

## Tilburg University

### Radical changes in inter-organizational network structures

Knoben, J.; Oerlemans, L.A.G.; Rutten, R.P.J.H.

*Published in:*  
Technological Forecasting and Social Change

*Publication date:*  
2006

[Link to publication in Tilburg University Research Portal](#)

*Citation for published version (APA):*  
Knoben, J., Oerlemans, L. A. G., & Rutten, R. P. J. H. (2006). Radical changes in inter-organizational network structures: The longitudinal gap. *Technological Forecasting and Social Change*, 73(4), 390-404.

#### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

#### Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



ELSEVIER

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

SCIENCE @ DIRECT®

Technological Forecasting & Social Change 73 (2006) 390–404

**Technological  
Forecasting and  
Social Change**

## Radical changes in inter-organizational network structures: The longitudinal gap

J. Knoben <sup>a,\*</sup>, L.A.G. Oerlemans <sup>a,b</sup>, R.P.J.H. Rutten <sup>a</sup>

<sup>a</sup>Department of Organisation Studies, Tilburg University, Warandelaan 2, P.O. Box 90153, 5000 LE Tilburg, The Netherlands

<sup>b</sup>Department of Engineering and Technology Management, University of Pretoria, Pretoria, Republic of South Africa

Received 29 November 2004; received in revised form 19 May 2005; accepted 20 May 2005

---

### Abstract

The main goal of the research presented in this paper is to provide an overview of the available insights concerning radical changes in inter-organizational network structures. The following research question has been formulated: *what is known about the way organizations in networks deal with, and are affected by, radical changes in inter-organizational network structures?*

In order to answer this question, a review of the most relevant literature dealing with changes in network structure over time is presented. The literature reviewed has been analyzed by comparing the role of change in the analysis (independent vs. dependent variable) as well as the manner in which change is conceptualized (incremental vs. radical change and dyadic vs. network change).

It is found that studies that observe networks changing over time are scarce. Nevertheless, the available studies provide some interesting insights concerning the formation, evolution and termination of dyadic ties, network evolution, and the effects of (radical) changes in network structure. However, more research on several specific topics seems necessary. These topics are: the link between dyadic change and change at the network level, the evolution of network structures, the processes through which critical events lead to changes in network structures, and the effects of radical changes in network structures.

© 2005 Elsevier Inc. All rights reserved.

*Keywords:* Inter-organizational networks; Radical change; Longitudinal research; Network structure

---

\* Corresponding author. Tel.: +31 13 4662111; fax: +31 13 4663002.

E-mail address: [J.knoben@uvt.nl](mailto:J.knoben@uvt.nl) (J. Knoben).

## 1. Introduction

Inter-organizational networks are in vogue. Interest in these networks has been steadily increasing across a wide variety of fields for several years [1]. The interest in networks is especially strong in the field of economics and organization science. In the corporate world, network mapping is becoming a standard diagnostic and prescriptive tool [2]. Furthermore, the Academy of Management conference 2002 was dedicated to networks, as were several special issues of its journals (for a recent example see: Academy of Management Journal, December 2004).

This upsurge of interest in networks has come at a time in which environmental (or market) uncertainty is very high [3]. Product ranges have become more diverse and new technological breakthroughs have given rise to many new technology-product-market combinations, resulting in markets characterized by high levels of dynamics and many (radical) changes. Simultaneously, the acceleration of technological development forced firms to specialize and subsequently led to an intensified division of activities between organizations. This specialization has resulted in firms not being able to generate all necessary knowledge and resources internally and, therefore, induces inter-organizational collaboration and networking [4,5]. Networks, as new organizational forms, are on the one hand an answer to these dynamics that could be potential sources for radical change, but on the other hand, these networks are under the influence of these changes as well.

Given the importance of networks as a governance system and the dynamics and complexity of the environment, researching changes, and in particular radical changes, in and of inter-organizational networks is a topic of great scientific and practical value. This leads to the following research question: *What is known about the way organizations in networks deal with, and are affected by, radical changes in inter-organizational network structure?* In this context, radical change in network structures is defined as significant variation in the underlying pattern of relationships that bind a given set of actors [6]. This definition implies that radical change can take place between two actors (radical dyadic change) as well as between several or all actors in the network (radical network change). The goal of this paper is to explore the available literature concerning the causes and consequences of radical changes in and of network structures to come to a “state of the art” overview.

The remainder of this paper is structured as follows. First, the research methods applied in this paper will be discussed (Section 2). In Section 3, the three distinct groups of papers that were found in the literature dealing with network change are discussed. Next, the patterns that can be found in this body of literature are presented in Section 4. Finally, in Section 5, the findings are discussed and some conclusions are drawn with respect to future research.

## 2. Research methods

An approach similar to the one applied by Oliver and Ebers [7] has been used for this literature review. A selection of the available literature has been made by means of the ISI database (available at: [www.isiknowledge.com](http://www.isiknowledge.com)). Using the ISI database, the five most influential journals (based on their impact scores) in the field of organization science were subsequently determined. This yielded the following journals: Academy of Management Review, Academy of Management Journal, MIS Quarterly, Strategic Management Journal, and Administrative Science Quarterly. However, since the Academy of Management Review published only non-empirical papers, the number six of the list,

Organization Science, has been added. Finally, since most journals mentioned above are US-based journals (with the exception of the Strategic Management Journal), the journals Organization Studies and Research Policy have been added since these are the European journals with the highest impact factor (position 12 and 17 respectively). These journals have been searched for the key words: longitudinal, network, change, radical change and dynamics. The key word “longitudinal” has been added since the concept of radical changes in network structure can only be studied in a longitudinal setting, as network change is by nature a dynamic process [8,9].

Due to limitations of the database used, only publications from the period 1984–2005 could be searched. The papers that resulted from this search were finally selected on the basis of their abstracts. An overview of all papers that were selected for this literature review can be found in Table 1.

This approach to sampling literature has some disadvantages, though. First, insights from non-longitudinal studies, or insights from theoretical studies are not taken into account. Secondly, papers from journals not included in the literature search as well as books and book chapters are not taken into account as well. Nevertheless, the literature reviewed gives a reliable overview of the content of the leading journals with regard to longitudinal network research. Therefore, it can be assumed to contain the most relevant insights concerning this field of science.

The above-mentioned papers have been analyzed on the role of the change in the analysis (dependent or independent variable) in order to discriminate between the causes and consequences of change in network structures. Furthermore, the papers were analyzed on the object of change and on the conceptualization of change (radical or incremental) as well as on the level on which the change took

Table 1  
Change in longitudinal network studies

Author(s) and year of publication	Change variable	Object of change	Conceptualization of change
Van de Ven and Walker (1984)	1	Alliance formation, development and termination	1 and 2
Levinthal and Fichman (1988)	1	Alliance termination	1
Burkhardt and Brass (1990)	1	Network evolution	3 and 4
Gulati (1995)	1	Alliance formation	1
Doz (1996)	1	Alliance evolution	2
Powell et al. (1996)	1	Alliance formation	1
Madhavan et al. (1998)	1	Network evolution	3 and 4
Stuart (1998)	1	Alliance formation	1
Gulati (1999)	1	Alliance formation	1
Koza and Lewin (1999)	1	Network evolution	3 and 4
Lorenzoni and Lipparini (1999)	1	Changes in the number of (in)direct ties	4
Ahuja (2000a)	1	Alliance formation	1
Ahuja (2000b)	2	Changes in the number of (in)direct ties	5
Doz et al. (2000)	1	Alliance and network formation	1 and 3
Human and Provan (2000)	1	Network evolution	3 and 4
Tsai (2000)	1	Alliance formation	1
Rosenkopf et al. (2001)	1	Alliance formation	1
Koka and Prescott (2002)	2	Alliance formation and development	3 and 4
Soh and Roberts (2003)	1	Network evolution	3 and 4

Change variable as: 1. Dependent variable; 2. Independent variable.

Conceptualization of change: 1. Radical and dyadic; 2. Incremental and dyadic; 3. Radical and network; 4. Incremental and network; and 5. Unclear.

place (dyad or network) in order to discriminate between different types of change. A general overview of the results is presented in [Table 1](#).

### 3. Longitudinal network research and change in network structure

Applying the evaluation criteria discussed in the previous section to the selected papers has identified three distinct groups of papers. The first group of papers deals with alliance formation, development and termination at the firm or dyadic level (eleven papers). The second group deals with network evolution (six papers), whereas the last group discusses the consequences of change in network structure for firm performance (two papers). The first two groups deal with the causes of change (change as a dependent variable), whereas the third group deals with the consequences of change (change as an independent variable). The most interesting insights concerning (radical) change in network structure from all three groups will be discussed below.

#### 3.1. Alliance formation, evolution, and termination

Most of the papers reviewed focus on the formation of dyadic alliances. These papers conceptualize the transition from two individual organizations into a dyadic relation as radical dyadic change. The causes of this form of radical change differ greatly between the various studies. Van de Ven and Walker [10] emphasize the role of resource dependency. Powell et al. [11] stress the importance of prior alliances and the experience with internal R&D. Rosenkopf et al. [12] focus on managerial volition, network position, and previous alliances. Gulati [13,14] focuses on the role of resource dependency and prior alliances. Finally, Doz et al. [15] focus on the difference between engineered and emergent relations and networks. A common factor in these studies is that they all focus on organizational characteristics when explaining radical dyadic change. Stuart [16], Ahuja [17], and Tsai [18] take a different perspective and try to explain alliance formation by looking at the centrality of the position a firm holds within an industry as well as other network measures.

Almost all of the studies mentioned above find significant results for their hypothesized trigger(s) of tie formation. Among the more interesting findings is the fact that, up to a certain level, the number of prior alliances correlates positively with the degree of new tie formation. However, after this threshold level has been passed the correlation becomes negative, resulting in a relationship that has an inverted U-shape. Another interesting finding is that the more central the position of the firm in a network or industry, the higher the degree of new tie formation.

Since the above-mentioned studies focus on the formation of dyadic ties, radical dyadic takes central stage in these studies. However, with the exception of Van de Ven and Walker [10] and Doz [19], none of the studies pays any attention to the processes that take place after the dyadic tie has been formed. Therefore, it is unclear whether or not this radical dyadic change has led to changes in the network as a whole. According to Van de Ven and Walker [10], the processes that take place after tie formation are important for understanding the dynamics of inter-organizational relationships (IORs). The formation of IORs has to have clear benefits for an organization since organizational parties prefer not to become involved in an IOR unless they are compelled to do so. This is the case since the formation of IORs implies that firms: 1) lose some of their freedom to act independently; 2) must invest some of their scarce resources and energy to develop and maintain relations, even though the potential returns on this

investment are often highly uncertain; 3) might incur damage to their reputation, and 4) experience an increase in the risk of imitations of innovations [20]. In order to gain insights into the nature of the benefits of IORs and how these benefits are ultimately realized, it is necessary to follow organizations after tie formation.

In their studies, both Van de Ven and Walker [10] and Doz [19] find that successful IORs develop incrementally (in contrast to by leaps and bounces) after the initial formation. According to Doz [19], the initial conditions of an IOR are very important for its future, as some initial conditions facilitate learning whereas others hamper or delay it. Initial conditions that facilitate learning are: clear task definitions, similar organizational routines, clear and transparent expectations from both parties, and an appropriate interface structure. As such, the findings of Doz [19] resemble the findings of the literature dealing with inter-organizational proximity [see for an overview: Ref. 21].

Ironically, the processes that create [21] and expand an IOR [10] might also contain the seeds of its disintegration. Two of the papers reviewed focused on tie disintegration, namely Van de Ven and Walker [10] and Levinthal and Fichman [22].

Levinthal and Fichman [22] focus on the duration and termination of dyadic ties and link this to the role of prior alliances and relation-specific investments. In their model, time plays a crucial role. When testing their model, Levinthal and Fichman [22] found a large influence of tie duration on tie termination. After the initial years of attachment, the so-called “honeymoon period”, in which the hazard of tie termination is relatively low, the risk of tie termination increases over time. After approximately 4 to 5 years, however, the hazard of tie termination starts to decline, giving the relation an inverted U-shape [cf. 23,24]. In terms of change, an episode of radical dyadic change (tie formation) is less likely to be followed by another episode of radical dyadic change (tie termination) once a certain threshold has been passed.

However, Van de Ven and Walker [10] found completely different results in a similar analysis. They concluded that, relations become stressed over time because: 1) increasing formalization and monitoring in an IOR can lead to conflicts between two parties struggling to maintain their autonomy in the face of growing interdependence, and 2) increasing transaction between two parties implies that the domains of these parties will shift from being complementary to being similar, which increases the likelihood of conflicts [cf. 25]. In terms of change, this implies that radical dyadic change (tie formation) is followed by incremental dyadic change (tie evolution) and is increasingly likely to end in another episode of radical dyadic change (tie termination) over time. Thus, in contrast to Levinthal and Fichman [22], Van de Ven and Walker [10] found that the risk of tie termination increased over time. Van de Ven and Walker [10] as well as Levinthal and Fichman [22], only discuss change at the dyadic level of analysis making it impossible to make any inferences concerning (radical) network change from their research.

The literature reviewed on dyadic tie formation, evolution and termination provides insights into why ties are formed, how they develop and, if so, why they are terminated. However, without data on the network level, it is impossible to study the (possible) network effects of these dyadic changes. The question if and why any of these processes eventually lead to radical change on a network level, therefore, remains unanswered by these studies.

### *3.2. Network evolution*

The selected papers that deal with the evolution of networks are the following: Burkhardt and Brass [26], Human and Provan [27], Koza and Lewin [25], Lorenzoni and Lipparini [28], Madhavan et al. [6],



and Soh and Roberts [29]. However, many of these authors focus on different aspects of network evolution. Burkhardt and Brass [26], Madhavan et al. [6], and Soh and Roberts [29] study the effects of technological change on network structure and the division of power, whereas Lorenzoni and Lipparini [28] focus on the influence of management on changes in network structure. Koza and Lewin [25] studied a single network and focused on the evolution of this network from birth till adulthood. Finally, Human and Provan [27] compared the development of a successful and an unsuccessful network and focus on the role of network strategies with regard to legitimacy.

In their research, Burkhardt and Brass [26] tried to answer the following question, “does technology drive structure, or does technology adapt to existing network structures, reinforcing established stable patterns of interaction?” As such, their object of change is the pattern of interactions among network actors. They state that minor, incremental changes in power and structure may occur over time, but that a major restructuring will only occur when the network encounters an “exogenous shock”, such as the implementation of a new technology [30: p. 80]. Therefore, their study focuses on radical changes in network structure. The exogenous shock is conceptualized as a sudden and dramatic increase in uncertainty. Attempts to cope with this uncertainty can lead to adjustments in network location and network power of those able to cope with the uncertainty relative to those who cannot. Therefore, it is possible that changes in technology result in changes in network structure, power divisions, or both. After the empirical testing of their theory, they concluded that changes in network structure and power can indeed result from the adoption of new technologies [26].

“Being central and powerful prior to the introduction of a new technology was not related to early adoption. Rather, early adoption was a function of [...] characteristics relevant to the change process. Thus, in accordance with the theoretical predictions, the ingredients for structural change were in place” [26: p. 119].

These findings indicate that, even though the network is in a relatively stable cycle of incremental change, exogenous events can cause network structures to undergo radical changes.

Madhavan et al. [6] and Soh and Roberts [29] deepen the topic brought up by Burkhardt and Brass [26]. Madhavan et al. [6] distinguish between two types of change, namely structure reinforcing and structure loosening change.<sup>1</sup> The former is often induced by central players in the network and strengthens the existing structure of the network, whereas the latter is often induced by peripheral players in the network and reconfigures the network structure. Their studies show that a new successful technology that is adopted by a peripheral player is likely to lead to structure loosening change, whereas adoption by a central player is likely to lead to a reinforcement of the existing structure. Interestingly, Soh and Roberts [29] also show that central players are more likely to adopt a new successful technology than peripheral players. Due to their central position they often determine whether or not a new technology becomes the standard in an industry. Even if a peripheral actor adopts such a technology first, the central players are often quick to form alliances with this actor or to simply take it over. As such, network structures are likely to experience large inertial forces [29]. These inertial forces are also reflected in the fact that the structure of past alliances is a good predictor of new tie formation (see Section 3.1).

---

<sup>1</sup> Even though this distinction suggests that Madhavan et al. [6] focus on the consequences of change in network structures, the rest of their paper focuses on predicting these different types of change and thus on the causes of changes in network structures.

All of the above studies attribute great power to individual actors in the network, who, with a decision to adopt a certain technology, can have a great influence on the overall structure of the network. As such, the analysis of organizational attributes, motivations, and behaviors may be helpful to understand how and why network structures change over time. However, these organizational characteristics are most often neglected in network research [31: pp. 67–70].

Koza and Lewin [25] focus on the development of a single network. In their case study, they analyze the reasons for the founding of the network under scrutiny, which is interesting in light of the question whether networks emerge as goal-directed structures or as serendipitous modes of interaction [see: Ref. 31]. They find that, even though it started as an emergent form, the network quickly became more and more goal-directed as the interactions became more formalized. As a consequence, it might be valuable to see the goal-directed/serendipitous distinction as a continuum. Every starting network is characterized by serendipity as well as by a certain amount of rationalization [25,33].

The case discussed by Koza and Lewin [25] also provides a nice example of the dangers of networking for individual organizations. Even though the network as a whole was quite successful, the exchange of information between participating firms eventually led to some firms thwarting each other. This is in line with the findings of Van de Ven and Walker [10] as discussed in Section 3.1. They predict that relations become stressed in the course of their existence since collaboration results in organizations becoming more and more identical over time.

Human and Provan [27] have studied the development of network legitimacy and the evolution of networks. Their object of change is the number of members of the network as well as the pattern of interactions among them. They studied the role of legitimacy in the formation, the evolution and the termination of networks. Even though the role of legitimacy in network evolution is interesting by itself, even more interesting are the changes in network structure that occurred completely by chance during their research. Both networks in their study (A and B) developed incrementally from the beginning. During this development, network A focused on internal legitimacy, whereas network B focused on external legitimacy. After a year or so, both networks encountered a critical event caused by a source outside the network (an exogenous shock). The showroom of the A-network, their main channel to build internal legitimacy, was unexpectedly sold. In the case of the B-network a major source of outside funding, which was important for their external legitimacy, was abolished. Both events led to drastic changes in network structure as both networks faced a huge decline in the number of members as well as in the number of interactions between the members. Whereas the A-network was able to cope with the crisis due to their large internal legitimacy, the B-network ultimately ceased to exist. Due to the small level of internal legitimacy of the B-network, none of the members tried to save the network from being terminated.

Human and Provan [27] use this example to emphasize the importance of building internal legitimacy in networks. Perhaps an even more interesting observation is that it might be possible for networks to break a cycle of radical change by following a certain strategy. Some network strategies might be more resilient to radical change and consequently face lower risk of being terminated as a result of radical change compared to others. In this light, the discussion concerning goal-directed vs. serendipitous network trajectories by Kilduff and Tsai [31] seems interesting. Kilduff and Tsai claim that serendipitous network trajectories (networks that evolve through random variation and selection without a clear pre-existent goal) are more robust in times of change compared to goal-directed network trajectories. The two types of network trajectories might provide some footholds for future research into the question of why some network structures survive periods of radical change and others do not.



The above findings are especially interesting in the light of the study of Lorenzoni and Lipparini [28], who focus on the building of networks through managerial design. These findings indicate that managers can indeed influence the structure of a network. However, the empirical evidence used is relatively thin and more research remains to be done. A combination of the findings of Lorenzoni and Lipparini [28] and those of Human and Provan [27] might provide some interesting insights into the way the manager(s) of a single organization in the network can influence the development of the entire network. Furthermore, all papers in this review take the event that triggered network change as a serendipitous event. Therefore, more research into events and processes that can lead to change in network structures is necessary.

### *3.3. Consequences of changes in network structure*

Even though the studies discussed so far provide useful insights concerning change in network structures, they tell us little about the consequences of these changes. The studies of Ahuja [34] and Koka and Prescott [32] focus on this aspect of change.

Ahuja relates changes in three aspects of a firm's ego network (direct ties, indirect ties and structural holes [cf. 35]) to its innovative output. Ahuja [34] concludes that increases in the number of both direct and indirect ties correlate positively with innovative output, whereas increases in the number of structural holes are negatively related to innovative output.

It is difficult to interpret the nature of the changes in network structure used by Ahuja [34] since the analysis takes place on a relatively high level of aggregation. The available information only indicates that the ego-network has become denser or that the number of (in)direct ties has increased. Both measures indicate changes in the number of relationships and thus represent radical dyadic change. It is not clear, however, with whom relations are formed (former partners or not) and what the content of these relations is. Therefore, it is impossible to discern any incremental change underlying the observed radical change and, as a result, the increase in innovative output cannot be attributed to either form of change.

The study of Koka and Prescott [32] does discriminate between radical and incremental change and their consequences for firm performance. Koka and Prescott [32] discriminate between changes in information volume, information density, and information richness. In their study they find that information volume (operationalized as the number of ties a firm has) is the most important variable for explaining firm performance, which emphasizes the importance of radical (dyadic) change. Their measures are rather coarse, however, and more fine-tuned measurements might provide different, or more nuanced, findings. Nevertheless, their research provides valuable additional insights into the impact of changes in network structures on the (innovative) performance of firms.

## **4. Patterns in longitudinal network research**

The first question that has to be answered is how (radical) change of network structures is conceptualized in the literature. Network structure is defined as the pattern of repeated interactions among actors [26]. In the context of network structures, (radical) change can take place on two levels, the dyad and the network. Most empirical research takes place on the dyadic level. Dyadic radical change is often defined as the formation or termination of a single relation between two organizations

[36]. However, significant changes (revolution) in the content of such a relation are sometimes defined as radical change as well [37]. Change in network structure can be considered radical when a change in the relationship between two organizations (formation, (r)evolution or termination) has consequences for the structure of the network as a whole and thus stretches beyond the firms directly involved in the relationship [36]. In this perspective, the discussion by Madhavan et al. [6] concerning change in network structure is clarifying.

“Network structure does not change merely because some actors leave a network position and some others enter it. [...] Network structure does not change because the rate of network activity increases or decreases. [...] In contrast, true structural change would be evidenced by significant variation over time in the underlying pattern of relationships that bind a given set of actors” [6: p. 441].

Radical changes in network structure are triggered by critical events, which can originate both exogenously and endogenously. Thus, a critical event is the impulse that allows tension to be released from the network and allows the network to reconfigure or even break down [38]. However, it is not the mere event that is critical, but the way that actors perceive and react to such an event [36,28,27]. Therefore, any event can be a critical one, making it difficult to predict them, which, in turn, might explain the fact that empirical studies often find radical change in network structures by serendipity. Often-identified critical events are: personnel changes in the upper echelon, shifts in organizational structure, changes in marketing and purchasing strategies, acquisitions, mergers, bankruptcies, partner switching, changes in technology, the entry of resourceful and determined competitors, changes in regulatory infrastructure, dramatic shifts in consumer preferences, and economic recessions [6,36]. However, these critical events are almost always identified ex post and more insights concerning the processes through which critical events can trigger changes in network structure seem valuable, both from a theoretical as well as a practical perspective.

In Fig. 1, which is adopted from Halinen et al. [36], two types of change and two levels of change are distinguished. The two inner bold arrows (1 and 2) represent the incremental change cycle, in which changes take place gradually, whereas the two outer bold arrows (3 and 4) represent the radical change

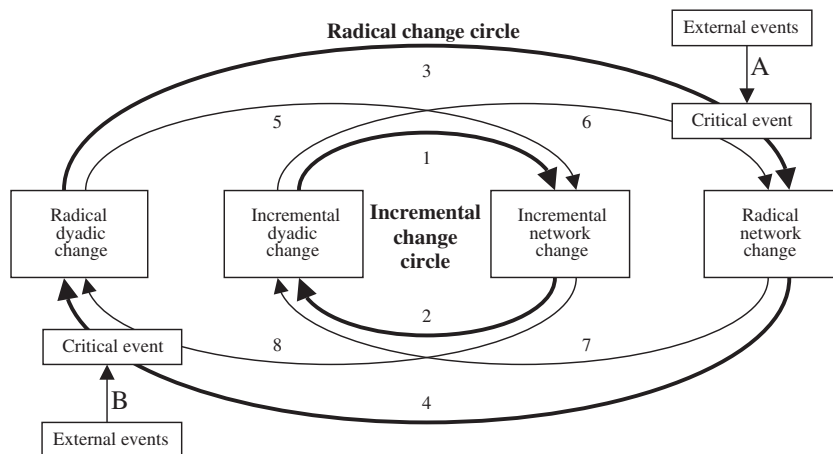


Fig. 1. A framework of change in networks and dyads [36].

cycle, in which changes take place by leaps and bounces. Furthermore, the left hand side (the four left hand text blocks) of the figure represents dyadic change, whereas the right hand side (the four right hand text blocks) represents change on the level of the network. Combining the two types of change and the two levels of change results in four different configurations of change. These four configurations of change can be seen as the relational equivalents of the four types of change distinguished by Meyer et al. [39]. Radical change is triggered by a critical event, which can have an endogenous or an exogenous source. The other arrows (5 through 8) depict the manner in which the different types and levels of change are linked. In the next sections the main findings of the literature review will be linked to Fig. 1.

#### *4.1. Alliance formation, evolution and termination*

The main insights that can be derived from the first group of papers concern the causes of radical dyadic change (the text block at the extreme left of the figure), which is conceptualized as the formation or termination of a dyadic tie. A relatively large number of studies deal with the question of why new ties are formed. Empirical evidence is found for the importance of many different triggers of IORs, which corresponds with the existing theoretical predictions [e.g. 40,41]. The question why they are terminated, another example of radical dyadic change, has been studied as well, although not as extensively. Interestingly, the findings concerning tie termination contradict each other. Much less is known about the developments of IORs over time after the initial formation. The research that does exist emphasizes the importance of incremental development of dyadic ties over time (the center left text block in Fig. 1). However, research that links changes on the dyadic level to changes on the level of the network seems absent. Therefore, the processes that underlie arrow 1, 3, and 5 in Fig. 1 are unclear. More research into this topic seems necessary.

#### *4.2. Network evolution*

The group of papers dealing with network evolution provides some interesting insights into the causes of radical changes in network structure. Interestingly, all of the four papers reviewed found exogenous causes (arrow A and B in Fig. 1) to be the trigger of radical changes in network structure. An interesting difference between the papers is that the critical events that were described in the study by Human and Provan [27] could not be influenced by the actors in the network itself, whereas the critical event portrayed in the study by Burkhardt and Brass [26] was triggered by a decision of one of the network actors. The studies by Madhavan et al. [6] and Soh and Roberts [29] provide some insights into which network actors may choose to trigger critical events and the consequences of these choices. In terms of Fig. 1, they provide insight into why and how certain external events turn into critical events (arrow A and B) and how these critical events ripple through the network as a whole (arrow 3, 4, 5, and 7).

#### *4.3. Consequences of changes in network structure*

Only two studies have been found that deal with the consequences of change in network structure for organizational outcomes. Even though Ahuja [34] finds highly significant results with regard to the effects of changes in the number of (in)direct ties and structural holes on innovative firm performance, it is difficult to discriminate between incremental and radical changes in network structure due to the high level of aggregation of the data. Koka and Prescott [32] partially solve this problem. Their study

emphasizes the importance of radical dyadic change (the text block at the extreme left of the figure) for firm performance. Even though these findings cannot be directly linked to Fig. 1, they do, however, underline the importance of detailed insights into radical changes in inter-organizational relations and networks.

## 5. Discussion and conclusions

The available literature on network formation, evolution, and development provides some valuable insights into the causes and consequences of radical changes in network structures. However, many questions are left unanswered. Very little is known about the following issues: the relationship between radical dyadic change and radical change at the network level, the evolution of network structures, the processes through which critical events lead to changes and network structures, and on the effects of radical changes in network structures on the performance of networks and its members.

First, none of the studies looking at radical dyadic change deal with its consequences at the network level, and all of the studies dealing with radical changes on the network level find that change has been triggered by external sources. As such, the link between radical change at the dyadic level and the network level has not been analyzed as yet. More research, linking the dyadic level of change to the network level, is necessary. A starting point for this research could be to focus on the effects of the formation and termination of dyadic ties (radical dyadic change) on the structure and functioning of the network as a whole. An example in this regard is the entry of an organization with a good reputation and high knowledge levels into the network. This might lead to the restructuring of the network, since many organizations will want to collaborate with the newcomer. This restructuring might result in a network characterized by higher levels of centrality and interconnectedness as well as higher levels of resource flows.

Second, little is known about the evolution of network structures. Even though some of the papers provide valuable insights, this body of knowledge is too fragmented to warrant any generalized statements. The theoretical distinction between serendipitous and goal-oriented network trajectories might provide a good starting point for future research [31]. Combining the claim that serendipitous network trajectories are more resilient to radical changes, on the one hand, and the observation that most networks become more goal-oriented over time [25], on the other hand, leads to the following hypothesis. The more mature networks become, the more sensitive they become to radical changes and the more likely they are to fall apart. Such a hypothesis might provide a good starting point for further research.

Third, the processes through which critical events trigger radical changes in network structure are largely a black box. The studies of Burkhardt and Brass [26], Madhavan et al. [6], and Soh and Roberts [29] provide some footholds by pointing at the importance of the network position of the first adopter of a successful new technology. However, this approach is useful only in cases where the change is triggered by the actions of a single network actor, such as the successful adoption of a radically new technology. Furthermore, this approach needs to be refined by looking at the behavior and motivations of these first adopters. However, these actor-level characteristics are often completely ignored in network research [31]. A possible valuable approach, which is used by Beckman et al. [42], is to categorize possible critical events into firm specific and market specific events and track the consequences of these events for the network structure over time. Beckman et al. [42] suggest that firm specific events are

likely to trigger radical dyadic and network changes (structure loosening change), whereas market specific events are likely to re-enforce existing dyadic relations and network structures (structure reinforcing change). Even though their empirical results only provide partial supports for these claims, they do provide an interesting starting point for future research. Critical events that come to mind are radical product innovation (due to the change of product standards [29]), radical process innovation (due to high levels of chain integration [26]) and firm relocation (due to the importance of spatial proximity for learning in networks [43]).

Finally, relatively little is known about the effects of radical changes in network structure on the performance of these networks and its participating firms. A starting point for future research might be offered by inter-organizational ecology theory [44]. This theory [45] predicts that attempts to change core features of an organization lead to an increased risk of organizational failure in the short-run. This risk of failure will decline over time as performance reliability is re-established and external relations are re-stabilized [44: p. 95]. The same reasoning could be applied to IORs and inter-organizational networks [46]. Over time, IORs can develop into locked-in dependency relations. Evolutionary processes can lead to a high degree of path dependence and institutionalized rigidities, which can, eventually, lead to a situation of inter-organizational or network inertia, in which changes in the inter-organizational structure can have large (negative) consequences for the organizations involved.

Some empirical support for the predictions from inter-organizational ecology can be found in the literature. Singh and Mitchell [20], for example, provide empirical support for the claim that the sudden collapse of a partnership can have far-reaching implications for the performance, and even the survival, of formerly partnered organizations. Even though this research focuses on dyadic ties, a similar reasoning may be applied on the level of the network [47]. Furthermore, Provan and Milward [48] encountered a poorly performing network in one of their case studies. From this case study they drew the preliminary conclusion that the large changes to which the structure of this particular network had been subjected prior to their study were, to a large extent, responsible for its poor performance. Both studies show that radical change in network structure can have large (negative) consequences for the performance of (firms in) networks. Interestingly, these findings contradict the results found by Ahuja [34] and Koka and Prescott [32]. This contradiction raises the question, “which changes in network structure are beneficial and which are not?” The findings presented in this paper suggest that it might be valuable to distinguish changes with beneficial results from changes with detrimental results. The distinction between structure loosening and structure reinforcing change [6] might provide a good starting point for analyzing the effects of different types of changes in structure on the performance of networks and its participants.

Despite the limitations of this literature study, it can be concluded that, even though these phenomena seem interesting and the existing literature hints at important findings, we just do not know enough about the causes and especially the consequences of radical change in network structure to make any well-founded general statements. In spite of the existing studies on the subject, very little is known about radical change in network structures. Recently, the Industrial Marketing and Purchasing Group published a working paper that deals with this problem [38]. In this working paper, they announce empirical research on the impact of mergers and acquisitions as well as the liquidation of IT companies (all examples of potential critical events) on the performance of networks.

Due to the large problems of gathering longitudinal network data, simulation studies might prove very valuable as well. Currently, the Sante Fe institute (see [www.santafe.edu](http://www.santafe.edu)) is using this technique in order

to study network evolution. Nevertheless, more longitudinal research dealing with (the causes and consequences of) radical changes in network structure seems necessary. Relatively much is known about the formation of dyads, but a longitudinal gap with regard to many other aspects of radical changes in network structures seems to exist.

## **Acknowledgements**

The authors would like to thank the participants of the MOPAN conference 2004 “Coalitions and Collisions”, the members of the research circle “Network Collaboration” of the Department of Organisation Studies at Tilburg University, Jörg Raab, Rob Jansen, and two anonymous reviewers for their valuable comments on earlier versions of this paper.

## **References**

- [1] S.P. Borgatti, P.C. Foster, The network paradigm in organizational research: a review and typology, *Journal of Management* 29 (6) (2003) 991–1013.
- [2] R. Cross, S.P. Borgatti, A. Parket, Making invisible work visible: using social network analysis to support strategic collaboration, *California Management Review* 44 (2) (2002) 25–46.
- [3] M. Marsili, F. Vega-Redondo, F. Slanina, The rise and fall of a networked society: a formal model, *Proceedings of the National Academy of Sciences of the United States of America* 101 (6) (2004) 1439–1442.
- [4] M.J. Piore, C.F. Sabel, *The Second Industrial Divide*, Basic Books, New York, 1984.
- [5] M. Storper, B. Harrison, Flexibility, hierarchy and regional development: the changing structure of industrial production systems and their form of governance in the 1990s, *Research Policy* 20 (1991) 433–455.
- [6] R. Madhavan, B.R. Koka, J.E. Prescott, Networks in transition: how industry events (re)shape interfirm relationships, *Strategic Management Journal* 19 (5) (1998) 439–459.
- [7] A.L. Oliver, M. Ebers, Networking network studies: an analysis of conceptual configurations in the study of inter-organizational relationships, *Organization Studies* 19 (4) (1998) 549–583.
- [8] B. Axelsson, G. Easton, *Industrial Networks: A New View of Reality*, Routledge, London, 1992.
- [9] P. Andersson, B. Molleryd, Channel network change and behavioral consequences of relationship connectedness, *Journal of Business Research* 46 (3) (1999) 291–301.
- [10] A.H. Van de Ven, G. Walker, The dynamics of inter-organizational coordination, *Administrative Science Quarterly* 29 (4) (1984) 598–622.
- [11] W.W. Powell, K. Kogut, L. Smith-Doerr, Inter-organizational collaboration and the locus of innovation: networks of learning in biotechnology, *Administrative Science Quarterly* 41 (1) (1996) 116–145.
- [12] L. Rosenkopf, A. Metiu, V.P. George, From the bottom up? Technical committee activity and alliance formation, *Administrative Science Quarterly* 46 (4) (2001) 748–772.
- [13] R. Gulati, Social structure and alliance formation patterns: a longitudinal analysis, *Administrative Science Quarterly* 40 (4) (1995) 619–652.
- [14] R. Gulati, Network location and learning: the influence of network resources and firm capabilities on alliance formation, *Strategic Management Journal* 20 (5) (1999) 397–420.
- [15] Y.L. Doz, P.M. Olk, P.S. Ring, Formation processes of R&D consortia: which path to take? Where does it lead? *Strategic Management Journal* 21 (3) (2000) 239–266.
- [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 (3) (1998) 668–698.
- [17] G. Ahuja, The duality of collaboration: inducements and opportunities in the formation of interfirm linkages, *Strategic Management Journal* 21 (3) (2000) 317–343.
- [18] W.P. Tsai, Social capital, strategic relatedness and the formation of intraorganizational linkages, *Strategic Management Journal* 21 (9) (2000) 925–939.



- [19] Y.L. Doz, The evolution of cooperation in strategic alliances: initial conditions or learning processes? *Strategic Management Journal* 17 (1996) 55–83 (Sp. Iss. Summer).
- [20] K. Singh, W. Mitchell, Precarious collaboration: business survival after partners shut down or form new partnerships, *Strategic Management Journal* 17 (2) (1996) 99–116.
- [21] R.A. Boschma, Proximity and innovation: a critical assessment, *Regional Studies* 39 (1) (2005) 61–74.
- [22] D.A. Levinthal, M. Fichman, Dynamics of inter-organizational attachments: auditor–client relationships, *Administrative Science Quarterly* 33 (3) (1988) 345–369.
- [23] M. Fichman, D.A. Levinthal, Honeymoons and the liability of adolescence: a new perspective on duration dependence in social and organizational relationships, *Academy of Management Review* 16 (2) (1991) 442–468.
- [24] S.H. Park, M.V. Russo, When competition eclipses cooperation: an event history analysis of joint venture failure, *Management Science* 42 (6) (1996) 875–889.
- [25] M.P. Koza, A.Y. Lewin, The coevolution of network alliances: a longitudinal analysis of an international professional service network, *Organization Science* 10 (5) (1999) 638–653.
- [26] M.E. Burkhardt, D.J. Brass, Changing patterns or patterns of change: the effect of a change in technology on social network structure and power, *Administrative Science Quarterly* 35 (1) (1990) 104–127.
- [27] S.E. Human, K.G. Provan, Legitimacy building in the evolution of small-firm multilateral networks: a comparative study of success and demise, *Administrative Science Quarterly* 45 (2) (2000) 327–365.
- [28] G. Lorenzoni, A. Lipparini, The leveraging of interfirm relationships as a distinctive organizational capability: a longitudinal study, *Strategic Management Journal* 20 (4) (1999) 317–338.
- [29] P.H. Soh, E.B. Roberts, Networks of innovators: a longitudinal perspective, *Research Policy* 32 (9) (2003) 1569–1588.
- [30] S.R. Barley, Technology as an occasion for structuring: evidence from observations of CT scanners and the social order of radiology departments, *Administrative Science Quarterly* 21 (1) (1986) 78–108.
- [31] M. Kilduff, W.P. Tsai, *Social Networks and Organizations*, Sage Publications Ltd., London, 2003.
- [32] B.R. Koka, J.E. Prescott, Strategic alliances as social capital: a multidimensional view, *Strategic Management Journal* 23 (9) (2002) 795–816.
- [33] J.M. Hite, W.S. Hesterly, The evolution of firm networks: from emergence to early growth of the firm, *Strategic Management Journal* 22 (3) (2001) 275–286.
- [34] G. Ahuja, Collaboration networks, structural holes, and innovation: a longitudinal study, *Administrative Science Quarterly* 45 (3) (2000) 425–457.
- [35] R.S. Burt, *Structural Holes: The Social Structure of Competition*, Harvard University Press, Cambridge, 1992.
- [36] A. Halinen, A. Salmi, V. Havila, From dyadic change to changing business networks: an analytical framework, *Journal of Management Studies* 36 (6) (1999) 779–794.
- [37] P.A. Havnes, K. Senneseth, A panel study of firm growth among SMEs in networks, *Small Business Economics* 16 (4) (2001) 293–302.
- [38] P. Dahlin, V. Havila, P. Thilenius, Dissolution in business networks: Swedish IT companies and radical changes, available at: <http://www.impgroup.org/>, 2003.
- [39] A.D. Meyer, G.R. Brooks, J.B. Goes, Environmental jolts and industry revolutions — organizational responses to discontinuous change, *Strategic Management Journal* 11 (1990) 93–110 (Spec. Iss. Sum).
- [40] C. Oliver, Determinants of interorganizational relationships: integration and future directions, *Academy of Management Review* 15 (2) (1990) 241–265.
- [41] M.S. Mizuchi, What do interlocks do? An analysis, critique, and assessment of research on interlocking directorates, *Annual Review of Sociology* 22 (1996) 271–298.
- [42] C.M. Beckman, P.R. Haunschild, D.J. Phillips, Friends or strangers? Firm specific uncertainty, market uncertainty, and network partner selection, *Organization Science* 15 (3) (2004) 259–275.
- [43] L.A.G. Oerlemans, M.T.H. Meeus, Do organisational and spatial proximity impact on firm performance? *Regional Studies* 39 (1) (2005).
- [44] J.A.C. Baum, Organization ecology, in: S.R. Clegg, C. Hardy (Eds.), *Studying Organization: Theory and Method*, Sage, London, 1999.
- [45] M.T. Hannan, J. Freeman, *Organizational Ecology*, Harvard University Press, London, 1989.
- [46] H.R. Greve, Interorganizational evolution, in: J.A.C. Baum (Ed.), *The Blackwell Companion to Organizations*, Blackwell Business, Oxford, 2002.

- [47] W. Mitchell, K. Singh, Survival of businesses using collaborative relationships to commercialize complex goods, *Strategic Management Journal* 17 (3) (1996) 169–195.
- [48] K.G. Provan, H.B. Milward, A preliminary theory of interorganizational network effectiveness: a comparative study of four community mental health systems, *Administrative Science Quarterly* 40 (1) (1995) 1–33.

**Joris Knobens** is a PhD-student at the Department of Organisation Studies at Tilburg University (The Netherlands). He holds a MSc degree in economics from Tilburg University with a focus on regional economics. His main research interests lie on the tangent plane of regional economics and inter-organizational network theory.

**Leon A.G. Oerlemans** is Associate Professor of Organisation Studies at Tilburg University (The Netherlands) and Extraordinary Professor of Economics of Innovation at the University of Pretoria (South Africa). He received his PhD from Eindhoven University of Technology (The Netherlands). His main research interests are organization theory, inter-organizational relations and networks, innovation, and regional economics.

**Roel P.J.H. Rutten** is an Assistant Professor at the Department of Organisation Studies of Tilburg University (The Netherlands). He received his PhD from Tilburg University (The Netherlands). His main research interests are networks, innovation and spatial proximity.