the role of embeddedness is that it has been understood under conditions of relative environmental stability. Here, embeddedness refers to routinization and stabilization of linkages among members as a result of a history of exchanges and relations within a group or community.[72] Under such structure-reinforcing conditions, the role of embeddedness is increasingly well understood.[73] These conditions connect with March's category of exploitation in which environmental uncertainty is rather limited and the focus is on the refinement and extension of existing competences and technologies.[74] The rationale for teaming up with partners then is formed by possibilities to obtain complementary know-how[75] and/or to speed up the R&D process in industries where time to market is crucial. Here, cooperation is attractive as partners have a good understanding of the relevant issues at hand[76] and alliances enable a rapid diffusion among partners, enhancing the efficiency and speed of cooperation.[77] This raises the question how to understand the role of network embeddedness in view of exploration that can be characterized by a break away from the established way of doing things, with a focus on the discovery and experimentation of new technologies.[78]

4.2. Exploration: Unsettled Issues

By its nature, exploration is not about efficiency of current activities, but rather forms an uncertain process that deals with the search for new, technology based business opportunities,[79] which requires production of new insights and knowledge.[80] This points to a different role of a firm's alliance network, namely its recombination potential in view of *new* knowledge creation rather than its function as a channel for diffusion of *existing* information and knowledge in view of exploitation. Existing literature has largely ignored this role of alliances for novelty creation and is therefore unable to explain the development of new knowledge and competencies.[81] Therefore it seems to be very important to create a better understanding of the context of exploration and to study its effects on optimal network embeddedness.

Following Schumpeter, new combinations can be considered as to originate from the recombination of both existing and novel parts of knowledge.[82] This implies that for exploration of such novel combinations, a firm's alliance network needs to bear an inherent tension in it, as firms are faced with a dual task. On the one hand, they need to develop access to cognitively distant sources of knowledge and in this way create access to novelty. This requires an emphasis on diversity and disintegrated network structures, which is related to Burt's argument stressing the benefits of access to non-redundant contacts to obtain novel information.[83] This has been stressed in the literature thus far.[84] On the other hand though, firms need to make sure that such novel knowledge, once accessed, is evaluated and when proven to be valuable, is adequately absorbed and related to its existing knowledge base and skills.[85] This process seemingly favours more homogenous network structures in view of integrating the diverse inputs obtained from distant partners.[86] Here, a dense structure enables a rapid diffusion across partners and in this way supports possibilities for 'triangulation'. In this way, the value of the acquired novelty can be assessed, which enhances an efficient absorption.[87] Moreover, such a dense structure creates a potential for social control, based on informal mechanisms such as social norms, reputation and so on, to prevent opportunistic behaviour, which is important for this absorption process. This is more in line with Coleman's view stressing the benefits of redundant network structures.[88]

This combination of redundant ties and non-redundant ties in view of for exploration is overlooked in the literature thus far. In earlier studies, the effect of non-redundant ties was considered,[89] however, without taking into account in how far this effect was conditioned by existing strong ties. Our arguments imply that there is only an effect of non-redundant ties in exploration when a firm also disposes of 'sufficient' redundant ties, indicating that in exploration it is the *combination* of existing, redundant ties and new, non-redundant ties that pays off.[90] Apparently, apart from a Burt 'rent in exploration', we anticipate that there may also well be a Coleman 'rent at work'. This suggests the following proposition:

> **Proposition 4:** *Under conditions of exploration, the use of non-redundant ties will be most effective in combination with redundant ties.*

4.3. Exploitation: Unsettled Issues

In exploitation, the focus is on the refinement and strengthening of its existing technology base and competencies. In general, in exploitation, dominant designs have emerged and technological and market uncertainty have decreased.[91] This enables the codification of product knowledge that diffuses more widely across the industry.[92] This makes process innovation an important way to achieve competitive advantage, leading to a focus on more incremental, process-based innovations.[93] Firms pursuing such a strategy might need specific and more fine-grained information that will provide a deeper knowledge of the particular process technology. Such process innovations generally entail more tacit knowledge that is best exchanged within more durable relations and trust-based relations.[94] Their partners have to be trusted before they can touch the 'heart' of the company, especially in the case of core technology. Moreover, in exploitation there is generally a stronger focus on competition so that potential partners may also be potential competitors. Exploitation therefore seems to favour Coleman's closure argument, stressing the benefits for redundancy as it provides a potential for trust-building and social control. Therefore we suggest the following proposition:

> **Proposition 5a:** *Under conditions of exploitation, the replication of existing ties in a redundant network is most effective.*

However, the relevance of Coleman's closure argument seems to be only part of the full story. In exploitation, considerations of efficiency are crucial, because competition has shifted to competition on price, with new entrants in the emerging market.[95] As argued by Burt, there are costs associated with maintaining contacts.[96] Therefore, the drive for efficiency in exploitation requires the elimination of redundant relations. In other words, there is a need for a less *dense* structure. The increased codification of knowledge furthers diffusion without the need for relation-specific investments of mutual understanding. This enables a less dense structure, since now one can identify what competencies are and will remain relevant, who has those competencies, and who is likely to survive in the industry.[97] Investments shift to large-scale production, distribution systems and brand name, which are all long-term, and increase in size and economic life. In view of such large and often sunk investments, with a long economic life, and to maintain efficient division of labour, network structure is likely to be stable. This suggests the following proposition:

Proposition 5b: *Under conditions of exploitation, a non-redundant network is most effective.*

At first sight, propositions 5a and 5b seem to be in contradiction. Proposition 5a stresses the benefits of redundancy in view of tacit knowledge exchange and trust building, conform Coleman, whereas proposition 5b stresses the benefits of non-redundancy in view of efficiency, which is in line with Burt's considerations. Which of the two claims holds is difficult to tell upfront. In exploitation, evidence has been found both for the benefits of redundancy[98] as well as for non-redundancy.[99] Again, we anticipate that also for exploitation there may be an industry effect at work in how exploitation 'settles' in specific industries. So, to verify these two contrasting propositions, it seems useful to bring in such an industry perspective by studying in which industries firms generally favour social control (redundancy) over efficiency (non-redundancy), or the other way around.

5. Firm's Action: From Exploitation to Exploration

In this section we consider how network characteristics and industry conditions may change through acts of firms. More specifically, we discuss how a move from exploitation

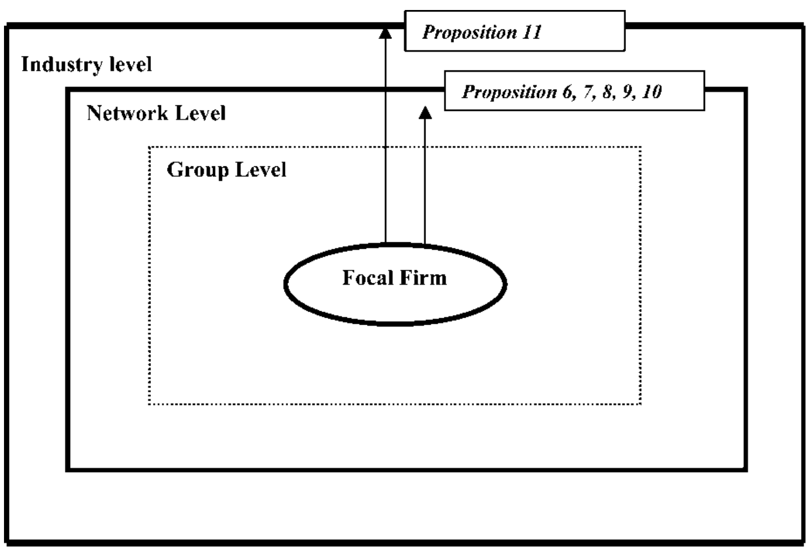

Figure 6. Effects of firms' action on network level and industry level

towards exploration may be induced by firm's actions, reflecting a more voluntaristic view (see Figure 6).

5.1. General Background and Converging Insights

Exploitation is generally considered to become dominant when technological variety that emerges from exploration is reduced, for example in the case of the emergence of a *dominant design*.[100] The establishment of such a dominant design significantly lowers technological uncertainty in the sector. It generally leads to the emergence of a new technological regime in which radical technological development is substituted by more focused, incremental and cumulative improvements along a specific technological trajectory,[101] which is competence enhancing.[102] This 'supports' the way the industry is functioning and the bases of competition, increasingly reinforcing the existing *status quo*.[103] Basically, this transition from exploration to exploitation can be considered as a 'structure reinforcing process'[104] with major consequences for the formation and functioning of alliance networks. Such a structure-reinforcing process at the industry level increasingly provides pressures to conform to the *status quo*, in 'organizational isomorphism'.[105]

As argued in Section 4, under such relatively stable conditions of exploitation firms tend to develop closed networks featuring strong, cohesive ties through frequent interaction. Strong ties[106] are solid, reciprocal and trustworthy relationships. They tend to create a large basis of trust and intimacy between the partners.[107] Since trust is an important basis for knowledge sharing and joint learning, firms are expected to be more productive in joint innovative activities. As those firms invest a substantial amount of time and energy to establish these strong relationships, changing transaction partners in the short run is not likely, since it involves substantial switching costs and implies the risk that existing relationships will dissolve.[108] Thus, when trustworthy partners are readily available, searching for or switching to new partners is difficult and costly.[109] Firms rather replicate their existing ties within their technological community than search for new ones.[110]

Furthermore, this repeated alliance formation in an alliance network based on strong ties through local search processes that characterize exploitation, leads the densely connected firms to mimic behaviour and develop similar preferences.[111] Similarity can encourage interaction and can be the cause of attraction. Scholars refer to this process as 'interaction breeds similarity' and 'similarity breeds attraction'.[112] So, in this process social capital drives the network to self-organize, self-transform and self-reinforce. The network actually becomes a growing repository of information on the availability, reputation, competencies and reliability of prospective partners.[113] In other words, these are Coleman rents 'pur sang', from which firms may benefit accordingly.

However, enjoying such benefits may come at a price as a serious risk is lurking. The enabling effect of embeddedness in alliance formation can turn into a paralysing effect as those firms may become 'locked into' these closed parts of the network: they only rely on partners in their own closed social system[114] or technological community. Then, over time those firms may start to suffer from 'over-embeddedness',[115] caused by relational inertia and the increasing similarity of firms' knowledge bases within the closed parts of the network. As a consequence, opportunities will diminish and potentially even disappear altogether.

The interesting question now is how one gets away from such over-embeddedness as well as from the existing dominant designs in technology and prevailing dominant logics of organization and competition.

5.2. Unsettled Issues: From Exploitation to Exploration

Here we focus on the question of how firms can make the transition from a sole focus on exploitation towards a focus on exploration. In various strands of literature there is still a strong focus on the role of 'local' search for organizational knowledge, reflecting exploitation. Evolutionary theory strongly emphasizes this path-dependent search for organizational knowledge that closely relates to past R&D outcomes and activity.[116] In the innovation literature, there is dominant focus on the working out of novelty, towards a 'dominant design', and in doing this transition process from exploitation to exploration is largely neglected.

Recently, some recent studies have elucidated that firms need to move beyond local search and engage in exploration in order to stay competitive in the long run.[117] These studies address the importance of creating access to distant and heterogeneous sources of knowledge but have ignored how such access can be created and how this affects a firm's alliance network. So, an important issue now is to develop an attempt to go inside the 'black box' of this transition process and to study how firms may move from exploitation to exploration and what are the implications for their alliance network. As a general idea one can argue that firms in exploitation need to move away from these core rigidities in dense networks and engage in relations with non-redundant contacts. Such partners may provide access to novel information,[118] which yields the potential for exploration of such novel combinations,[119] In this respect, firms that line up with outsiders may generate more opportunities for exploration than when replicating ties within their existing technological 'community'. We therefore propose to follow Burt here and suggest the following proposition:[120]

> **Proposition 6:** *When moving from exploitation to exploration, firms that create ties that are non-redundant with their existing network will be more innovative than firms that replicate existing ties.*

A next question now is in how far possibilities to create non-redundant ties are equally spread across firms in the alliance network. The network literature is quite inconclusive about how network position influences the ability to form non-redundant ties. According to one view, a move towards exploration instigates a structure-loosening process in which a peripheral position would be more beneficial.[121] Being at the periphery may be more beneficial as selection forces exerted by the existing network, such as the expectation of loyalty and shared norms of reciprocity in the alliance group, are generally less stringent here than in the group core.[122] As a consequence, a peripheral position may create more possibilities for all kinds of leeway and to experiment with ties outside the group. More central firms may not always have this option, as social pressure and loyalty to the existing group may pre-empt them from doing this. Here, central firms need to make an explicit trade-off between moving beyond their existing network to access new technology that can enhance their innovative performance *vs* the disadvantage of negative reputation effects that result from leaving. This may be especially difficult for such centrally positioned firms given their commitments to existing partners and technology, and this may be generally less the case for more peripheral firms. In this way, peripheral players may more easily create access to new information, which implies greater opportunities for learning. As a consequence, we can expect that the peripheral players are more innovative than their central counterparts, when moving from exploitation towards exploration. This suggests the following proposition:

> **Proposition 7:** *When moving from exploitation towards exploration, peripheral firms enjoy more opportunities to initiate the formation of non-redundant ties than central firms.*

When accessing novel knowledge through such non-redundant contacts, peripheral firms may be able to create new combinations that can lead to the development of innovations with potentially disruptive consequences for existing technology and dominant designs.[123] This may lead to a structure-loosening process in which established positions diminish in importance as former central players, if they keep replicating existing ties, are increasingly relegated towards the periphery. In contrast, former peripheral players may move towards a newly emerging network core as they are more and more in the midst of action.[124] As a consequence, the level of network centralization, i.e. the degree to which the network shows a tendency of a single firm (or a limited number of firms) to be more central than all others, will decrease when moving from exploitation towards exploration. Regarding such consequences of firms' actions for the network level, we suggest the following proposition:

> **Proposition 8:** *When moving from exploitation towards exploration, network centralization will decrease.*

However, an opposing view may hold as well. According to this view, it may be easier for central players to access novel information held by outsiders.[125] Central firms become generally better informed about what is going on in the network.[126] Moreover, such central players are more visible and powerful in the network and have more direct ties than less central players. This enhances their status and attractiveness to others as their central position serves as a signal of their qualities as well as their experience and ability in strategic partnering.[127] For outsiders, i.e. firms that are non-redundant as seen from the existing network, it may be attractive to cooperate with such high-status, central firms as their status may spillover to them so that they gain in legitimacy.[128] In this way, central firms can reinforce their centrality, which again leads to a further increase of network centralization. Based on this, we suggest the following two propositions:

> **Proposition 9:** *When moving from exploitation towards exploration, central firms enjoy more opportunities to initiate the formation of non-redundant ties than peripheral firms.*
>
> **Proposition 10:** *When moving from exploitation towards exploration, network centralization will increase.*

In terms of the validity of the arguments of Burt *vs* Coleman, propositions 7 and 9 are fully in line with one another. Both propositions clearly predict reflect a Burt rent when engaging in non-redundant ties when moving towards exploration. The question is, however, which position will be most advantageous to create such ties. This may again depend to some extent on the type of industry. Moreover, another possibility may be that *both* central and peripheral positions can engage in non-redundant contacts but that this will yield *different* outcomes. Being at the periphery generally implies that one is outside the immediate sight of dominant and more central players. Because of this, selection forces to comply with dominant designs and existing systems of production, organization, technical standards and so on, may be somewhat less stringent. Hence, deviating from such prevailing 'industry recipes'[129] becomes easier.[130] As a consequence, firms at the periphery may enjoy more freedom to experiment freely with different kinds of non-redundant partners. In contrast, central firms may have large sunk costs in the existing technology and may therefore explore to a more limited degree. Regarding such consequences of firms' actions for the industry level, we suggest our final proposition:

> **Proposition 11:** *When engaging in relations with non-redundant contacts, outcomes of exploration by peripheral firms will be more disruptive when compared with their central counter parts.*

6. Summary and Conclusions

The aim of this paper has been to provide an overview of the most recent literature on strategic alliance networks with respect to interfirm learning and innovation. First we have provided an overview of key issues in this vast body of alliance literature, while a second step was to identify some major gaps in this literature that may inform future research. In this respect, we refer to Figure 7 that schematically portrays what these two steps have delivered.

As the figure shows, there is ample agreement on why and when alliances are formed (exogenous factors), as well as on how and with whom (endogenous factors). Regarding the role of endogenous driving forces, insights have meanwhile also converged regarding the role of competition in bilateral alliances (dyadic perspective). The same applies to the role of embeddedness, which has been increasingly well understood under conditions of relative environmental stability. Overall this reflects the received wisdom in the literature and it is here where most of the agreement can be found. Beyond this point, however, the literature is still in strong disagreement what constitutes an optimal network structure once it has been formed. According to the social capital view of Coleman, a dense network structure is most beneficial in situations when trust building, social control and recurrence are important. In contrast, the structural hole view of Burt advances the benefits of non-dense, or non-redundant, network structures in view of efficiency and the possibilities to create access to novel knowledge. In the literature, the empirical findings show a mixed picture, with evidence pointing in both directions.

In this respect, a central claim of this paper is that both views may well be true but that their validity is dependent upon the environmental context. Although several studies have meanwhile acknowledged such a contingency argument,[131] systematic insights in relevant conditions and in their specific effect on optimal network embeddedness are lacking. In this paper we have discussed this role of specific conditions from two different angles. One is that we followed the dominant view in the literature that takes on a deterministic perspective by considering how environmental conditions determine network optimality. Here we differentiated between the group-, network and industry-level. A second approach was taken by developing a more voluntaristic view that aims to understand how such environmental conditions may change through acts of firms. Moreover, we considered the associated implications for optimal network embeddedness. Based on this combination of views, we have reviewed the literature and identified four important gaps. Each gap

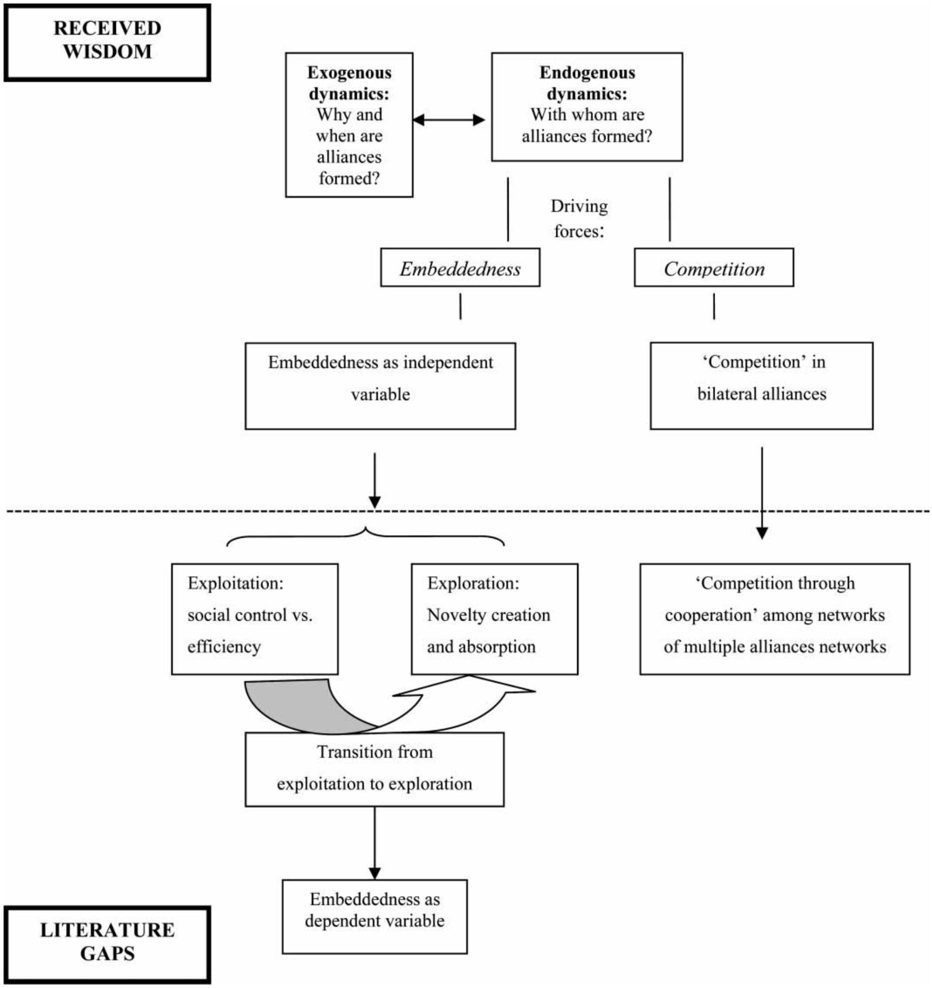

Figure 7. Overview of received wisdom and literature gaps

specifies conditions that may shed a different light on the validity of the claims by Burt and Coleman. See Tables 1 and 2 that summarize the results of our analysis.

We can now draw a number of conclusions. One is that the literature has shown a bias to understand the role of embeddedness under conditions of relative environmental stability. In other words, embeddedness and network optimality are understood for exploitation but remain in their infancy for exploration. This is a striking observation as the importance of exploration is getting more and more important. Given the increasing rate of change that characterizes most industries, existing technology obsoletes more rapidly and requires the timely creation and development of new technology.[132] In other words, understanding the role of embeddedness in view of exploration deserves a high priority on the future research agenda. A second conclusion is that the two different views indeed seem to form opposites that cannot be reconciled. However, conditions of exploration seem to form an exception as a combined Burt–Coleman rent may be expected here. This is a novel insight that has

Table 1. Relevance and implications of the two views according to levels of analysis

Conditions	Views on network optimality: Social capital view (Coleman)	Structural hole view (Burt)	Who is right under which conditions?
Group level	Replicate ties within group	Create ties beyond groups	Coleman rent *within* group, Burt rent *beyond* groups
Network level			
—From exploitation to exploration	Inhibits firms to make the transition to exploration	Create access to non-redundant contacts	Only Burt rent (negative effect of a social capital view)
Industry level			
—Exploration	Build-up of shared absorptive capacity	Create access to novel knowledge	Combined Burt–Coleman rent
—Exploitation	Social control, reputation and trust-based relations	Build efficiency in alliance network	Depends on the industry under study

Table 2. Propositions according to levels of analysis and views on network optimality

Conditions	Views on network optimality: Social capital view (Coleman)	Structural hole view (Burt)
Group level	Proposition 3	Proposition 1, 2
Network level		
—From exploitation to exploration	Received wisdom: 'risk of overembeddedness'	Proposition 7, 8, 9, 10, 11
Industry level		
—Exploration	Proposition 4	Proposition 4
—Exploitation	Proposition 5a	Proposition 5b

been entirely absent in the existing literature with its focus on conditions of exploitation and its emphasis on how the two views differ. A third conclusion is that exploring a more voluntaristic view seems to have interesting future potential. It reflects a new perspective on embeddedness as it counters the dominant structuralist view. As a consequence, it has yielded several new directions for future research and we feel that it definitely reflects the newest and most 'exiting' topics to advance our understanding of embeddedness in alliance networks. One is that this view seems better able to capture change and network dynamics, an issue that has been largely ignored by the structuralist view. Second is that it considers network properties as dependent variables and in this way may explain why non-redundant networks ('structural holes') or dense networks ('closure') emerge in the first place, apart from which of the two is more beneficial. This connects with the arguments by Salancik and Powell *et al.* that the literature has too long ignored such 'why-questions'.[133] Taking a more voluntaristic approach as explored here, seems to form a good starting point for that. Overall, we hope that we have been able to shed more light on the issue of alliances and innovation under various different contexts.

Notes and References

1. J. Hagedoorn & J. Schakenraad, The effect of strategic technology alliances on company performance, *Strategic Management Journal*, 15, 1994, pp. 291–309.
2. M. E. Porter, *The Competitive Advantage of Nations* (London, Macmillan Press, 1990); G. Hamel & C. K. Prahalad, The core competence of the corporation, *Harvard Business Review*, May-June, 1990, pp. 79–91; G. Grabher, *The Embedded Firm, on the Socio-Economics of Industrial Networks* (London, Routledge, 1993); P. Smith Ring & A. van de Ven, Developmental processes of cooperative interorganisational relationships, *Academy of Management Review*, 19, 1994, pp. 90–118; J. Hagedoorn, Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences, *Strategic Management Journal*, 14, 1993, pp. 371–385; Hagedoorn & Schakenraad, *op. cit.*, Ref. 1; R. E. Spekman, T. M. Forbes III, L. A. Isabella & T. C. Macavoy, Alliance management: a view from the past and a look to the future, *Journal of Management Studies*, 35, 1995, pp. 747–772; B. Uzzi, Social structure and competition in interfirm networks: the paradox of embeddedness, *Administrative Science Quarterly*, 42, 1997, pp. 35–67; B. Nooteboom, *Interfirm Alliances: Analysis and Design* (London, Routledge, 1999); B. Nooteboom, *Inter-firm Collaboration, Learning and Networks; An Integrated Approach* (London, Routledge, 2004); G. Ahuja, Collaboration networks, structural holes and innovation: a longitudinal study, *Administrative Science Quarterly*, 45, 2000, pp. 425–455; T. Rowley, D. Behrens & D. Krackhardt, Redundant governance structures: an analysis of structural and relational embeddedness in the steel and semiconductor industries, *Strategic Management Journal*, 21, 2000, pp. 369–386.
3. For a more elaborate overview, see e.g. Hagedoorn, *op. cit.*, Ref. 2.
4. See e.g. G. M. Duysters & J. Hagedoorn, Core competences and company performance in the worldwide computer industry, *Journal of High Technology Management Research*, 11, 2000, pp. 75–91.
5. B. Kogut & U. Zander, Knowledge of the firm, combinative capabilities, and the replication of technology, *Organization Science*, 3, 1993, pp. 383–397; W. W. Powell & P. Brantley, Competitive cooperation in biotechnology: learning through networks, in: N. Nohria & Robert G. Eccles (Eds) *Networks and Organizations: Structure, Form and Action* (Boston, MA, Harvard Business School Press, 1992), pp. 366–394.
6. G. B. Richardson, The organization of industry, *Economic Journal*, 82, 1972, pp. 509–518; J. Pfeffer & P. Nowak, Joint ventures and interorganizational interdependence, *Administrative Science Quarterly*, 21, 1976, pp. 398–418; C. Garcia-Pont & N. Nohria, Local versus global mimetism: the dynamics of alliance formation in the automobile industry, *Strategic Management Journal*, 23, 2002, pp. 307–321.
7. J. Pfeffer & G. Salancik (Eds), *The External Control of Organizations: A Resource Dependence Perspective* (New York, Harper & Row, 1978); B. Wernerfelt, A resource-based view of the firm, *Strategic Management Journal*, 5, 1984, pp. 171–180.
8. S. H. Park, R. R. Chen & S. Gallagher, Firm resources as moderators of the relationship between market growth and strategic alliances in semiconductor start-ups, *Academy of Management Journal*, 45, 2002, pp. 527–545.
9. W. W. Powell, K. W. Koput & L. Smith-Doer, Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology, *Administrative Science Quarterly*, 41, 1996, pp. 116–145; G. Walker, B. Kogut & W. Shan, Social capital, structural holes and the formation of an industry network, *Organization Science*, 8, 1997, pp. 109–125; A. Grandori, *Interfirm Networks, Organization and Industrial Competitiveness* (London, Routledge, 1999).
10. For example R. Gulati, Social structure and alliance formation patterns: a longitudinal analysis, *Administrative Science Quarterly*, 40, 1995, pp. 619–652; R. Gulati, Alliances and networks, *Strategic Management Journal*, 19, 1998, pp. 293–317; Walker *et al.*, *op. cit.*, Ref. 9; R. Gulati & M. Gargiulo, Where do inter-organizational networks come from?, *American Journal of Sociology*, 104, 1999, pp. 1439–1493; S. A. Chung, H. Singh & K. Lee, Complementarity, status similarity and social capital as drivers of alliance formation, *Strategic Management Journal*, 21, 2000, pp. 1–20.
11. Gulati (1995), *op. cit.*, Ref. 10; Gulati & Gargiulo, *op. cit.*, Ref. 10.
12. For example M. Granovetter, Problems of explanation in economic sociology, in: N. Nohria & Robert G. Eccles (Eds) *Networks and Organizations: Structure, Form and Action* (Boston, MA, Harvard Business School Press, 1992), pp. 25–56; Gulati (1998), *op. cit.*, Ref. 10.
13. Powell *et al.*, *op. cit.*, Ref. 9.
14. Hagedoorn, *op. cit.*, Ref. 2.

15. G. Hamel, Competition for competence and inter-partner learning within international strategic alliances, *Strategic Management Journal*, 12, 1991, pp. 133–139.
16. T. E. Stuart, Network positions and propensities to collaborate: an investigation of strategic alliance formation in a high-technology industry, *Administrative Science Quarterly*, 43, 1998, pp. 668–698.
17. See J. S. Coleman, Social capital in the creation of human capital, *American Journal of Economic Sociology*, 94 (supplement), 1988, pp. 95–119 and R. S. Burt, *Structural Holes, the Social Structure of Competition* (Cambridge, MA, Harvard University Press, 1992).
18. Burt (1992).
19. Coleman, *op. cit.*, Ref. 17.
20. R. Nelson, *Understanding Technical Change as an Evolutionary Process* (Amsterdam, Elsevier, 1987); M. McKelvey, Using evolutionary theory to define systems of innovation, in: C. Edquist (Ed.) *Systems of Innovation, Technologies, Institutions and Organizations* (London, Pinter, 1997).
21. B. McEvily & A. Zaheer, Bridging ties: a source of firm heterogeneity in competitive capabilities, *Strategic Management Journal*, 20, 1999, pp. 1133–1156.
22. Ahuja (2000).
23. Walker *et al.*, *op. cit*., Ref. 9.
24. J. Bae & M. Gargiulo, *Local action and efficient alliance strategies in the telecommunications industry*, INSEAD Working Paper, 2003.
25. Rowley *et al.*, *op. cit.*, Ref. 2; G. M. Duysters & J. Hagedoorn, Learning in dynamic inter-firm networks—the efficacy of multiple contacts, *Organization Studies*, 23, 2002, pp. 525–548.
26. R. Burt, The network structure of social capital, Paper presented at the 'Social Network and Social Capital Conference', Duke University, Durham, NC, 1998; Ahuja, *op. cit*., Ref. 2; Rowley *et al.*, *op. cit.*, Ref. 2.
27. Here we differentiate between the meaning of hypothesis *vs* proposition. A hypothesis suggests a causal logic that requires the use of measures in view of empirical testing. A proposition involves concepts and does not necessarily imply/suggest empirical testing (D. A. Whetten, What constitutes a theoretical contribution?, *Academy of Management Review*, 14, 1989, pp. 490–495). Therefore, we prefer to use 'proposition' as it reflects the conceptual nature of this paper and in this way serves as an indicative direction for future research.
28. B. Gomes-Casseres, *The Alliance Revolution: The New Shape of Business Rivalry* (Cambridge, MA, Harvard University Press, 1996); Y. L. Doz & G. Hamel, *Alliance Advantage, The Art of Creating Value through Partnering* (Cambridge, MA, Harvard Business School Press, 1998).
29. G. M. Duysters & C. E. A. V. Lemmens, Alliance group formation: enabling and constraining effects of embeddedness and social capital in strategic technology alliance networks, *International Studies of Management and Organization*, 33, 2003, pp. 49–68.
30. Gulati (1995), *op. cit*., Ref. 10.
31. D. R. Gnyawali & R. Madhavan, Cooperative networks and competitive dynamics: a structural embeddedness perspective, *Academy of Management Review*, 26, 2001, pp. 431–445.
32. J. C. Baum, T. Calabrese & B. S. Silverman, Don't go it alone: alliance network composition and startups performance in Canadian biotechnology, *Strategic Management Journal*, 21, 2000, pp. 267–294.
33. Gomes-Casseres, *op. cit.*, Ref. 28; Gnyawali & Madhavan, *op. cit.*, Ref. 31.
34. Gomes-Casseres, *op. cit.*, Ref. 28; R. M. Guidice, A. Vasudevan & G. M. Duysters, From 'me against you' to 'us against them': alliance formation based on inter-alliance rivalry, *Scandinavian Journal of Management*, 19, 2003, pp. 135–152.
35. T. K. Das & B. Teng, Partner analysis and alliance performance, *Scandinavian Journal of Management*, 19, 2003, pp. 279–308.
36. Gomes-Casseres, *op. cit.*, Ref. 28.
37. M. Sakakibara, Formation of R&D consortia: industry and company effects, *Strategic Management Journal*, 23, 2002, pp. 1033–1055.
38. Gomes-Casseres, *op. cit.*, Ref. 28; Das & Teng, *op. cit.*, Ref. 35.
39. Gomes-Casseres, *op. cit.*, Ref. 28.
40. *Ibid.*; Duysters & Lemmens, *op. cit.*, Ref. 29.
41. Hagedoorn, *op. cit.*, Ref. 2.
42. Gulati (1995, 1998), *op. cit*., Ref. 10.
43. Baum *et al.*, *op. cit.*, Ref. 32.
44. *Ibid*.

45. *Ibid*.
46. B. Gomes-Casseres, Group versus group: how alliance networks compete, *Harvard Business Review*, 72, 1994, pp. 62–70; B. Gomes-Casseres, The logic of alliance fads: why collective competition spreads, in: M. P. Koza & A. Y. Levin (Eds) *Strategic Alliances and Firm Adaptation: A Coevolution Perspective* (M. E. Sharpe, 2001); Garcia-Pont & Nohria, *op. cit.*, Ref. 6.
47. Gomes-Casseres (2001), *op. cit.*, Ref. 46.
48. Baum *et al.*, *op. cit.*, Ref. 32.
49. J. March, Exploration and exploitation in organisational learning, *Organisation Science*, 2, 1991, pp. 71–87.
50. Ahuja, *op. cit*., Ref. 2.
51. Baum *et al.*, *op. cit.*, Ref. 32.
52. Stuart, *op. cit.*, Ref. 16.
53. B. Uzzi, The sources and consequences of embeddedness, for the economic performance of organizations: the network effects, *American Sociological Review*, 61, 1996, pp. 674–698.
54. Duysters & Hagedoorn, *op. cit.*, Ref. 25.
55. A. Zaheer & G. G. Bell, Benefiting from network position: firm capabilities, structural holes, and performance, *Strategic Management Journal*, 26, 2005, pp. 809–825.
56. Stuart, *op. cit.*, Ref. 16.
57. Rowley *et al.*, *op. cit.*, Ref. 2.
58. S. Wuyts, M. G. Colombo, S. Dutta & B. Nooteboom, Empirical test of optimal cognitive distance, *Journal of Economic Behaviour and Organization*, 28, 2005, pp. 277–302.
59. Ahuja, *op. cit*., Ref. 2.
60. *Ibid*.
61. *Ibid*.; Baum *et al.*, *op. cit.*, Ref. 32; McEvily & Zaheer, *op. cit.*, Ref. 21.
62. W. W. Powell, Neither market nor hierarchy: network forms of organization, *Research in Organizational Behavior*, 12, 1990, pp. 295–336; Gulati & Gargiulo, *op. cit*., Ref. 10.
63. Gulati (1995, 1998), *op. cit*., Ref. 10.
64. Chung *et al.*, *op. cit*., Ref. 10.
65. N. Lin, Building a network theory of social capital, *Connections*, 22, 1999, pp. 28–51.
66. Walker *et al.*, *op. cit*., Ref. 9; Gulati (1995), *op. cit*., Ref. 10; Powell *et al.*, *op. cit.*, Ref. 9.
67. S. Berg, J. Duncan & P. Friedman, *Joint Venture Strategies and Corporate Innovation* (Cambridge, MA, Oelgeschlager, Gunn and Hain, 1982).
68. Ahuja, *op. cit*., Ref. 2.
69. C. Freeman, Networks of innovators, a synthesis of research issues, *Research Policy*, 20, 1991, pp. 499–514.
70. D. Leonard-Barton, *Wellsprings of Knowledge* (Boston, MA, Harvard Business School Press, 1995).
71. J. Owen-Smith & W.W. Powell, Knowledge networks as channels and conduits: the effects of spillovers in the Boston biotechnology community, *Organization Science*, 15, 2004, pp. 5–21.
72. Gulati (1998), *op. cit*., Ref. 10.
73. *Ibid*.; R. Madhavan, B. R. Koka & J. E. Prescott, Networks in transition: how industry events (re)shape interfirm relationships, *Strategic Management Journal*, 19, 1998, pp. 439–459; B. R. Koka, R. Madhavan & J. E. Prescott, The evolution of interfirm networks: environmental effects on patterns of network change, *Academy of Management Review*, 30(4), 2005, pp. 721–737.
74. March, *op. cit.*, Ref. 49
75. D. Teece, Profiting from technological innovation: implications for integration, collaboration, licensing and public policy, *Research Policy*, 15, 1986, pp. 285–305.
76. M. T. Hansen, J. M. Podolny & J. Pfeffer, So many ties, so little time: a task contingency perspective on corporate social capital, in: S. M. Gabbay, R. T. A. J. Leenders (Eds) *Research in the Sociology of Organizations*, Vol. 18 (Amsterdam, Elsevier Science, 2001), pp. 21–57.
77. V. A. Gilsing, *The Dynamics of Strategic Alliances, Exploration, Exploitation and Co-evolution* (Cheltenham, Edward Elgar, 2005).
78. March, *op. cit.*, Ref. 49; B. Nooteboom, *Learning and Innovation in Organizations and Economies* (Oxford, Oxford University Press, 2000).
79. Rowley *et al.*, *op. cit.*, Ref. 2; Nooteboom, *op. cit.*, Ref. 78.
80. The distinction between exploration and exploitation is related to the distinction between first and second order learning [G. Bateson, *Steps to an Ecology of Mind* (London, Paladin Book, 1972)], and between

single and double loop learning [C. Argyris & D. A. Schon, *Organizational Learning* (Reading, MA, Addison-Wesley, 1978)].

81. J. Hagedoorn, A. Link & N. Vonartas, Research partnerships, *Research Policy*, 29, 2000, pp. 567–586; C. Phelps, *Technological exploration: a longitudinal study of the role of recombinatory search and social capital in alliance networks*, Working Paper, University of Washington, June 2005.
82. J. A. Schumpeter, *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process* (New York and London, McGraw Hill, 1939).
83. Burt, *op. cit.*, Ref. 17.
84. Ahuja, *op. cit*., Ref. 2; Rowley *et al.*, *op. cit.*, Ref. 2.
85. W. M. Cohen & D. A. Levinthal, Absorptive capacity: a new perspective on learning and innovation, *Administrative Science Quarterly*, 35, 1990, pp. 128–152.
86. Hansen *et al.*, *op. cit.*, Ref. 76.
87. Duysters & Hagedoorn, *op. cit.*, Ref. 25.
88. Coleman, *op. cit.*, Ref. 17.
89. Ahuja, *op. cit*., Ref. 2; Rowley *et al.*, *op. cit.*, Ref. 2.
90. Indirect empirical evidence for this position is found in B. E. Beerkens, External acquisition of technology, exploration and exploitation in international innovation networks, ECIS PhD-thesis, Eindhoven University Press, Eindhoven, 2004: past involvement in alliances, indicative for strong ties in terms of durability is positively associated with exploration, whereas over the same period, also evidence is found for the weak tie argument for exploration.
91. W. J. Abernathy & J. M. Utterback, Patterns of industrial innovation, *Technology Review*, 81, 1978, pp. 41–47.
92. F. Malerba & S. Breschi, Sectoral innovation systems: technological regimes, Schumpetarian dynamics and spatial boundaries, in: C. Edquist (Ed.) *Systems of Innovation, Technologies, Institutions and Organizations* (London, Pinter, 1997).
93. Gilsing, *op. cit.*, Ref. 77.
94. Uzzi, *op. cit.*, Ref. 2; Nooteboom, *op. cit.*, Ref. 78.
95. S. Klepper, Industry life cycles, *Industrial and Corporate Change*, 6, 1996, pp. 145–181.
96. Burt, *op. cit.*, Ref. 17.
97. Gilsing, *op. cit.*, Ref. 77.
98. Rowley *et al.*, *op. cit.*, Ref. 2; Beerkens, *op. cit.*, Ref. 90.
99. Hansen *et al.*, *op. cit.*, Ref. 76; A. H. W. M. Roijakkers, Inter-firm cooperation in high-tech industries: a study of R&D partnerships in pharmaceutical biotechnology, PhD thesis, Datawyse/Universitaire Pers, Maastricht, 2003; V. A. Gilsing & B. Nooteboom, Density and strength of ties, an analysis of multimedia and biotechnology, *European Management Journal*, 2, 2005, pp. 179–197.
100. Abernathy & Utterback, *op. cit.*, Ref. 91; W. J. Abernathy, *The Productivity Dilemma: Roadblock to Innovation in the Automobile Industry* (Baltimore, MD,Johns Hopkins University Press, 1978); W. J. Abernathy & K. B. Clark, Innovation: mapping the winds of creative destruction, *Research Policy*, 14, 1985, pp. 3–22.
101. G. Dosi, R. R. Nelson, G. Silverberg & L. Soete (Eds), *Technical Change and Economic Theory* (London, Pinter, 1988); G. M. Duysters, *The Dynamics of Technical Innovation: The Evolution and Development of Information Technology* (Cheltenham, Edward Elgar, 1996).
102. M. L. Tushman & P. Anderson, Technological discontinuities and organizational environments, *Administrative Science Quarterly*, 31, 1986, pp. 439–465.
103. *Ibid.*; Madhavan *et al.*, *op. cit*., Ref. 73.
104. Madhavan *et al.*, *op. cit*., Ref. 73.
105. P. J. Dimaggio & W. W. Powell, The iron cage revisited: institutional isomorphism and collective rationality in organizational fields, *American Sociological Review*, 48, 1983, pp. 147–160.
106. M. Granovetter, The strength of weak ties, *American Journal of Sociology*, 78, 1973, pp. 1360–1380.
107. *Ibid.*; D. J. Brass, K.D. Butterfield & B.C. Skaggs, Relationships and unethical behavior: a social network perspective, *Academy of Management Review*, 23, 1998, pp. 14–31.
108. Chung *et al.*, *op. cit*., Ref. 10.
109. *Ibid.*
110. Gulati (1995, 1998), *op. cit*., Ref. 10; Walker *et al.*, *op. cit*., Ref. 9.
111. D. Knoke & J. H. Kuklinski (Eds), *Network Analysis, Series: Quantitative Applications in the Social Sciences* (Beverly Hills, CA, Sage, 1982).
112. Brass *et al.*, *op. cit*., Ref. 107.

113. Walker *et al.*, *op. cit*., Ref. 9; Gulati (1995), *op. cit*., Ref. 10; Powell *et al.*, *op. cit.*, Ref. 9.
114. Duysters & Lemmens, *op. cit.*, Ref. 29.
115. Uzzi, *op. cit.*, Ref. 2.
116. For example, R. R. Nelson & S. G. Winter (Eds), *An Evolutionary Theory of Economic Change* (Cambridge, MA, Belknap Press, 1982); T. E. Stuart & J. M. Podolny, Local search and the evolution of technological capabilities, *Strategic Management Journal*, 17, 1996, pp. 21–38.
117. Stuart & Podolny, *op. cit.*, Ref. 116; D. J. Teece, G. Pisano & A. Shuen, Dynamic capabilities and strategic management, *Strategic Management Journal*, 18, 1997, pp. 509–533; L. Rosenkopf & A. Nerkar, Beyond local search: boundary-spanning, exploration, and impact in the optical disk industry, *Strategic Management Journal*, 22, 2001, pp. 287–306; L. Rosenkopf & P. Almeida, Overcoming local search through alliances and mobility, *Management Science*, 49, 2003, pp. 751–776; G. Ahuja & R. Katila, Where do resources come from? The role of idiosyncratic situations, *Strategic Management Journal*, 25, 2004, pp. 887–907.
118. Walker *et al.*, *op. cit*., Ref. 9; Rowley *et al.*, *op. cit.*, Ref. 2.
119. Rosenkopf & Nerkar, *op. cit.*, Ref. 117; Ahuja & Katila, *op. cit.*, Ref. 117. This connects with the evolutionary notion of 'diversity' that is considered to form a crucial condition for learning and innovation (Nelson & Winter, *op. cit.*, Ref. 116). It refers to the heterogeneity of resources or knowledge, which yields the potential for Schumpeterian novel combinations to emerge.
120. Burt, *op. cit.*, Ref. 17.
121. Madhavan *et al.*, *op. cit*., Ref. 73.
122. N. Eldredge & S. J. Gould, Punctuated equilibria: an alternative to phyletic gradualism, in: T. J. M. Schopf (Ed.) *Models in Paleobiology* (San Francisco, CA, Freeman, Cooper, 1972), pp. 82–115; Nooteboom, *op. cit.*, Ref. 78.
123. C. M. Christensen & J. L. Bower, Customer power, strategic investment and the failure of leading firms, *Strategic Management Journal*, 17, 1996, pp. 197–128.
124. Koka *et al.*, *op. cit*., Ref. 73.
125. J. M. Podolny & T. E. Stuart, A role-based ecology of technological change, *American Journal of Sociology*, 5, 1995, pp. 1224–1260.
126. Burt, *op. cit.*, Ref. 17.
127. Stuart, *op. cit.*, Ref. 16. This is comparable to what is known as the 'Matthew-effect' in science, namely the idea that the work of a high-status member of the scientific community is considered more important, acting as a key guide for future research, than the work of a low(er) status member (R. K. Merton, The Matthew-effect in science, *Science*, 159, 1968, pp. 56–63; Podolny & Stuart, *op. cit*., Ref. 125; Stuart, *op. cit.*, Ref. 16).
128. Stuart, *op. cit.*, Ref. 16.
129. J. C. Spender, *Industry Recipes* (Oxford, Basil Blackwell, 1998).
130. V. A. Gilsing & B. Nooteboom, Exploration and exploitation in innovation systems, *Research Policy*, 1, 2006, pp. 1–22.
131. Burt, *op. cit*., Ref. 26; Ahuja, *op. cit*., Ref. 2; Rowley *et al.*, *op. cit.*, Ref. 2.
132. D. C. Mowery & R. R. Nelson (Eds), *Sources of Industrial Leadership, Studies of Seven Industries* (New York, Cambridge University Press, 1999).
133. G. R. Salancik, Wanted: a good network theory of organization, *Administrative Science Quarterly*, 40, 1995, pp. 345–349; W. W. Powell, D. R. White, K. W. Koput & J. Owen-Smith, The growth of interorganizational collaboration in the life sciences, *American Journal of Sociology*, 110, 2005, pp. 1132–1205.