network evolution

towards an evolutionary perspective on network dynamics

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Preface

Dear family and friends, I need to thank you,
In this note that I'm sending you, I need to show my gratitude
I truly indebted to you. Thank you for pulling me through

Dear family and friends, I really need to thank you
You are there for me, so I will always be - there for you
And this is how I show my gratitude
(Pete Philly & Perquisite – Grateful)

Well, I guess this is it for now. The following pages are the product of my graduation research, symbolizing the end almost seven years of study at Tilburg University. It has been a wonderful time with plenty of opportunities for my evolution as a *human thesis*[**].
This thesis expresses my findings after two years of explorative research on the changes of interorganizational networks. It is written in English, not my native language, as I would love to see it contribute in any form to international research and possibly as a base for my personal future in research. It has been a truly exciting process although it was a lonely expedition at some times. However, it gave me the opportunity to enter unexplored scientific fields as well as discover my own scientific passions and capabilities. All in all, it was a very interesting and exciting journey.
This journey had not been as interesting or at all possible without some people, who supported me from their own functional node in my personal network. I highly value the way in which they continuously contributed to the content of our specific relationships.

A few of them I would like to thank specifically. Firstly, my supervisors. Leon, thank you for your very constructive comments, and the way in which you shared your wisdom on interorganizational networks. Tobias, thanks for those great years in which you gave me the opportunity to experience the beauty of the academic world and scientific reasoning. I really look back at those days with great pleasure.
Thanks also go out to the members of the research circle on interorganizational collaboration from the department of organization studies, thank you all for your comments on earlier drafts and the chance you gave me to experience the fun of discussing research papers.
I am very grateful to the experts Chris Buskes, Ron Boschma, Bart Nooteboom, and Koen Frenken who commented on an earlier draft from their field of expertise. Thanks! It was a very valuable experience, both with respect of this research as well as personally.

[**] Refering to a specific species: half man, half theory (quoted from the PBS series “Evolution”, http://www.pbs.org/wgbh/evolution/)

Thanks also go out to Alex and Bettine, for their useful comments concerning the clarity and grammar of the text.

And to all my friends, who put in the effort trying to follow me while I was driveling about the exciting possibilities of an evolutionary perspective, the similarities between biology, organizations and humans; the power of sexual selection; the essence of replicators, etc.
Jac, Betje, Heid, Bram, Mikkie, and all others social nodes… Thank you a lot for your friendship and love, putting up with my ravings, your moral support in tougher times, and your questions which pushed my thinking to fields I would have omitted otherwise. Thanks for contributing to my thesis in your own way, and more important: to my life.

Finally, I would like to thank my direct 'ancestors'. Of course, thank you for procreating, but even more; thank you for keep believing in me and supporting me, making these seven remarkable years possible. Thank you. A lot. Therefore, this one is for you.

And if there's anything good to be said about me,
Than it's true that I owe it all to you.
(Pete Philly & Perquisite – Grateful)

I hope you will enjoy reading this thesis with as much inspiration and enjoyment as I experienced while writing it.

Arnout
Tilburg, June 2006

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Network evolution: towards an evolutionary perspective on network dynamics

Arnout Drenthel

Summary

Research on network change appears to be struggling to get a grip on the complexity of its dynamics. This paper is an attempt to develop a meta-theoretical perspective in order to explain dynamics in interorganizational networks by applying mechanisms analogous to the theory of evolution, in an effort to find out the feasibility of the application of an evolutionary perspective to explain dynamics. It addresses change as an ongoing process, being the result of variation, selection, retention and a struggle to survive. Current literature on network dynamics is analyzed and alternative explanations are developed. This results in suggestions for an evolutionary perspective on network dynamics, like kin selection, partner selection, and innovation processes. The paper is concluded with a discussion of the possibilities and shortcomings of the evolutionary perspective for use on interorganizational networks.

Introduction

Researchers have in the past insistently pressed for studies on network change. Different theories are presented in the literature explaining the rationale of relationship formation and partner selection, but still only little is known about the mechanisms by which networks change. Research on network change appears to be struggling to get a grip on its complexity. This paper endeavors to present a perspective on network dynamics in an attempt to explain change from a more comprehensive standpoint, based on insights of evolutionary theory. It addresses change as an ongoing process, being the result of variation, selection, retention and a struggle to survive.

Several authors have stressed the necessity for further research on network developments and change (Borgatti, 2003; Knoben, Oerlemans, & Rutten, 2006; Walker, Kogut, & Shan, 1997). Additional research is suggested to focus on network antecedents and incorporate a longitudinal perspective (Borgatti, 2003). Moreover, attention to a whole network-perspective is called for as the largest part of present research focuses on dyadic relationships (Baker & Faulkner, 2002). Evidently, there is a need for research focusing on network change with attention to all of its complexity.

Furthermore, some theoretical standpoints in current literature seem contradictory. For example the literature on the value of cohesion and social embeddedness (Uzzi, 1997) contradicts structural hole literature (Burt, 1992; Coleman, 1990; Granovetter, 1973). Both perspectives differ on the value of proximity of partners in creating output. Another example of conflicting literature are the contradictory conclusions on the effects of uncertainty on partnering behavior by Beckman, Haunschild and Philips (2004) and Hoetker (2005). A meta-theoretical perspective might unify these apparent contradictions, thereby providing a better overall insight in the dynamics of networks. But, taking this current state of contradicting network literature in consideration, it seems explicable that hardly any attempt at meta-theorizing on such complex network dynamics has been undertaken.

Aldrich and Ruef (2006) have shown how the theory of evolution can be used as a meta-theory of organization studies. As shown by Stephen Borgatti (2003), common theoretical constructs and ideas like institutional theory and resource dependence theory are part of network thinking but have become part of mainstream organization studies themselves. Aldrich and Ruef integrated these major theoretical constructs in an evolutionary perspective on organization approaches. To contribute to the need in network research, it seems a logical step to extend the evolutionary perspective to interorganizational networks (IONs) and ION dynamics.

Although parts of evolutionary theory thinking have been used in organization studies (cf. population ecology) and economics (cf. evolutionary economics) before, it has not been applied to the understanding of network dynamics. Therefore, this paper proposes to develop analogous mechanisms of the evolutionary theory to explain dynamics in IONs. It so happens that the evolutionary theory, originating from the field of biology, incorporates those concepts network researchers seem to be looking for. It explains the phenomena of continuous evolving interdependent organisms from a holistic and longitudinal perspective, with attention for multi-actor and multi-level complexity and diversity. These characteristics result in the power of the evolutionary theory in its ability to offer an understanding of dynamics of change by providing an analogous perspective in another field of dynamics (Sammut-Bonnici & Wensley, 2002).

This paper is an attempt to develop a meta-theoretical perspective in order to explain dynamics in IONs by applying mechanisms analogous to the evolutionary theory, in an effort to find out the feasibility of the application of an evolutionary perspective to explain dynamics. This aim is guided by the following research question: *In which ways can the theoretical concepts and mechanisms of theory of evolution be applied, to come to explanations of aspects of ION dynamics?* These concepts and mechanisms will be confronted with current literature that focuses on explanations of ION dynamics, developing alternative explanations. Together, these competing explanations should give an indication for an evolutionary analogy of network dynamics. This analogy will then contribute to the current network literature by providing a meta-theoretical perspective on its complex dynamics. Such a meta-theory trusted by analogy could unify the fragmentation found in current literature and guide future research, as suggested by Janesick (1994) and Bailer-Jones (2002).

In the next section the central concepts and mechanisms of the evolutionary theory are briefly discussed. The conclusions that will be drawn from this discussion serve as a theoretical starting point for the development of the analogy in the field of interorganizational networks. The following section discusses what comprises ION dynamics. Then, the applied methodology is explained in section four in section four, followed by the presentation of the results of the literature review, which provide input for the development of an analogy in section 6. Finally the findings are discussed and conclusions are drawn.

Theory of evolution

The evolutionary theory provides an explanatory mechanism for understanding dynamics in a competitive environment, in which organisms struggle to survive due to scarcity of resources. Based on the findings by Charles Darwin, scientists developed a powerful theory that was able to explain the dynamics of variation in biology. In this section, the central mechanism and antecedents of evolution are explained in more detail. First a description of how relationships are explained from an evolutionary perspective is presented, in order to indicate the theory's potential for use in interorganizational relationships.

Corporation and relationships in evolutionary theory

From an evolutionary perspective, initially relationships with others actors may seem odd, as at the same time, these other actors are one's direct competitors for the scarce resources However, in evolutionary biology cooperative relationships do occur on different levels and in various forms.

From an evolutionary perspective, relationships between organisms roughly serve two related functions. Either they enhance the survivability of the individual organisms by increasing fitness through cooperation, or they serve as a means to procreate. And from a true holistic evolutionary perspective, both can be regarded as attempts in continuation, because both serve the survival of the genetic material, as will be shown below. Below, different forms of relationship in biology and conditions for forming relationships will be discussed.

The most primitive form of relationship occurs in cell biology. Single cell organisms started to cooperate in multi-cellular organisms resulting in variation with a higher fitness in the specific environment. On a higher level we also see organisms of different species cooperate. There is, for example, the case of the rhinoceros being groomed by the small bird called oxpecker. Or even more commonly, plants and trees depending on birds and insects for the dispersion of their seeds. These two examples present functional relationships of cooperation and interdependence, mutually beneficial for both organisms as in result fitness and survival chances are increased.

More advanced relationships, however, may involve a more complex form of social behavior called altruism. Although it might seemingly appear as not mutually beneficial for both organisms, it actually is on a deeper genetic level. Altruistic behavior is often associated with sacrificing for the benefit of genetically close actors, a process referred to as *kin selection*[1]. In this way, genetic proximity largely influences the exchange relationship and it makes clear that an evolutionary mechanism operates on more levels than solely on the organism-level. Still, relationships are formed to increase mutual survival chances.

Advanced coordination of reciprocal behavior requires the memory of and ability to interpretate social relationships[2], and the ability to communicate on an advanced level (e.g. Ridley, 1996; Williams, 1966/1996; Wilson, 1978; Zimmer, 2001). With these abilities, delayed returning of a favor became a possibility in human evolution, introducing the possibility to invest in relationships over a time scale. This opened the path for the division of labor thereby, which meant benefiting from increased efficiency through cooperation and a better allocation of time and energy.

With the increasing ability to express one‘s self (i.e. through use of language), social identity developed and with it culture (Zimmer, 2001). With the development of social relationships and the ability to communicate about abstract ideas, culture started to evolve. Different authors use the term *memes* when referring to the equivalent of genes in cultural evolution (e.g. Blackmore, 1998; Goudsblom & Wilterdink, 2000; Williams, 1966/1996). Meme can be referred to as cultural modes of thought and was a term originally coined by Richard Dawkins (1976/1989).

The functionality of (social) relations in the evolutionary theory have led to various attempts to incorporate evolutionary theory in a socio-cultural perspective, ranging from the effects of biological evolution on socio-cultural components (e.g. Goudsblom & Wilterdink, 2000), fields of sociology (e.g. Ridley, 1996; Wilson, 1975), psychology (e.g. Geary, 2005), and economics (e.g. Boschma, Frenken, & Lambooy, 2002; Hodgson, 2000, 2002; Nelson, 1995; Nelson & Winter, 2002), to the actual evolution of socio-cultural components themselves (e.g. Dawkins, 1976/1989; Ridley, 1996). These contributions indicate how an evolutionary perspective is successfully applied outside the field of biology. The attempts contribute to our general understanding of (social) relationships from an evolutionary perspective. Also, it is suggested above in what ways relationships can be explained from an evolutionary perspective. Together, these perspectives can be combined to form suggestions on the evolutionary dynamics of systems of relationship such as IONs. The basic understandings and the mechanisms fundamental to the process of evolution are explained in more detail below.

Evolutionary perspectives

Evolutionary theory is mainly known for the findings of natural selection by Charles Darwin and his *"On the origin of species"* (1859/1985). His theory of natural selection was based on a combination of new insights, which were not compatible with the common beliefs at that time. Probably the most revolutionary element of Darwin's conclusions was its break with the paradigm of *essentialism* (or: typological thinking). Essentialism holds that all seemingly variable phenomena in nature can be sorted into classes which are characterized by their (stable) definition, or: by their essence. Instead of accepting the idea of constant classes (types), Darwin introduced the idea that every

[1] For an overview of cooperative behavior and associated game theoretical strategies, see Ridley (1996)
[2] This is also referred to as theory of mind in psychological literature.

individual in a population is uniquely different from every other individual, a notion now referred to as *population thinking*. This forms the basic thought style in modern biology. With this idea, Darwin could incorporate variation as a central mechanism by which natural selection operates. This resulted in a process of evolution of organisms in which natural selection, chance, history, and time play a fundamental role.

However, it is important to emphasize here that Darwin's theory of natural selection is not the only perspective in evolutionary thinking. Following Depew & Weber (1995) a taxonomy of three paradigms can be made that explain different evolutionary phenomena: theory of natural selection, probability theory and complexity theory. Where the theory of natural selection (based on Darwin's findings) focuses more on behavior and gradual change, complexity and probability theory focus on system design and punctuated equilibria.

First, the process of *natural selection* is a process in which trial and error and chance play a dominant role. The fitness of an organism's characteristics in its environment, determines its chances of survival. Favorable characteristics are preferred and unfavorable ones eliminated through natural selection. This is a chance process as the origin of characteristics lies in a chance process of genetic alteration.

Second, the *probability paradigm* focuses on evolution as a result of the stabilizing propensity of large populations and the innovative capacity of small (isolated) populations. Chances of survival of a new characteristic of organisms are higher when it has a relatively larger share within a population. Therefore, small isolated populations are an ideal breeding place for innovative characteristics (variations), because the dominance of the existing alternative is relatively less powerful. Once an advantageous characteristic has developed far enough to overcome the resistance of the dominating propensity of the existing alternative, this can cause a punctuated equilibrium (Eldredge & Gould, 1972). The probability paradigm thus focuses on evolution through punctuated equilibria as a result of the development of new variations in traits in small isolated populations.

Third and last, the *complexity paradigm* describes systems as being the result of simple rules for individual actors in a population which will develop in a complex but continuously evolving equilibrium. However, there is no preliminary plan or design for the complex formation. Examples are flocks of birds and shoals of fishes, or more popular nowadays: the Butterfly Effect and the related Chaos Theory. The complexity perspective focuses on the impact of individual actors within the system and pays less attention to effects of the environment. Thus, the evolution tendencies primarily take place in and through the system (and its set of rules) itself.

The evolutionary algorithm

Albeit these different perspectives, fundamental to any form of evolutionary thinking is the algorithm of variation, selection and retention. The term algorithm refers to an ongoing symbiotic process of these three mechanisms, staged in an environment of limited resources. This results in what we know as an evolutionary process in a continuous struggle for survival. However, this does not imply that this process is deterministic as the three main mechanisms may be either intentional or unintentional. These differences are discussed in more detail below.

Darwin suggested that the small differences (or: variation) between individuals (hence his population thinking) could enhance survival chances over other individuals (through higher fitness) in the struggle to survive. In other words, beneficial traits are selected[3] through competition as they have a higher fitness with the environment. These beneficial traits are passed on through a process of retention. With the (re)discovery of Mendell's laws of heritability in the 1930's and later with the developments in the fields of genetics throughout the 20th century, this evolutionary condition from the 1890's became fully tenable.

Dynamic phenomena on which this VSR-algorithm applies are called evolutionary, and as such, these three concepts will be used as characterizing evolutionary thinking in this research. The central concepts of this algorithm are explained in more detail below.

VARIATION

Variation is a central notion in evolutionary thinking. Underlying its apparently simple surface is a multilevel and rather complex construction. Essential to an understanding of evolution is the distinction between replicators and interactors. Using a biological organism as an example, the replicator is the in DNA encoded genetic information of an organism (or: genotype), so to say the 'blueprint'. The interactor on the other hand is the physical representation of that organism (phenotype); i.e. the actual animal we see, which interacts with the physical environment in the struggles for survival. Differences in genetic coding result in different traits of the organism, which may influence its survival chances in the process of selection as an interactor. In the modern synthesis of the evolutionary theory, traits are seen as the units that are selected . A total organism substitutes a collection of traits thereby embodying the pay off of all combined traits. As these traits are determined by the underlying replicator, one could also argue that the selection operates on the genetic level. In that way, the interactor is the temporary vehicle by which the replicator competes for survival in the physical world. This argument was introduced by Richard Dawkins in his seminal work "The Selfish Gene" (Dawkins, 1976/1989).

But where does this variation among replicators come from? Two sources for variation can be discerned. The first and most direct source is mutation (i.e. as a result of exposure to radiation or of errors in cell copying). The resulting replicator might introduce new traits that enhance chances of survival, although these chances are relatively small. The second source is reproduction. As a result of mating, most living organisms reproduce by recombining two strands of DNA. This merging of different replicators results in a unique genotype and phenotype. Variation in the input of the reproduction process may be gene flow (or: migration) and genetic drift (a statistical tendency related to population size, which forms a central base in the population perspective).

In biology, the sources of variation are complex and very much subject to a process of chance. This chance component forms the base for the complexity paradigm of evolution. It also makes it very hard to make long-term or complex predictions from an evolutionary perspective.

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[3] This does not imply that the best possible configuration will survive, only that the best available variation has the highest chances of survival.

SELECTION

The process of selection favors those organisms with the most beneficial traits in a specific environment, or in other words: it favors the interactor with the highest fitness. Fitness is the level of adaptation to the specific environment. This environment consists of biological (e.g. climate, food), ecological (e.g. food resources, predators) and social (e.g. social acceptance, kin selection) dimensions.
As competition takes place on different levels (e.g. between individual actors, cells, groups, cultures, etc.), selection operates in different forms. Selection may be natural or artificial. Artificial selection is intentional favoring, as for example in the breeding industry. Natural selection however, is unintentional and the result of a complex interaction in the system of individuals, species and environment.
There are two forms of natural selection, on which experts do not agree which one has a highest impact (Zimmer, 2001). Sexual selection operates in the process of reproduction and favors traits with high fitness by social standards (e.g. attractiveness) and of reproductive strategies. Some traits are favored as they signal survival strength (known as female choice), other traits are favored as they provide opportunities to mating (known as male competition). Ecological selection concerns the survival in the competitive system of acquiring food over competitors, the ability to catch prey, evading predators and coping with climatic conditions.

RETENTION

Useful traits will be preserved by the process of retention. In fact, evolution is nothing more than the perseverance of those traits with the highest fitness, preferred through the process of natural selection. In biology these traits are encoded in genetic material and preserved thanks to heredity of genetic blueprint. As the biological interactors are mortal, it is essential that their replicators are passed on through the process of reproduction before the death of their interactor, as thereafter their genes cannot be replicated. However, this is the case in biology, but is not necessary for evolution to occur when replicators can be retained separate from the existence of its interactor.[4]

Conclusions

The evolutionary theory can be summarized as a holistic perspective on complex dynamics incorporating the algorithm of variation, selection and reproduction, and the struggle for survival resulting in a system's state of equilibrium[5] in an environment. These mechanisms operate on different levels simultaneously (e.g., genetic, organic and socio-cultural levels), enabling a perspective on the explanation of dynamics incorporating high complexity.
From an evolutionary perspective, relationships are formed in an attempt to create higher fitness, either directly by increasing own survival chances, or indirectly through

[4] This statement may stirr a philosophical discussion on the essence of replicators and its interactors. However, we do not want to start this discussion here, but we would like to indicate the possibilities for an evolutionary perspective outside biology.

[5] In evolutionary thinking, equilibrium is not used as a stable state, but as a complex balance of highest fitness, build by multiple factors which are continuously changing, either internally (variation) or externally (environmental or competition). This differs from neo-classical thinking of an equilibrium as an *optimal* state.

reproduction. Partners for these processes are selected on the basis of their complementary resources and characteristics (natural selection), and on the basis of fitness and some forms of proximity (sexual selection). After all, potential partners must be able to understand and assess traits from their concerning perspective, which results from their social and cultural background.

ION dynamics

In network literature, researchers find it hard to come to a unified perspective on networks (Borgatti, 2003; Gulati & Gargiulo, 1999). Terms like industry, population, community and network seem to be used interchangeably at some occasions (Aldrich & Ruef, 2006). However, interorganizational networks can be characterized by some returning concepts. Network can be considered as an *interrelated set of actors*, where the *actors* in this case are organizations. The filling-in of the *set*-aspect may differ from study to study. The set may for instance be constructed around one focal organization (ego), as a description of a field of business, or of a population (Baker & Faulkner, 2002). The notion of *interrelatedness* in the above presented definition is fundamental in networks. It implies that actors have (or lack[6]) some form of relation in which they organize the exchange[7] of some kind (e.g. resources like goods, money or knowledge), as Levine and White (1961) argued. Furthermore, interorganizational networks can be considered scale-free networks (Barabási, 2002), in which actor's centrality is heterogeneous.

A true network perspective incorporates heterogeneous actors in an atmosphere of cooperation and competition (Aldrich & Ruef, 2006; Baker & Faulkner, 2002). Although dyadic relationships and ego-networks are parts of a larger true network, in essence they are not true networks (Borgatti, 2003). Since they are straightforward units of analysis, understandably they are used frequently in network research. Network studies should however incorporate an holistic perspective to understand its full complexity and dynamics, as argued by various authors (Baker & Faulkner, 2002; Borgatti & Foster, 2003; Jones, Hesterly, Fladmoe-Lindquist, & Borgatti, 1998). Furthermore, a holistic perspective should also take into account the evolving environment of the network, as this determines how well a specific network is able to function, as argued in contingency theory.

Networks thus, are the result of a very precarious and complex balance of many internal and external variables. Any force altering this balance may result in a change somewhere in the network as described by chaos theory (Kiel & Elliot, 1996). The processes and mechanisms by which forces produce change in the equilibrium of the network state (regarding the structure and content of relationships), are referred to as *network dynamics*. And as these forces are constantly pushing the equilibrium, the process of network dynamics also is a continuous process.

Network state can be considered an equilibrium state and form of available relations within a contextual condition. This brings to mind evolutionary thinking; a selected state of fitness resulting from available variations in a selecting environment. The evolutionary

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[6] Cf. the discussion on structural holes and their value (Burt, 1992)

[7] This exchange however, may vary in form, content, frequency, similarity and intensity.

theory describes and explains different forms of dynamics which combined evolve into a state of equilibrium. This equilibrium may be affected by small incremental changes or radical changes (hence the probability paradigm in evolutionary theory), a phenomenon described by Knoben et al. (2006) in the field of organization studies.

A certain network state thus is a function of its external environment, its own internal relationships and the propensities, characteristics and strategies of individual actors. Network change can be explained as the result of external or internal dynamics and may be reflected in the interrelationships of its actors. These dynamics may be reflected in alteration of the physical relationships (structure) or in the characteristics of these relations (content). Some aspects of structure and content related network dynamics are explained below.

Structural dynamics

We define the structure of a network as the physical relationships between actors. It can be illustrated through quantitative figures as number of relationships, density, and actor centrality[8]. It refers to the question of who relates to whom, and it results can be drawn up in a sociogram with software tools like UCInet, Pajek or NetDraw. Structural network analysis is mainly based on observable quantitative data which makes this type of analysis popular among researchers.

Structural changes can operate on different levels. Changes may appear at a *dyadic* level concerning linkage actions between two actors, or on a *network* level concerning more than two actors. Clearly, both influence the structural formation of the network by itself and through resulting co-evolutionary effects. Structural changes on a dyadic level incorporate the choice to form relationships with others, and the selection of an appropriate partner. Network level changes discuss network stability (e.g. by entry and exit levels of firms), actor centrality, density, etc.

Content dynamics

As networks are characterized by exchange relations of some sort, not only their quantitative structural connectedness is relevant, but also the qualitative interpretation of these exchange relations. We refer to this as the content of network relations. These also may be subject to changes over time as a result of external and internal processes. Changes in the perceived trust among network members, the types of relationship, shared institutional norms and values, subject of communication and communication intensity are all characteristics incorporating different qualitative aspects of interorganizational (network) relationships. As a result of change in relationships' content, the role of actors or network relationships may take a more dominant role in the network due to expert knowledge or prestige. However, this might just not be expressed in structural formation of the network. For example, the content and frequency of communication in a two firm-buyer-supplier relationship may change as the product matures from pioneering and experimental to mass-market (Darr & Talmud, 2003). With a decrease in communication intensity the cognitive proximity of both partners may drift apart, thereby altering the

[8] See Garton, Haythornwaite and Wellman (1997) or Freeman (2004) for more detail on structural characteristics of social networks.

content of their relationship but remaining in their structural buyer-supplier relationship. Other examples of change in content might include trust, culture, institutions, nature of exchanged resources, shifting assymetrical power relations, change in an actor's legitimization needs (Human & Provan, 2000), etc.

An example of research on the content of relationships on a dyadic level, is the theorizing on the changing hazard rate of interorganizational relations as a function of a relationship duration (Levinthal & Fichman, 1988; Park & Russo, 1996). It is suggested how interorganizational relations qualitatively change over time. In a nonmonotonic pattern, the hazard rate of dissolution increases in the initial years of the relationship, but declines after a certain honeymoon period. Researchers suggest that may be caused by initial optimism by the actors about the viability of the relationship, which gradually declines. However, as Park & Russo also suggest, more research on such content dynamics of relationships is needed (even on a dyadic level) to be able to fully understand such dynamics

One can imagine that aspects of relationship content are just as important in understanding network processes as structural characteristics. Both are therefore taken into account in developing an evolutionary perspective on network dynamics.

Methodology

Although IONs and related topics have received increasing attention in scientific literature since the 1970s, little attempt has been made to develop a comprehensive perspective of the dynamics within this matter. Also, no attempts where found which linked the evolutionary theory to the dynamics of interorganizational networks.

To develop an understanding of the contemporary state of affairs in literature on the explanations of network dynamics, the literature is systematically reviewed in line with the method described by Pittaway, Robertson, Munir, Denyer & Neely (2004). In this way, developed explanations for dynamics are derived from a collection of high-ranked journals. These explanations are then confronted with competing explanations from an evolutionary perspective.

The different stages in the design of the systematical review method are explained below to add to the transparency of this study. The following steps are taken:

(1) Provisional keywords[9] on the subject were identified based on the experience of the authors and constructed into search strings for use in online databases.

(2) In an iterative process, some initial searches where undertaken to fine-tune the selection of keywords and the construction of the search strings. For example, additional words[10] were found to be used to describe the phenomena under investigation. The combination of relevant keywords was then constructed in a final search string[11].

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[9] e.g. networks, change, dynamics, evolution

[10] like inter-organizational, development and transformation

[11] TS=(networ* OR interorgani$ational OR inter-organi$ational) AND TS=(chang* OR evol* OR dynamic* OR develop* OR transform* OR longitud*) AND TS=(organisatio* OR organizatio* OR busines* OR corporati* OR firm*)

(3) Two online citation databases (ABI/Inform Proquest and ISI Web of Knowledge) were searched using the search string from step (2). The search was limited to a selection of 45 top-ranked ISI journals relevant in the field of ION dynamics, and to a date range of 1990 to 2005. This resulted in respectively 420 (ABI/Inform Proquest) and 734 (ISI Web of Science) hits.
(4) Papers' titles and abstracts were then reviewed and selected on the base of inclusion and exclusion criteria (see appendix).
(5) The systematic review of steps (1)-(4) resulted in a collection of 24 articles, which represents papers of particular relevance because they directly describe ION dynamics in line with the perspective of (parts of) IONs as presented. Through forward and backward citation analysis this list was expanded to a final list of 26 articles.
(6) Per article, the presented network dynamic under investigation was determined along with its given explanation. The provided explanations were then analyzed from an evolutionary perspective and alternative evolutionary mechanisms were selected where appropriate. These mechanisms made it possible to develop competing alternative explanations from an evolutionary perspective.
(7) The papers were then grouped based on the type of network dynamics described, making it possible to develop an overall picture on the arguments presented in the literature and developing possible evolutionary alternatives.
(8) To test the reliability of these findings, the results were presented to four experts on the field of the evolutionary theory, interorganizational relationships and economic geography in a consulting round. Their comments were processed where possible.

Methodological Challenges

The method used has some limitations which should be pointed out here. First, the used databases only provide journal articles, thereby neglecting books and book chapters which might provide additional explanations. Second, the timeframe selection was limited to the 1990 – 2005 period, which excludes prior articles. However, in this way a discussion is started based on the contemporary state of the literature. Besides, interest for research on whole networks only seems to take off after 1990.

Thirdly, arguments from and insights based on for example solely dyadic research which might be extended to whole network effects, are excluded from the A-list. However, conclusions drawn from such articles in a meta-analysis literature review like this are disputable as it would not do justice to the complexity of that particular research. As the selection of articles is based on their abstracts, poorly written abstracts may prevent articles from being selected; a type II error.

A definitional challenge which is inherent to the subject of network research, are the ambiguous interpretations of the concept of networks. Authors still do not agree on a single definition of networks, and terms like fields, alliances, and population are used for what we understand as networks. On the other hand, the term networks is used for a far wider concept than ours, e.g. for personal social networks and ego-networks. This indistinctness troubles making a search and selection of the literature, thereby enabling type I and II errors in selecting the literature.

A final challenge was the bridging of two different fields of research. The evolutionary theory, how general its construct may have become, still carries the baggage of its origin: biology. Although this produces an abundance of lively illustrations, the translation to the thought style of organization studies should be made with precaution. Other attempts in making translations like population ecology (Hannan & Freemann, 1977) and evolutionary economics (Nelson, 1995; Nelson & Winter, 2002) only used suitable parts of the evolutionary theory, not its entire mechanism (Young, 1988). However, these previous works may provide suggestions for analogous processes (e.g. Penrose, 1952).

Results

Below the findings of the literature analysis are presented. A total of 26 papers were analyzed and are presented in matrixes below. As discussed above, network dynamics are divided in structural network dynamics and content dynamics and will be presented in that order. A few papers from the analysis will be picked out per subject, to illustrate the line of reasoning. The alternative explanations per article are also presented in the last two columns of these matrixes, and will be discussed in the "Evolutionary perspective" section.

Analysis of the literature shows that some forms of dynamics are yet to be investigated in network research. Current research predominantly focuses on structural network dynamics, especially from a dyadic level. This is reflected in the analysis presented below.

Structural dynamics

Structural network dynamics refer to all mechanisms which influence the changing of physical network structure. A total of 24 papers were found to discuss any form of structural change, a vast majority of the total literature current research addressing the topic of network dynamics. Likewise, most research on structural network dynamics focuses on a dyadic level like relationship formation inducement and possibilities (10 papers), and partner selection (7 papers). Whole network perspectives are scarce in research literature as was already argumented by different authors (Baker & Faulkner, 2002; Borgatti & Foster, 2003; Jones et al., 1998). However, some papers cannot unambiguously be classified as dyadic. The Beckman et al. (2004) paper for example addresses the topic of partner selection, but regards it as a form of network stability. Similarly, dyadic relationship formation may contribute to network centrality and density.

The papers on a structural dynamics were found to depart from two levels: a more dyadic perspective and a network perspective. From the dyadic perspective, network relations are approached on a more detailed level of *relationship formation*. These papers can build on a fairly rich history of dyadic research. The papers presented here however, consider relations as a part of the network and as a resulting network configuration, thereby approaching whole network thinking one step further than pure dyadic papers.

The papers starting from a network perspective consider the dynamics of structural network change as a function of *network stability*. Research on network stability focuses on the continuous dynamics in network change, as individual firms enter and exit the network. Although labeled stability, these papers investigate structural network change, clearly from a network perspective.

Although these differences are neither exclusive nor exhaustive, they give a coarse classification of the found research on network dynamics. However, some papers provide explanations for network stability as well as relationship formation. Their relevant explanations in question are discussed in the appropriate groups. Below, first the papers discussing relationship formation will be discussed. After that the papers focusing on network stability will be presented.

RELATIONSHIP FORMATION

Most literature (15 papers) focuses on the process of relationship formation and elaborates on extensive experience in dyadic research. However, the process of relationship formation can be regarded as a function of three related processes. Firstly, a firm's *inducement* for linkage determines the need to form relationships (firm specific consideration), followed by a firm's *possibilities* to form linkages at all (consideration by the firm's social environment). Thirdly, the process of *partner selection* (a dyadic process) determines with whom a firm will form a relationship. This final focus is strongly related to both prior processes, as a firm's needs automatically selects a pool of potential partners and a firm's possibilities can be considered a process of reversed partner selection. As a lot of research focuses specifically on process of partner selection, these papers will be dealt with separately from those focusing on relationship formation. Again, some papers address more than one consideration and its respective arguments are presented in the appropriate groups. A full overview of the papers on relationship formation is presented in Table 1. Below we highlight the found explanations from a few of the papers, to illustrate the line of reasoning in this research.

Haunschild (1993) explains how the inducement to form relationships can be the result of a social process. He argues how directorships result in imitation behavior of relationship formation. Managers on the board of other firms, are confronted with linkaging activities of those firms. Haunschild found that the firms of these managers develop relations at a higher rate. Exposure to the idea of linkage formation apparently trusts relationship formation.

Ahuja (2000) focuses on the actor level by investigating the relation between stock of technical and commercial capital, and the inducements and opportunities of firms to form linkages. Ahuja argues that a high stock of technical and commercial capital increases a firm's opportunity to form relationships, but on the other hand, those firms with access to sufficient capital will tend to be become more reserved to form linkages as new linkages will increase costs of investment but diminished returns. Thus, firms having both the ability and the intention to form linkages, are more active in forming relationships. Firms

Table 1 Literature on relationship formation: inducement and possibilities to form linkages

Author	*Network description*	*Lon git.*	*Structural dynamic*	*Explaining variable(s)*	*Given mechanism*	*Alternative evolutionary mechanism*	*Evolutionary analogy*
Axelrod et al. (1995)	Unknown	No	Linkage inducement	Alliance size and presence of (close) rivals	Firm's inducement to join a specific standard-setting alliance increases with the size of the alliance and decreases with the presence of (close) rivals. The result of alliance formation is a Nash equilibrium as all firms join alliances from which defecting does not outweigh potential profit of joining another alliance.	Probability paradigm; Survival	Alliance size indicates the viability of the technical standard (alliance offspring), which suggests some security over the investment of relationship. By entering an alliance with direct rivals, competition will be intense and may cost more resources. Firms are tempted to find alternative alliances and to develop a distinguishing position (variation) which would result in a better overall payoff.
Davis and Mizruchi (1999)	Bank non-bank board relationships (1982-94)	Yes	Linkage inducement	Individual strategy of banks	As a result of a shift in product clientele, banks change their strategy and relationship inducement, resulting in decline in executives joining bank boards.	Multi-level effects of co-evolution.	In a reaction to the market (market-level), banks change their strategy (firm-level) which can be considered a process of co-evolution. One of the effects thereof is that on a structural network level, relationships perish.
Gimeno (2004)	Global airline industry (1994-98)	Yes	Linkage inducement	Exposure to rival's alliancing activities	Firms react strategically to rivals' alliancing activities by either allying with those rival's partners (when rival's alliance is non-specialized) or by building countervailing alliances (when rival's alliance is co-specialized and focal firm is excluded by the alliance).	Co-evolution and intentional variation	In order to enhance their fitness in reaction to other firms incrementing fitness, firms seek to develop valuable variation by forming linkages with similar partners.
Gulati (1995; with Gargiulo, 1999)	Three worldwide industries	Yes	Linkage inducement	Strategic interdependence and embeddedness by prior alliances	New alliances are more likely to form when there is a strategic interdependence between two organizations. Also, probability increases with the existence of a context of social embeddedness emerging from prior alliances.	Ecology; kin selection	In an attempt to increase fitness, organizations look for partners that add valuable variation. As a result of social proximity (or: embeddedness), close partners are preferred to build a cooperative relation.
Gulati (1999)	Three worldwide industries	Yes	Linkage inducement	Network resources	Access to knowledge of potential partners and networking capabilities is influential in a firm's decision to enter in new alliances.	Sexual selection; female choice	Information about potential partners influences the choice to form relationships. The more is known about a partner, the faster a decision to invest in a relationship can be made.

Author	*Network description*	*Lon git.*	*Structural dynamic*	*Explaining variable(s)*	*Given mechanism*	*Alternative evolutionary mechanism*	*Evolutionary analogy*
Haunschild (1993)	Multiple industries (1981-90)	?	Linkage inducement	Exposure to acquisition activity	As a result of directorships, managers are exposed to the acquisition activities of firms, which results in the imitation of this behavior.	Co-evolution and retention	On the meme-level, by the spread of the idea of acquisition through imitation, it is retained. On the firm-level, the reaction to acquisition behavior can be considered a process of co-evolution.
Ahuja (2000)	Global chemicals industry (1979-91)	Yes	Linkage inducement and linkage possibilities	Firm's stock of technical and commercial capital	Firm's with high levels of stock capital have low inducement to form new linkages as payoff of the linkages does not outweigh the investment. However, high levels of stock also result in high linkage possibilities as firms with high capital levels are desirable partners for other firms. Low levels result in high inducement, but low opportunities. As a result, firms with moderate stock levels form most linkages. Important inventions form additional paths to linkage formation.	Ecology and variation	Stock levels are a valuable asset (variation) for firms as they increase their chance of relationships by potential partners (selection). However, when a firm has high levels of capital stock (high fitness) and potential partners cannot deliver additional value (variation), the inducement to form linkages declines and selfishness is the best survival strategy.
Powell et al. (2005)	Biotech life science industy	Yes	Linkage possibilities	Richness in collaborator-diversity	Those organizations with diverse portfolios of well-connected collaborators are found in central positions and have a large hand in shaping the evolution of the network. Centrality thus increases a firms' ability to form additional relationships.	Probability paradigm and (natural) selection	Organizations that have access to multiple resources through various collaborators are desirable for other (structural hole theory) actors and are better able to form linkages. However, thereby they are better able to form the network to suit them resulting in stability and selection.
Stuart (1998)	Semi conductors industry	Yes	Linkage possibilities	Firms position and prestige	Firms in crowded positions (participate in technological segments in which many firms actively innovate) and those with high prestige (track record of developing seminal inventions) form alliances at the highest rates	*Sexual selection*: display of fitness enhances desirability by potential partners	Access to valuable resources (position) and the display of fitness (prestige) increase a firm's desirability for potential partners.

with low stocks of capital however, will not be able to form linkages as they are not preferred by potential partners. However, Ahuja suggests that firms with a low capital stock can overcome their deficiency, by introducing important inventions. Such radical innovation could shock the relationship forming tendencies and make a first insignificant actor suddenly attractive for potential partners, thereby increasing its possibilities for relationship formation.

The possibilities for relationship formation are discussed in more detail by Powell et al. (2005). They argue how well-connected organizations take a central role in organization networks. In central network position they have the ability to form relationships as they fulfill a structural hole function for other actors in the network. As a result, the central organizations have a large hand in determining the structural evolution of the network.

Seven papers are found to discuss partner selection, addressing the question with which potential partner organizations would form a relationship and how this selection takes place. The results from this analysis can be found in Table 2. Below, again some papers will be discussed in more detail to give an indication of the process of analysis.

Gulati (1995) discusses how relationship formation is influenced by the social environment of the focal organization. Prior relationships result in trust and as such, the existing network forms a source of information on potential partners. Social proximity, in the form of prior mutual alliances, common third parties, and joint centrality in the alliance network, enhance the chances of relationship formation. Gulati and Gargiulo even suggest that these social processes mitigate the effect of strategic interdependence resulting in a path dependent process of social factors reinforcing the existing network structure.

Other authors focused on the role of uncertainty on network dynamics and more specifically on partner selection. For example (Hoetker, 2005), who tested a model composed of three different theories on the effects of uncertainties on partner selection. When faced with low levels of uncertainty, firms were found to chose suppliers based on their capabilities. Faced with moderate levels of uncertainty, firms favor prior relations and internal suppliers, an argument in line with transaction cost theory. And when confronted with high levels of uncertainty, firms choose internal suppliers.

Concluding from the analysis on partnership formation, current literature suggests that the inducement of relationship formation is explained as a result of the need to acquire additional resources in an attempt to survive competition. The possibilities to form relationships for any firm however, are based on its attractiveness for other firms. This may be the result of valuable resources or a central network position. The selection of a partner is suggested to be subject to different social and path-dependent processes. Partners are not only selected on the basis of strategic interdependence, but also on the basis of perceived reliability. This information is passed on through network or displayed in a firm’s prestige. The process of relationship formation in a network clearly is not only a rational and optimal result of strategic interdependence, but is heavily influenced by social processes.

Table 2 Literature on relationship formation: partner selection

Author	*Network description*	*Lon git.*	*Structural dynamic*	*Given Antecedent*	*Given mechanism*	*Alternative evolutionary mechanism*	*Evolutionary analogy*
Beckman et al. (2004)	Interlock and alliance networks for 300 largest US firms	?	Partner selection	Different types of uncertainty	Whether networks are stable or changing depends on the type of uncertainty experienced by firms. Confronted with firm-specific uncertainty, firms tend to acquire additional resources through new partners (exploration). The instability resulting from market-level uncertainty is dealt with by developing additional ties with existing partners (exploitation).	Ecology; Kin selection	In order to increase their chances of survival, organizations team up with partners with additional beneficial resources (female choice) in case of firm-specific uncertainty. In case of market-level uncertainty actors will then tend to form relationships with others who share similar ideals and values (memes)
Gimeno (2004)	Global airline industry	Yes	Partner selection	Specialization of rival alliances	Firm's ally with rival's partners when the rival's alliance is not specialized. When the rival's alliance is specialized however, the alliance partners promise mutual exsclusivity thereby excluding rivals from forming relationships. The focal firm than has to form countervailing with other partners.	Parentage and the investment of upbringing.	When an alliance is exclusive in the sense it produces unique offspring, both partners must commit to the alliance to safeguard their investment in offspring. In this mutual dedication, rival partners are excluded to form alliances as the alliance partners need each other's devotion
Gulati and Gargiulo (1999)	Three worldwide industries	Yes	Partner selection	Prior relationships	Firms base their partnerships selection on the context emerging from prior alliances	Kin selection	The actors in the social context emerging from prior relationships have proven their value and are now relatively easy accessible, resulting in attractive partners with clear added value. Social proximity (kin) results in path-dependant investment in the developed social structure (retention and stability).
Li and Rowley (2002)	Investment banking industry	?	Partner selection	Inertia	Both inertia and several evaluation criteria, including reciprocity, experience, and prior performance, are suggested to influence partner selection.	Ecology; kin selection	Partners are selected on the basis of their additional value as well as their 'genetic' similarity.
Hoetker (2005)	Supplier relations in notebook-industry	No	Partner selection	Level of uncertainty	Level of uncertainty influences partner selection: (1) low: capabilities determine supplier (firm capabilities theory), (2) moderate: prior relationship and internal supplier (transaction cost theory), (3) extremely high: internal supplier (inter-firm relationships)	Kin selection	In times of uncertainty, actors tend to make risk avoiding actions thereby

Author	*Network description*	*Lon git.*	*Structural dynamic*	*Given Antecedent*	*Given mechanism*	*Alternative evolutionary mechanism*	*Evolutionary analogy*
Podolny (1994)	Investment banking relationships in debt markets	Yes	Partner selection	Level of market uncertainty	The greater the market uncertainty, the more organizations engage in exchange relations with whom they have transacted in the past and with those of similar status.	Kin selection	Market uncertainty leads to uncertainty about individual survival chances. Therefore it becomes more important to invest in relationships with one's closest partners (kin) as they represent similar cultural beliefs/ideas/concepts/etc. Prior relationships withstood prior tests of proximity and already developed communal ideas/concepts (memetic proximity)
Zajac (1998)	Largest U.S. corporations	Yes	Partner selection	Lower level struggle for survival	Variation in CEO-board power relations across orgs has contributed to a segmentation of corporate director network (directors and boards both try to maintain power by selecting a power-accepting opposite partner)	Ecology and complexity paradigm	Lower level strategies (personal survival) have consequences on higher level (network relations)

NETWORK STABILITY

Research on a more holistic perspective focuses on structural changes affecting a whole network. This is referred to as network stability in organization literature. Network stability as such can be regarded a form of structural network dynamics, or the lack thereof. Predominantly, network stability is associated with the entry and exit of firms, but other dynamics, such as structure-reinforcing or structure-loosening processes resulting from actor centrality can be regarded as network stability as well. The findings of these papers are presented in table 3 and again, two arguments are illustrated below.

Powell et al. (2005) illustrate the path dependency of network structure. Central actors have the best possibilities to influence structural changes in the network, but will be tempted to secure their own powerful position. The relationships they form will benefit their needs and as such, their centrality will remain. By this mechanism, the structure of a network remains stable to threatening forces. Walker et al. (1997) and Kogut and Walker (2001) provide a similar suggestions on the stability of networks. New network relations are guided more by social capital arguments than by structural hole arguments. This results in a reinforcement of the existing network in stead of the continuous introduction of innovative (distant) linkages. Although the formation of a structural hole relationship may result in access to scarce resources, major innovations, and a powerful position as a structural hole node to another network, firms are found to develop socially close relationships with many partners.

Network stability also relates to the process of firms entering and exiting a network. For example, Rowley et al. (2005) argue that the tendency of firms to stay in or exit a clique (a micro-level network) is at least partly considered a function of social and instrumental phenomena. They found that similarity, interconnectedness, complementarity and inequality among network members reduced firm exiting from the network, resulting in more network stability.

Overall, networks display mechanisms able to cope with external pressures like a dynamic system. The structural stability of a network seems to be the result of path-dependant processes, in which the role of self-interest should not be underestimated. Besides that, the social processes and characteristics of the network appear to have a significant effect on a firm’s decisions to join or exit a network.

Content dynamics

Although networks are in vogue, the majority of network research focuses only on structural characteristics of the network. Hardly any research has been done on dynamics regarding the content of the network relations. Only three papers were found to discuss any form of dynamic in qualitative characteristics of relationships. These papers are presented in table 4 below.

Beckman et al. (Beckman et al., 2004) suggest that intensity of relationships change, when firms are faced with market-level uncertainty. In an attempt to stand up to uncertainty, firms develop relationships with other organizations. Beckman et al. argued that when a firm is faced with market-level uncertainty in particular, firms tend to choose existing partners to form additional relationships, thereby changing the intensity of

Table 3 Literature on network stability

Author	*Network description*	*Lon git.*	*Structural dynamic*	*Given Antecedent*	*Given mechanism*	*Alternative evolutionary mechanism*	*Evolutionary analogy*
Beckman et al. (2004)	Interlock and alliance networks for 300 largest US firms	?	Network stability	Uncertainty	Faced with firm-level uncertainty, firms react by developing relationships with new partners, thereby increasing the density of the network.	Ecology; Kin selection	In order to increase their chances of survival, organizations team up with partners with additional beneficial resources (female choice) in case of firm-specific uncertainty. In case of market-level uncertainty actors will then tend to form relationships with others who share similar ideals and values (memes!) (Sjostrand, 1992)..
Jones et al. (1998)	?	No	Network stability	Selfish versus communal focus of individual firms	Due to the focus of individual firms, promiscous (due to individualistic firms) or polygamous (due to collectivistic firms) networks develop, in which the latter is stable and the first should be organized around a governance system to develop stability.	Game theory??	Natural stable networks exist when actors approach from a cooperative approach. When actors are individualistic, (artificial) institutional setting must bring stability. (Ergo: networks are in essence result of cooperative entities?)
Kogut, Walker and Kim (1995)	Semi-conductor industry	No	Network stability: firm entry	Established standard technology	The certainty of an established standard in technology indicated by a high centrality, correlates with the entry of (start-up) firms into a network.	Probability theory	When a certain technology (variation) becomes dominant in the network, it has the ability to procreate by attracting new firms. This is inline with the probability argument of path dependency.
Kogut and Walker (2001)	German firms in three industries	No	Network stability	…	Network remain stable in spite of major global events (like globalization); small worlds appear to be stable as the “small worlds” replicate themselves	Retention; Stability	Networks remain stable although confronted with external forces. Slow evolution through proximity paradigm and path-dependency of variations prevent reactive responses.
Madhavan et al. (1998)	Global steel industry	Yes	Network stability	Industry events	Industry events may be either structure-reinforcing or structure-loosening as they benefit or alter the foundations of the establishment.	Complexity theory;	Stability of the network is a function of external factors (here: industry events) and the strategic actions by the central actors in order to keep out revolutionizing events.
Olk and Young (1997)	U.S. based R&D consortia	No	Network stability: firm exit	Perfomance, conditions of membership and alternatives	Performance, the conditions of membership (knowledge-related involvement, network ties, learning) and alternatives are related to the decision to stay in or leave, with an interaction between performance and membership conditions, suggesting performance leads to the conditions of membership, and that the continuity decision for a poorly performing consortium differs from that for one performing well.	Ecology	In order to survive firms want to invest and maintain in high performing partnerships (alliances with high fitness and thus chances of survival). The decision to join/invest in such relationships is a function of resource investments, pay-off and alternatives.

Author	*Network description*	*Lon git.*	*Structural dynamic*	*Given Antecedent*	*Given mechanism*	*Alternative evolutionary mechanism*	*Evolutionary analogy*
Powell et al. (2005)	Biotech life sciences industry	Yes	Network stability	Actor centrality	Those organizations with diverse portfolios of well-connected collaborators are found in the most cohesive, central positions and have the largest hand in shaping the evolution of the field. These core participants will remain centralized as they determine network evolution and enjoy higher multiconnectivity.	Probability paradigm	Stability of a field is a function of large population-effect and path-way dependency), and level of access to variation (access to resources; higher when multiconnected), influences the survival and consolidation of an actor's position and thus the stability in network evolution.
Rao et al. (2000)	Firms in NASDAQ and NY Stock Exchange	No	Network stability: firm exit	Social identity	Effect of identity discrepant cues (other group members defect to another group) result in defecting the in-group. Effect is reduced by strong ties to in-group members and enhanced by strong ties to out-group. Proximity to defectors increases cross-over.	Kin selection	Cultural relation (memetic proximity) keeps actors to a group as they favour. Memetic proximity with out-groups or with defecting in-group members enhances the chance of leaving the network.
Rowley et al. (2005)	Canadian investment banks	Yes	Network stability: firm exit	Social similarity and cohesion	Complementarity and inequality are more powerful antecedents of clique exits than similarity and cohesion. Clique stability seems to be a function of three social and instrumental processes: building social attraction to govern exchanges, developing complementarity to accomplish collaborative tasks, and distributing the value created by a clique among its members	Kin selection, co-evolution	Social attraction triggers cooperative atmosphere (kin selection) and thus network stability (less exits), complementarity enables co-evolution among members, distributing value….
Walker et al. (1997)	Biotechnology network	?	Network stability	Arguments for relationship formation	Indsutry networks are relatively stable as new relationships are guided more by social capital arguments (close relations to many actors), and less by structural hole theory (unique relations to valueable distant actors).	Probability theory; Kin selection	The bigger the network, how more stable it is as variations have lower impact. Also actors tend to prefer close partners (memetic proximate) as they are probably close memetic representatives.
Walker et al. (1997)	Biotechnology network		Network stability	Arguments for relationship formation	Industry networks are relatively stable as new relationships are guided more by social capital arguments (close relations to many actors), and less by structural hole theory (unique relations to valuable distant actors).	Retention; Stability	Networks remain stable through internal dynamic which reinforces the structure. Dominant structure is preferred, selected and reinforced.

Table 4 Literature on content dynamics

Author	*Network description*	*Lon git.*	*Content dynamic*	*Given Antecedent*	*Given mechanism*	*Alternative evolutionary mechanism*	*Evolutionary analogy*
Beckman et al. (2004)	Interlock and alliance networks for 300 largest US firms	?	Relationship intensity	Uncertainty	Faced with market-level uncertainty, firms react by reinforcing relationships with their existing partners partners, thereby increasing the stability of the network.	Ecology; Kin selection	In order to increase their chances of survival, organizations team up with partners with additional beneficial resources (female choice) in case of firm-specific uncertainty. In case of market-level uncertainty actors will then tend to form relationships with others who share similar ideals and values (memes!) (Sjostrand, 1992)..
Darr and Talmud (2003)	Markets of emergent technology and mass markets in consumer electronics	No	Relationship intensity	Maturity of the martket	"In markets of emergent technology seller and buyers have to communicate to develop a common interpretation of the product and to transfer contextual knowledge, whereas mass markets communicate more codified knowledge. Emergent markets have formed networks accordingly with more heterogenity, higher concentration and more hierarchy relative to mass markets in which rich communications is less necessary. (social embeddedness argument)"	Kin selection	Network structure is structured to enable the development of a unifying culture (memetic isomorphism) which demands intense communicatin in emergent industries. In more mature industries, less interaction is necessary as memetic proximity is high. It underlines the importance of developing a mutual shared set of memes before going into 'mainstream'
Auster (1992)	Japanese companies in the U.S.	No	Type of relationship asymmetry	Industry evolution	Faced with changing technological, environmental and competitive conditions over the maturing of industries, firms choose different linkage coordination forms (ecological and resource dependence arguments). Emerging industries require low resource investment linkages because environment is dynamic and unstable, high resource investment linkages fit the firm's expansion needs in a growing industry, and mature industries require direct investments to acquire necessary resources for survival in hypercompetive market.	Kin selection	Initially low cultural overlap may exist between international parties, resulting in loosely relationships (LRIL). With the maturing of the industry, culture is transmitted and crystallized, thereby increasing memetic proximity resulting in more intense and tighter linkages.

existing relations. This form of intensifying of an existing relationship can be considered a change in the content of a network relationship.

Other research focuses on the effects of industry maturity. Darr and Talmud (Darr & Talmud, 2003) discuss how the content of a relationship change over time. In emergent markets of a developing technology or product, both actors need to develop a common interpretation of the concerning product and need to transfer contextual knowledge. As a result, relationship in an industry of emergent technology or products, are found to reflect intense communication. Communal understanding of the application of the product, the standards, and the used terminology are in development. Even the semantics of exchanged knowledge may be in development. The relation will thus reflect a high intensity of communication of a tacit nature. In a more matured industry, there is a mutual understanding of the subject in communication, terminologies has riped and exchange of knowledge can become more codified. Communication will reduce to necessities that can be exchanged in codified knowledge (or: information). The content of the relationship thus changes with the development of a communal understanding.

As only little and very fragmented research has been done on the characteristics concerning the content of network relationships, it will be hard to use these results in the further analysis. Research on dyadic relationships may provide with more information on the changes in interorganizational relationships in general. However, these papers were excluded based on their mere dyadic approach. Although these findings cannot directly be generalized to a network level, they may provide interesting material for the further development of metatheoretical perspective on network dynamics in the future.

Evolutionary perspective

Based on the literature review and the evolutionary perspective presented above, a cautious evolutionary analogy on interorganizational network dynamics can be developed. Each article and explaining theoretical mechanism is carefully reviewed and analogous mechanisms from the evolutionary theory were developed. The last two columns of the four tables above contain alternative explanations analogous to the evolutionary theory perspective. Below, the line of reasoning will be illustrated by a discussion of the papers selected in the previous section.

Structural dynamics

Relationships are found in both ION literature and evolutionary theory. In both fields of study, the basic reason for relationship formation seem to be reducible to reasons of retention, either by ecological survival (increasing ones fitness) or by procreation (the creation of offspring). However, investigation of further analogies in both portrayed dynamics will really add to the development of a metaperspective understanding of network dynamics.

RELATIONSHIP FORMATION

From an ecological survival perspective, organizations invest in the formation of linkages to achieve a higher fitness, either by acquiring necessary resources, or by acquiring some form of valuable innovation which increases the firm’s fitness. In both cases, relationships provide variation. And providing this variation is valuable in some form, a firm’s fitness increases. Both explanations for the inducement to form linkages are suggested by the literature.

However, the actual process of relationship formation can also be considered a variation on the passive state of not developing a relationship. Haunschild (1993) discusses how firms whose managers were confronted with other firm’s acquisitioning activities, were found starting to make acquisitions themselves. Considering the idea of acquisitioning as an example of memetic variation, it is retained through imitation (quite literally a process of reproduction). In this way, the intention to form physical interorganizational relationships can be the result of the evolutionary development of underlying memetic variations.

From an ecologic perspective, actors are continuously striving for an optimal fitness in their specific environment. This requires the careful consideration of investing and obtaining necessary resources in an efficient way. With this balancing ecological mechanism in mind, the findings by Ahuja (2000) can be reframed in an evolutionary perspective. Organizations operating as ecological actors, carefully try to obtain the necessary resources in a thriftily way in order to develop a fitness with highest possible survival chances. As relationships provide an opportunity to acquire resources, a lack of resources will result in an inducement to invest in relationships. However, forming relationships requires the investment of own resources (e.g. time and energy), and as such, the inducement to form linkages will decline when available resources are higher; the payoff of any additional investments is negative.

The possibilities a firm has to form linkages are, from this same ecological perspective, related to the amount of assets it can provide to potential partners. Firms with many are preferred over firms with little assets. So, the ability to form linkages is positively related to the amount of assets an organization has to offer.

This results in a function in which those organizations that still feel an ecological need to acquire additional resources, and have some assets to offer as well, are in the best position to form relationships. Firm’s with no assets to offer are not attractive for partners and stand little chance to form relationships. Ahuja suggests this can be overcome when such organizations are able to introduce an important innovation. This can be considered as a sudden variation (e.g. a mutation in biological sense), which can mix up a partners attractiveness.

The attractiveness of partners relates to the third aspect of relationship formation, partner selection. Some partners are preferred over others, and not only on the base of their accessibility to desirable resource, as was suggested by for instance Gulati (1995). The social context resulting from prior relationships, provide valuable information on potential partners, resulting in the selection of prior partners over new partners from outside the existing network.

From an ecological perspective, this can be explained from a transaction cost argument. The costs of acquiring valuable social information on potential partners are relatively low through network resources, compared to alternative ways of finding out. Besides that, relating with a prior partner probably prevents from going through a costly process of getting to know each other. This may result in an apparently suboptimal configuration of interorganizational partners; however, when considering the total payoff, they may just prove to have the highest fitness in total given the circumstances.

Another evolutionary mechanism which can account for the favoring of existing network members, is the process of kin selection. In biology, kin are considered those who are genetically related to the focal actor. As actor's kin can be regarded as slightly modified genetic copies of the actor, the favoring of kin is a survival strategy of the genes (Dawkins, 1976/1989).

This phenomenon also seems at work in partner selection processes in situations of uncertainty. Higher levels of uncertainty lead to the choice of partners closer to the focal actor (Hoetker, 2005). As environmental uncertainty leads to uncertainty of survival, firms react in a defensive strategy by choosing suppliers in their social proximity. This seems analogous to altruistic behavior displayed in times of danger. Actors sacrifice their own survival chances in order for their offspring to survive. From a genetic perspective this can be considered successful behavior as it survives over generations, benefiting the survival chances of kin. In organizations similarly, firms stop selecting suppliers based on there capabilities in times of uncertainty, thereby endangering their own fitness. In stead, firms forms relations with social proximate suppliers such as prior partners (when faced with moderate uncertainty) or even internal suppliers (in situation of extreme uncertainty).

NETWORK STABILITY

The conclusions of Powell et al. (2005) concerning the evolution of a network, is analogous to the arguments of path dependency in probability paradigm. In this perspective, an evolutionary system is regarded a stabilizing entity, because a dominant variation was able to take a central position in the network, influencing further system evolution. In a system of interorganizational networks, central actors may represent this dominant variation, using their centrality to influence network evolution. This results in a dynamic mechanism reinforcing the structure of the network, as these dominant players will push the network evolution in a direction beneficial for them.

The membership of a network is considered a function of social and instrumental phenomena. From a network member's point of view, the instrumental outcome of network membership (complementarity and equality) can be understood from an ecological perspective as investment in a network should result in a positive payoff. Besides that, social aspects like social identification (similarity) and social bounding (interconnectedness) contributed to the decision to stay. Network stability is thus not merely based on instrumental arguments, but members also weigh intangible factors of the social relation in their decision to stay in or leave. Similarity and interconnectedness both can contribute to a feeling of social or cultural proximity, thereby introducing of kin selection on memetics besides instrumental reasons of network stability. As firms are less likely to defect the group when their social bond is more intense (higher similarity and interconnectedness), research on network stability should consider the process of kinship on a memetic level, thereby introducing the favoring of memetic proximate (kin) evolution in networks evolution.

Content dynamics

Although not much research has been done on dynamics of network relationships' content, some evolutionary suggestions can be made.

With respect to the argument of Beckman et al. that firms reinforce their existing relationships when faced with market-level uncertainty, a possible analogy can be found again in the kin selection. When confronted with environmental uncertainty, firms reinforce the relationships with existing partners as they share similar beliefs and ideas, thereby securing their memetic heritage. By doing so, they increase the survival chances of (part of) their offspring (hence: retention) by investing in the fitness of proximate partners through reinforcing their relationships.

In industries of emergent technologies, communal understanding have to be developed around the focal product (Darr & Talmud, 2003) as well as a network culture. This can be considered a full process of evolution. Over time, content of network relations change as trust, confidence and mutual understanding develop. As a result, communication changes as well as the accompanying network structure. Here, dynamics on a structural and content level seem to interact, resembling the multilevel evolutionary process of interactor and replicator in evolutionary theory.

Discussion

Below we will discuss the possibilities and considerations for an evolutionary perspective on ION dynamics, guided by the central principles of the evolutionary algorithm; variation, selection and retention. The discussion will be completed by some additional considerations on possible analogies and the value of an evolutionary perspective at all.

Firstly, variation plays a central role in any evolutionary development. In organization studies, one of the sources for variation is suggested to be interorganizational relationships. Innovations and imitation are found to be a source for dynamics in networks. This variation may result in either radical development, related to explorative relationships and the exchange of tacit knowledge, or in incremental change, related to explorative relationships and the exchange of codified knowledge. These relationships are suggested to incorporate local as well as non-local partners to optimize variation input (Boschma & Ter Wal, 2006). This is also suggested by Nooteboom (1999; 2000) who opts for innovative partners with enough distance to supply additional knowledge (novelty value) but some cognitive proximity to accommodate communication and knowledge exchange (absorptive capacity).

In biology, variation is considered blind and unintentiona. However, the extent to which variation is blind and unintended is disputable for apparently goal-driven interactors like organizations and network relationships. Human action appears to be rational and intentional. But, as argued by David Hull, the considerable degree of chance processes should not be underestimated in seemingly intentional processes, e.g. the development of scientific knowledge (Buskes, 1998; Hull, 1988; Hull, 2001). Every form of innovation contains a process of trial-and-error, and we should not consider the variations driving network evolution (such as technological innovations or new ideas) as rational and deliberate as they sometimes are portrayed. Hull argued that we must be aware that in retrospect we tend to only see a smooth and rational path of development, although the process in reality is much jerkier.

This touches on the question of the deterministic or voluntaristic perspective of actors. From an evolutionary perspective actors do influence their environment, but as suggested above, it is highly questionable if the variation they introduce can be considered intentional. Multiple processes influence the evolutionary process. As a result, due to bounded rationality and the presence of chance in the development of variation, it is more appropriate to label actor behavior as highly deterministic to the environment from an evolutionary perspective. Also, their behavior is driven by 'genetic instincts' (i.e. by predispositions resulting from reproduction and survival strategies on the level of the replicator). This type of interplay in which actor's behavior is bounded by as well as influences the environment, is in line with reasoning of the structuration theory in strategic management literature (e.g. Child, 1997).

Critics put forward human's ability of pre-selecting possible variations in which the interactor actively influences the replicator (e.g. scenario-development and management planning within organizations). Variation appears to be guided by prior experience with selection. This pre-testing however, is already part of the evolutionary selection process. Not only are ideas selected when put in practice, first it has to have an appropriate amount of fitness in the process of selection within an organizational or manager's mind. This is no less evolutionary than the ecological struggle of organizations in a market environment[12].

Another consideration on variation is if it needs to be blind at all to be able to speak of evolution. In biology the natural sources of variation are considered unintentional. However, dropping the condition of blindness does not affect the dynamic mechanism of evolution. The variation still has to be confronted with the selecting environment and has to be retained. Rejecting guided variation as not being evolutionary seems to not do justice to the dynamic and complex scope of the perspective.

Remains the question on what is the unit of variation that influences evolutionary network dynamics. Therefore, an evolutionary perspective would benefit from distinguishing its interactors from replicators. As the behavior of humans and their organizations determine change in networks, they should account for the analogy of the interactors competing in the physical environment. The literature analysis provided some suggestions for the replicator in the direction of a cognitive and cultural element. Many selection and social proximity effects seem to play a central role in ION dynamics. In biology, genetic proximate others are favored as they are related trough kinship to the

[12] Some authors suggest this is a Lamarckian form of evolution. We do not want to elaborate on the possibilities and limitations of Lamarckism as opposed to Darwinism here. We refer to Hodgson and Knudsen (2006) for an extensive discussion on this matter.

altruistic actor. In IONs we see kin selection in times of uncertainty favoring social proximate partners (e.g. Hoetker, 2005; Podolny, 1994). These social proximate partners apparently accommodate the key to ‘genetic similarity’ to the focal firm. Another phenomenon that catches the eye, is the role of knowledge exchange (Darr & Talmud, 2003) and that of trust and social norms (Aulakh, Kotabe, & Sahay, 1996). Considering that networks are communities of interdependent actors, the existence of a shared cultural identity goes without saying. The concept of the meme (Dawkins, 1976/1989) imposes itself as a probable replicator in the evolution of ION dynamics.

Memes can be defined as self-replicating elements of culture (e.g. ideas, behavior, skills, social norms) and are passed on by imitation. Ideologies, fashion, catch-phrases are examples of the expression of memes (Sammut-Bonnici & Wensley, 2002). Imitation is recorded in the ION literature as a source of spreading of ideas (e.g. Gimeno, 2004; Haunschild, 1993).

When this acceptance of memes as the central replicator in network dynamics is taken even a step further, it could mean that long suggested economic motivation for organization and networking is not the ultimate goal, but only provides means for the memes to compete for existence, hence the evolutionary discussion of replicators and interactors. However, this proposition of memes as the central replicating unity in interorganizational networks, is only a suggestion which should be investigated further through additional research.

Second, the mechanism of selection of those variations with the highest fitness is associated with ecological principles on network actors in their environments. This process operates in different forms. For example, the selection of partners seems to be analogous to that of sexual selection in biology. Actors weigh their possibilities and inducements in the process of partner selection. Partners portraying high fitness in survival capabilities and social network positions are preferred[13]. Especially the evolutionary mechanism of female choice bears similarities with partner selection strategies by organizations. Both actors need to make careful considerations of partner’s fitness and commitment before investing in a relationship. The tenability of this analogy should be tested in further research however.

Social behavior also plays its part in the selection process, as the favoring of others enhances their chances of survival (c.f. fitness). In biology, kin selection favors those who are genetically close (i.e. resembles one’s own set of replicators) and similar processes were found in the literature on network dynamics. Preferably partners that were considered close were selected, especially in times of uncertainty. When considering memes as the replicators within networks (argued above), the proximity of network actors is bound to cognitive and cultural likeness. Prior partners, internal partners and partners from the same social group are likely to have some memetic overlap and therefore can be considered kin.

Other authors explain social behavior not as the result of relatedness, but as a form of evolutionary strategy. In game theory, the essentially cooperative tit-for-tat strategy is considered the optimal strategy in several types of games (Ridley, 1996).Game theory

[13] Behold the preferred attachment argument by Barabási (2002)

arguments can possibly be used to explain further cooperative network behavior within an evolutionary perspective.

Another issue related to selection is the specific environment in which the interactors operate. The original theory of evolution by Darwin departs from the mechanism of natural selection which put a big emphasis on the process of ecology. Applying this ecological perspective on interorganizational networks moves the attention to the selecting role of the environment on network processes. Although studies in population ecology adopt this perspective, they hardly focus on the dynamic process of interorganizational networks. Recently, the field of economic geography has moved towards this topic (e.g. Boschma & Frenken, 2006; Boschma & Lambooy, 1999), but still focuses heavily on the effects of location and dynamics of clusters in regional geography, in stead of larger networks.

Thirdly and finally, the mechanism of retention completes the evolutionary algorithm. Defining memes or any other cognitive unit as the replicators of the evolutionary process, the process of retention is represented by communication, or in other terms; the exchange of knowledge[14]. Retention is established through intra- and interorganizational communication on e.g. project development and the development of a mutual understanding of culture, in processes of cooperation in joint ventures, imitation, story-telling, etc. As in biology, the process of retention is a source of variation by itself. In biology new genetic combinations are developed when two strands of different DNA combine in procreation. Communication also offers a big source of variation. When a message (knowledge) is transmitted from the sender to the receiver, the receiver interprets this knowledge from her specific perspective and backgrounds. New interpretations and combinations are made, thereby forming an important source of variation.

However, distinguishing replicators from their interactors has some consequences for the mechanism of retention. After all, the replicator has to 'survive' apart from the interactor (hence the mechanism of retention). Ensuring the survival of replicators (and thus the selected traits with high fitness) the interactors follow two strategies. Firstly they try to survive themselves, and secondly, they procreate thereby transmitting their traits encoded in the replicators. Phenomena like new product cycles, innovations, new joint-ventures, spin-offs, imitation, etc. can be regarded 'offspring'.

This leads to the question of mortality of the interactor. In biology, an organism cannot pass on its genes after death. Therefore, the interactor's lifespan is the timespace the replicator has to replicate and transmit in offspring, to ensure its survival. However, we should take into consideration whether this unilateral dependency is necessary for the process of evolution to hold out. In the field of organizations, bankruptcy apparently resembles mortality. However, single innovative ideas belonging to that organization can be copied to other organizations after its bankruptcy. There are two possible explanations. Either replicators seem to be able to live on separate from its interactor, or they should be regarded as having transmitted to another type of interactors (e.g. stories, people, drawings), before being implemented by another organization. Here, the shoe pinches.

[14] This includes a wide spectrum of tacit and excplicit knowledge, ranging from codified information to tacit cultural beliefs.

Either way, the splitting up of replicators from their interactors seems essential, but the concept of potential interactors and their mortality provides room for future debate.

In this paper we have tried to make some suggestions on how network dynamics can be explained from an evolutionary perspective. We conclude this discussion with some thoughts on the value and feasibility of this perspective for use in interorganizational networks. A limitation of an evolutionary meta-perspective is the impossibility to make solid predictions. The evolutionary mechanism provides suggestions on how dynamics can be explained, but the complexity of the involved causes for the dynamics, make it impossible at this moment to make predictions. However, by providing a model to understand dynamics and the sources of fitness, it may opt suggestions for management or policy makers on how fitness can be increased in interorganizational networks. Also, this meta-perspective may suggest some directions for further research to enhance our understanding of interorganizational networks.

Another concern is to what extent is the perspective is still evolutionary. As argued, some alterations have to be made to the original biological interpretation. The apparent simple algorithm basic to the theory of evolution, has fargoing implications in order to understand its work. The beautiful simplicity of evolutionary theory thereby, seems to be lost. However, this is not less the case in its original field of study. In biology there are multiple discussion on the interpretation of some evolutionary mechanisms. In this paper, only the top of the iceberg called change by evolution is made visible. Furthermore, a theory describing such a complex process cannot be expected to be simple when looked into in more detail. We think that discussing the complexity of the perspective's backstage, does not undermine the use of the perspective.

Conclusions

The evolutionary perspective comprehends some basic principles and a specific thought style suiting the explanation of complex dynamics. Applied to interorganizational networks it provides some interesting ideas on the explanation of their dynamics. However, the suggestions made should only be valued as such, as the number of articles on network dynamics (which formed the data for this research) stays behind despite the growing interest in IONs. Furthermore, almost all found literature on network dynamics focuses at structural change, which does not do justice to the importance of the content of network relationships.

Some authors have introduced evolutionary thinking or parts thereof, into studies of organizations and interorganizational relations before. For example Hannan and Freemann, who applied the ecological thinking of natural selection on organizational populations (Hannan & Freemann, 1977), Nelson and Winter (1982) who introduced an evolutionary perspective on economics, and some authors focused on ecological processes within organizations (Galunic & Weeks, 2002; Weeks & Galunic, 2003). More recently, the scope is being applied to regional interorganizational relations by economic geographic researchers (e.g. Boschma & Frenken, 2006; Boschma & Lambooy, 1999).

Some of these attempts can hardly be called evolutionary anymore, as authors seem to have jettisoned all redundant mechanisms they did not manage to apply. These dropped mechanisms, however, play a crucial role in the original theory of evolution. For example, population ecologists and evolutionary economists focus primarily on the process of (natural) selection within a specific environment, while economic geographers focus on the role of variation generation within environmental niches. However, it should also be noted that some authors do incorporate more than just the process of natural selection. Nelson and Winter for example distinguished replicators (routines) from interactors, and Weeks and Galunic made a case for the use of memes as replicators in organizational evolution.

Still, all these attempts seem to pass over some typical mechanisms intrinsic to the wealth of the evolutionary perspective, such as the role of reproduction, partner selection, altruism and kin selection. Furthermore, they hardly pronounce upon interorganizational networks, what is called for lately.

To re-interpret ION dynamics from a true evolutionary perspective results in intriguing analogies. It provides a meta-perspective from which prior described behavior and dynamics of and within networks can be understood. This perspective incorporates a dynamic view on phenomena in stead of the more traditional static view. Furthermore it covers a wide complexity by incorporating multi-level process (e.g. networks, populations, organizations, humans), distinguishing replicators from interactors, and taking the specific environment in considerations at the same time.

Some mechanisms appear to bear great similarities with biological processes explained in evolutionary theory, while other analogies are harder to draw at this stage. The perspective does provide some interesting suggestions, such as preserving the difference between replicators and interactors. Analyzing the literature from an evolutionary perspective suggests that the replicators in interorganizational networks have a highly cognitive character (including culture, knowledge, social norms, etc.), which raises the comparison with Dawkin's 'memes' (1976/1989). Related to the replicator discussion is the phenomenon of kin selection, in which actors show behavior beneficial to proximate others (i.e. kin). Such behavior is found in the network literature discussing the effects of external uncertainty on network relations. The perspective also provides explanations of partner selection to increase fitness. It suggests that partners should be as well close to be able to interact (higher absorptive capacity) as well as distant to introduce sufficient variation (novelty value), which is in line with the arguments by Nooteboom (1999).

However, some analogies are still problematic. For example, an exact definition of replicator as well as the exact allocation of interactors, lacks at this stage. Also, some typical biological traits have to be sacrificed to make the mechanism of evolution applicable to the field of IONs. Phenomena like mortality and the replicator's dependence on their interactors are not univocally applicable to network phenomena at this moment.

Several evolutionary explanations for network dynamics are suggested, and an evolutionary perspective appears to comprehend valuable power for further use. This paper achieved its aim to propose an evolutionary meta-perspective for the explanation of dynamics in IONs, to find out its feasibility in explaining ION dynamics. By searching for similar phenomena in biology and splitting replicators from interactors, the evolutionary mechanism can be applied to field of interorganizational networks. However, further empirical research on the tenability of possible analogies is necessary.

Possible implications for management and policy making

Although the evolutionary perspective hardly provides room for predictions due to its complexity, it does give some handles to understand the process of change. The biological analogy can offer nice illustrations for use as a metaphor. This value of metaphors and analogies is underlined in literature (Bailer-Jones, 2002; Burrel, 1996) and may benefit the empirical field.

Furthermore, the propability paradigm of evolution stresses the value of isolated niches for innovation capacity. Premature variations have higher chances of survival in isolated pools, as the chance it is sabered by the existing variation is smaller as its dominance is relatively lower. For managers and policy makers this implies that premature innovations have a higher chance to blossom in an incubator or an alternative field of development. Also, R&D teams should not be too big and include the right level of variation, as they also can be considered an isolated pool of development.

Finally, it underlines the necessity of variation. In times of turbulence and uncertainty, the networks' structure may change radically when peripheral players are able to adopt new technologies. This opts for the search of valuable partners in times of uncertainty, opposed to the tradition inclination. The tendency of organizations to shift towards proximate relationships, thereby giving up part of their innovative capacity, was found in current empirical data.

Possible implications for further research

As a theoretical contribution, this paper provides suggestions for a meta-perspective to understand change in networks. However, this perspective is still in its infancy and additional research is necessary as several areas and mechanisms in the evolutionary perspective cannot be translated into the field of ION dynamics based on the present available literature. Prior research has predominantly focused on structural dynamics and we suggest this to be complemented with research on the dynamics of the content of network relationships. In our discussion we provided several suggestions for further research related to evolutionary phenomena (e.g., replication and exchange replication in relationships, altruistic behavior of 'genetically related' actors, and the effects of uncertainty), as well as some problematic topics which would benefit from further scientific attention.

For a start, existing fields of research already seem to fit some aspects of the evolutionary perspective. Combining the study of economic geography with network elements would fit questions concerning the population paradigm and niche effects on innovation. And when an evolutionary perspective would be applied in the research on innovative interorganizational relationships, this would benefit the understanding of retention, replicators and subsequent kin selection.

In this paper, we showed how complex network dynamics can be understood from an evolutionary perspective and how this meta perspective can help us to understand the different processes in network dynamics put forward in the literature. Incorporating the evolutionary algorithm of variation, selection and retention in a competitive environment with scarce resources, suggestions were made for a perspective on network dynamics taking a holistic view on networks and preserving the complexity of these processes.

Critics will disapprove of its sparseness as it needs to superadd several mechanisms and phenomena to explain all dynamic processes. However, we should not forget that this provides a meta-perspective on highly complex dynamics, able to include similarly opposing theories, as was proven for organization studies by Aldrich and Rueff (2006). Also, in its original form in biology similar additions had to be made as well, but the theory is still valued for its explanatory power. Finally, as our understanding of social processes continues to develop, we will be able to understand and explain with more richness and complexity. In fact; this increasing complexity is just evolution[15].

Resources

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[15] In his work “The blind watchmaker”, Richard Dawkins (1986) argues seemingly complex (biological) phenomena are the result of the process of evolution, i.e. increasing complexity is evolutionary.

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Appendix: exclusion and inclusion criteria

Exclusion criteria

No.	*Criteria*	*Reason for exclusion*
1	Neural networks	These are not inter-organizational networks
2	Network externalities	These are not inter-organizational networks
3	Network effects	These are not inter-organizational networks
4	Information systems	Exclude many articles on networking that focus on how IT systems are linked together
5	Information technology	Exclude many articles on networking that focus on how IT systems are linked together
6	Compatibility	Exclude many articles on networking that focus on how IT systems are linked together

Inclusion criteria

No.	*Criteria*	*Reason for inclusion*
1	Articles from **ISI journals**	Ensure high-end input
2	Qualitative and quantitative emperical research	Capture all empirical evidence
3	(Change in) ION is *not* an independent variable	Examine the possible theorized *causes* of network dynamics (dependent variable). Correlating variables do not show a causal relationship, but are of interest in understanding dynamics.
4	Content and structure changes in relationships	Describe in the analysis
5	Profit and non profit networks	Capture both private and public sectors in the research to capture all explanations