

# How do inter-organizational networks change: an evolutionary dynamics perspective (WORKING TITLE)

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## Introduction

Research struggles to get a grip on interorganizational networks (IONs). Although attempts have been made (e.g. Baker & Faulkner, 2002; Borgatti & Foster, 2003; Candance Jones, Hesterly, & Borgatti, 1997), no unified definition is agreed upon in the literature, let alone a meta-theory for explaining network behaviour (Borgatti, 2003; Ranjay Gulati & Martin Gargiulo, 1999). This is partly explained by the phenomena under investigation. True networks are highly complex and continuously evolving phenomena. Research has mainly focussed on dyadic relations, avoiding the call for true networks perspective incorporating a holistic, longitudinal view and attention to complexity (Baker & Faulkner, 2002; Walker, Kogut, & Shan, 1997). As argued by Borgatti (2003), a lot of network research so far has treated IONs as given and focussed more on its consequences (e.g. Park, 1996; Provan & Milward, 2001), rather than its antecedents and dynamics.

Evolution theory, originating from the field of biology, seems to incorporate those concepts network researchers are 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 evolution theory in its ability to offer an understanding of dynamics of change (Sammut-Bonnici & Wensley, 2002). Although parts of evolution theory thinking has been used in organization studies (cf. population ecology) and economics (cf. evolutionary economics), it has not been applied to the understanding of network dynamics.

This paper will therefore develop in an eclectic attempt an alternative perspective on the current knowledge of ION dynamics, by answering this research question: *In which ways can the theoretical concepts and mechanisms of evolution theory be applied, to come to competing explanations of aspects of ION dynamics?* These concept and mechanisms will be confronted with current literature explaining ION dynamics, developing alternative explanations.

Together, these competing explanations should give an indication for an evolutionary analogy of network dynamics.

In the next section the central concepts and mechanisms of evolution theory are discussed. In section three the applied methodology is explained. In section 4 the results of the literature review are presented, which provide input for the development of an analogy in section 5. Finally in section 6 the findings are discussed and conclusions drawn.

## Evolution theory

### Introduction

As this research investigates the applicability of the theory of evolution in inter-organizational network dynamics, an exploration on and discussion of the evolution theory are fundamental. The conclusions that will be drawn from this discussion serve as a theoretical framework for the development of the analogy in the field of inter-organizational networks. The discussion is based on a review of some seminal works in evolution theory (Darwin, 1985/1859; Dawkins, 1986, , 1989/1976; Maynard Smith, 1993/1958), some comprehensive works discussing the general theory (Gould, 2002; Mayr, 2001; Millstein, 2002; Zimmer, 2001), as well as some works focusing on the socio-cultural implications of the theory (Goudsblom & Wilterdink, 2000; L. H. Nelson, 2003; Ridley, 1996; Williams, 1996/1966) and the implications for human thinking (Carruthers & Chamberlain, 2000; Geary, 2005)

Evolution theory is mainly known for the findings of natural selection by Charles Darwin and his "*On the origin of species*" (1985/1859). His theory of natural selection was based on a combination of new insights, which were not compatible with the common belief 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 could be sorted into classes which are characterized by their (stable) definition, or: essence<sup>1</sup>. Instead of accepting the idea of constant classes (types), Darwin introduced the idea that every individual in a population is uniquely different from every other individual, a notion now referred to as *population thinking* forming the

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<sup>1</sup> In the domain of the essentialism paradigm, two streams explaining evolution are discernable. Transmutation explains evolution as being the result of the development of new species or types through mutation or saltation. According to transformationism evolution is a gradual process where species are directly influenced by the environment, or by an intrinsic drive to a definite goal of greater perfection (a thought style known as finalism), or through the inheritance of acquired characteristics. Note that this last explanation is in line with the explanation for evolution provided by Jean-Baptiste Lamarck

philosophical basis of modern biology today. With this idea, Darwin could incorporate variation as a central mechanism by which natural selection operated, resulting in the evolution of species in which natural selection, chance, and history and time play a fundamental role.

However, it should be made clear that Darwin's theory of natural selection is not the only perspective in evolutionary thinking. Based on Depew & Weber (1995) a taxonomy of three paradigms explaining different evolutionary phenomena can be made: theory of natural selection, probability theory and complexity theory. Where the theory of natural selection (based on Darwin's findings) focuses more on behaviour and gradual change, complexity and probability theory focus on system design and punctuated equilibria. 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. Favourable characteristics are preferred through natural selection and unfavourable ones eliminated. This is a chance process as the origin of characteristics lays in a chance process of genetic alteration.

The probability paradigm focuses on evolution as a result of stabilizing propensity of large populations and 'innovation' within small (isolated) populations. Because the chances of survival of a new characteristic are higher when it has a relative larger share within a population, small isolated populations are an ideal breeding place for innovative characteristics. This can cause a punctuated equilibrium once an advantageous characteristic is well-developed enough to overcome the resistance of the dominating propensity of the out-group majority (Eldredge & Gould, 1972). The paradigm of probability thus focuses on evolution through punctuated equilibria as a result of the development of traits in small isolated populations.

The complexity paradigm describes systems as the result of simple rules for individual actors in a population which will develop in a complex 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 more on the impact of individual actors and the effect of the environment is minimal. The evolution tendencies take place primarily in and through the system (and its set of rules) itself. Interesting to see is that actors within these populations seem to comply with the concept of isomorphism, either through imitation through competition or as a result of institutional pressures (DiMaggio & Powell, 1983). Complex systems may seem highly dynamic and adaptive, due to path dependency

they can be highly rigid in suboptimal configurations as a result of increasing results and lock in of prior developments (Sammut-Bonnici & Wensley, 2002). Examples hereof are the VHS video-system, the QWERY keyboard-layout and the human kind species.

Albeit these differences, any theory of evolution can be described as a general theory of dynamics<sup>2</sup>. It describes a mechanism for gradual (or: evolutionary) change. Although apparently simple, the algorithmic mechanism combines sources and effects of change on multiple levels, thereby employing a holistic perspective on dynamics. In biology for example, it explains change being the result of environment (habitat, weather, etc.), ecological surrounding (predators, prey, competition, etc.) and cultural preferences (e.g. sexual selection). Although Darwin's revolutionary conclusions were controversial in its time, the theory has proven its value and now forms the basis of biological dynamics. Since the scientific revolution Darwin initiated, the theory has been further developed and refined and its scope has now been broadened beyond the fields of biology into fields of sociology (e.g. Ridley, 1996; Wilson, 1975), psychology (e.g. Geary, 2005), economics (e.g. Boschma, Frenken, & Lambooy, 2002; Hodgson, 2000, , 2002; R. R. Nelson, 1995; R. R. Nelson & Winter, 2002), and medicine<sup>3</sup>.

Ernst Mayr (2001, p. 116) summarized Darwin's observations and inferences as<sup>4</sup>:

**Fact 1:** *Every population has such high fertility that its size would increase exponentially if not constrained.*

**Fact 2:** *The size of populations, except for temporary annual fluctuations, remains stable over time (observed steady-state stability).*

**Fact 3:** *The resources available to every species are limited. (also reinforced by Malthus)*

**Inference 1:** *There is intense competition (struggle for existence) among the members of a species. (Malthus)*

This struggle for existence is a crucial driving source of evolution. As resources are scarce, organisms have to compete<sup>5</sup> in order to survive (or: to safeguard their continuity). Mayr continues:

**Fact 4:** *No two individuals of a population are exactly the same (population thinking). (Source: animal breeders and taxonomists)*

**Inference 2:** *Individuals of a population differ from each other in the probability of survival (i.e., natural selection). (Darwin)*

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<sup>2</sup> Dynamics is referred to as change resulting from an underlying cause.

<sup>3</sup> For a overview of evolutionary thinking outside biology, see Zimmer (2001).

<sup>4</sup> Between brackets: the source that inspired Darwin

<sup>5</sup> Competition in this extent is a multilevel process. Darwin distinguishes three levels of competition: "either one individual with another of the same species, or with the individuals of distinct species, or with the physical conditions of life" (Darwin, 1985/1859: 117)

Darwin suggested that the small differences (this variation is part of his population thinking) between individuals could benefit survival chances over other individuals in the competition to survive. In other words, beneficial traits are selected<sup>6</sup> through competition as they have a higher fitness with the environment. Mayr completes the line of argumentation:

*Fact 5: Many of the differences among the individuals of a population are, at least in part heritable. (source: animal breeders)*

*Inference 3: Natural selection, continued over many generations, result in evolution. (Darwin)*

The beneficial traits have to be passed on in a way. This retention of favourable traits is the third crucial element in evolutionary thinking. 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 20<sup>th</sup> century, this evolutionary condition from the 1890's became fully tenable.

From these inferences evolution theory arises. Central in these findings is the algorithm of Variation, Selection and Retention. Dynamic phenomena on which this algorithm applies are called Darwin Machines, named after the man who was the first to introduce this evolutionary algorithm. His findings still form the basis of all modern evolutionary thinking, and as such, these three concepts will be used as characterizing evolutionary thinking in this research. They are explained in more detail below.

## **Variation**

In the theory of natural selection, the presence of variation is the key to evolution. Small variations among individual organisms may result in beneficiary traits enhancing fitness. Although this seems a clear component of the total theory, it contains a multilevel and rather complex construction underlying its apparently simple surface. This lies in the dichotomy of genotype and phenotype. Using a biological organism as an example, the genotype is the in DNA encoded genetic information of an organism, so to say the 'blueprint'. The phenotype on the other hand is the physical representation of that organism; e.g. the actual animal. Differences in genetic coding result in different traits of the organism's phenotype which may influence its survival chances in the process of selection. In the modern synthesis of evolution theory, traits are seen as the units which are selection. A total organism substitutes a collection of traits thereby making a total pay off of all combined traits. As these traits are the determined by the underlying genotype, one could also argument that the selection operates on the genetic level. In that way, the phenotype is the temporary vehicle by which the

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<sup>6</sup> This does not imply that the best possible configuration will survive, only the best available variation have the highest chances of survival.

genotype competes for survival in the physical world. This argument was introduced by Richard Dawkins in his seminal work “The Selfish Gene” (Dawkins, 1989/1976).

But where does this variation among genotypes come from? Two sources for variation can be discerned. The most direct (but uncommon) is mutation, for example as a result of exposure to radiation or errors in cell copying. The resulting genotype might introduce new traits enhancing survival chances, although these chances are relatively small. The second source is more common in biology and result from reproduction. Most living organisms reproduce by recombining two strands of DNA as a result of mating. This merging of different genotypes results in a unique genotype and phenotype. The variation of input for reproduction may be the result of different processes like genetic drift and gene flow.

In biology, the sources of variation are 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.

## **Selection**

The process of selection favours the survival chances of those with most beneficial traits in that specific environment, or in other words: it favours the genotype 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 (see footnote X), selection operates in different forms. Selection may be natural or artificial. Artificial selection is the favouring by intent, as for example in the flower breeding industry. Natural selection takes place within the complex system of individuals, species and environment. There are two forms of natural selection, on which experts do not agree which has a highest impact. Sexual selection is the favouring of traits in the process of reproduction. Some traits are favoured as they signal survival strength (the selection thereof is called female choice), other traits are favoured as they provide the way to mating (a selection process called 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 climatological conditions.

As the whole context is continually evolving and variation is highly affected by chance, the process of selection will improbably lead to an optimal adaptation of a species. This immediately clears up a common misunderstanding of evolution theory.

Geary (2005) describes the strength of evolutionary selection as the result of two effects; the effect of genetic influences on the phenotypic trait and the effect of phenotypic traits on social or ecological outcome. Together, these two traits determine the effect of evolution.

## **Retention**

In line with Darwin's third inference as presented by Mayr, useful traits should be preserved on the long run to be able to speak of evolution. In fact, evolution is nothing more than the perseverance of the best fitting traits, preferred by the process of natural selection. In biology these traits are preserved thanks to heredity of genetic blueprint. As the phenotype is mortal, it is essential that these genes are passed on through the process of reproduction.

## **Evolution of socio-cultural systems**

Although the theory of evolution is best illustrated in its original field of study, the mechanism also seems to work outside the field of biology. Different attempts have tried to incorporate evolution theory in socio-cultural perspective. Ranging from the effects of biological evolution on socio-cultural components (e.g. Goudsblom & Wilterdink, 2000; Wilson, 1975) to the actual evolution of socio-cultural components themselves (e.g. Dawkins, 1989/1976; Ridley, 1996).

In biological wildlife, preference for related genotypes can be found. In several organisms this is expressed through altruistic strategies and kin selection. More complex organisms may have adopted the abilities of communication and some social intelligence (the ability to recognize other individuals) opening the path to for example delayed returning of a favour and long lasting relationships. Humans have developed some unique features which enables them to develop far more complex socio-cultural systems. A combination of sophisticated use of complex language combined with an ability to empathise with others and being able to understand others' motives, made it possible for humans to develop complex socio-cultural communities and for example cheating and the division of labour (Ridley, 1996; Wilson, 1978). These socio-cultural abilities have probably increased the chances of selection, as they did increase efficiency and humans were better able to organise their allocation of time and energy. In psychology this idea of a theory of mind has gained wide attention. The social value of communication is nicely illustrated with the fact that most of human interaction concerns the exchange of social information, or gossiping.

Culture developed with the expression of social values (Zimmer, 2001). Ingroup cohesion was strengthened by discerning the differences with the outgroup and the shared identity built trust

and facilitated ingroup cooperation. This new phenomenon also started to develop. Although we physically resemble our ancestors, our culture has developed significantly since. Different authors use the term memes referring to the equivalent of genes in cultural evolution (e.g. Blackmore, 1998; Goudsblom & Wilterdink, 2000; Williams, 1996/1966). Meme can be referred to as cultural modes of thought and was a term originally coined by Richard Dawkins (1989/1976).

### **Relationships in an evolutionary perspective**

Relationships with others may seem odd from an evolutionary perspective as potential partners also are one's direct competitors as resources are scarce. However, in biology relationships do occur on different levels and in different forms. Above we've seen why humans have been able to form complex relationships which led to e.g. the division of labor. However, more primitive forms of relationships also occur. The mating of couples is a form of relationship and even on a cell level we can find operational relationships between cells like the development of unicellular prokaryotes into more complex cell structures (eukaryotes), which is the result of functional cooperation of cells. The major two reasons for forming relationships from an evolutionary perspective are the increase of efficiency by cooperation (a form of survival by variation), or the intention of reproducing (or: survival by retention).

### **Conclusions**

Evolution theory can be summarized as a holistic perspective on complex dynamics incorporating an algorithm of variation, selection and reproduction. The theory incorporates interdependence of systems in their struggle for existence (e.g. genotype and phenotype in biological organisms). Darwinian machines answering to the evolutionary algorithm may operate on different levels, such as genetic, organic and socio-cultural levels simultaneously. The evolution theory explains how small, long term but fundamental changes are a result of a path dependent process in which variations are selected on the basis of their fitness within a specific environment. This research tries to find a suitable explanation from the above perspective for application in understanding the dynamics of inter-organizational networks.

## Methodology

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

To develop an understanding of the contemporary state of affairs in literature on the explanations for network dynamics, the literature is systematically reviewed in line with the method described by Pittaway, Robertson, Munir, Denyer & Neely (2004). In this way, given explanations for dynamics are derived from a collection of high-end journals. These explanations are then confronted with alternative explanations from an evolution theory 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) Keywords on the subject were identified based on the experience of the author, e.g. networks, change, dynamics, evolution. These keywords were constructed into search strings for use in online databases.
- (2) In an iterative process, some initial searches were undertaken to fine-tune the selection of keywords and the construction of the search strings. For example, additional words like inter-organizational, development and transformation were found to be used to describe the phenomena under investigation. The combination of relevant keywords was then constructed in the final search string: 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 (ISI Web of Science and ABI/Inform Proquest) were searched using the search string from step (2). The search was limited to a selection of 45 (see appendix) top-ranked ISI journals relevant in the field of ION dynamics and a date range of 1990 to 2005. This resulted in respectively 420 (ABI/Inform Proquest) and 734 (ISI Web of Science) hits.
- (4) By reviewing papers according to inclusion and exclusion criteria (see appendix) on the basis of their title and abstract, papers were selected.
- (5) On the basis of its relevancy and position, the papers were then divided into three lists (A, B and C). List A represents papers of particular relevance because they directly

described ION dynamics in line with the perspective of (parts of) IONs as presented above. The articles on this list will constitute the primary focus in the data analysis. The B-list contains papers that possibly may provide additional suggestions to list A papers, but which lack the direct description of an ION dynamic (e.g. clearly dyadic level). The C list contains articles that offer interesting insights (e.g. from personal networks, or with network dynamics as an independent variable) and was contained as it might be used as input in the discussion. The selection criteria are presented in the appendix.

- (6) The systematic review of steps (1)-(4) resulted in a collection of XX articles on the A list. Through forward and backward citation analysis this list was expanded to a final list of 29 articles.
- (7) These articles were then analyzed on criteria of ‘level of analysis’, ‘described network dynamic’, ‘given explanation’. The results of this analysis are presented below in the data analysis section of this paper.
- (8) Per article, alternative explanations from an evolution theory perspective are then developed, based on the theoretical framework presented in section 2. These alternatives together form the basis of a comprehensive analogy of the mechanism of evolution theory for use in the explanation of network dynamics.
- (9) To test the liability of these findings, the results are presented to XX experts in a consulting round, based on the Delphi techniques.

## **Methodological Challenges**

The method used has some limitations, which should be pointed out here. First of all the databases used 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 be taking 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 evolution 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 & Freeman, 1977) and evolutionary economics (R. R. Nelson, 1995; R. R. Nelson & Winter, 2002) only used suitable parts of evolution theory, not its entire mechanism (Young, 1988). However, these previous works may provide suggestions for analogous processes (e.g. Penrose, 1952).

### **Limitations**

Although we aimed at including structural as well as content-related dynamics, only a few papers were found address the dynamic of relationship content. The blatant majority of papers concerns structural dynamics as partner selection, relationship formation, actor centrality and network stability. The few papers that just slightly address the question on why the content of relationships change, are as diverse as they are sparse. Besides that, they limit themselves to a dyadic level. Therefore, it is difficult to extract general conclusions on network dynamics from them and this aim had to be excluded from the literature analysis. However, attention will be paid to relational content in the discussion of the evolutionary analogy.

## **Data analysis**

The majority of the found papers is written around the concepts of relationship formation and partner selection. As no coherent group of papers could be selected on network content dynamics, these are kept out of the analysis. This results in three groups identified in the review of the literature. The first group (11 papers) describes antecedents for relationship formation, the second group (9 papers) discuss partnership selection and the third group (9

papers) deal with different forms of network evolution in a broader sense. In the following, the findings from the literature review are presented and found patterns herein discussed.

## **Relationship formation**

Eleven papers present the issue of relationship formation and all broadly address the question why organizations engage in relationships. The findings of these papers are presented in table **1**.

---- insert table 1 here ----

Multiple studies discussed the question which antecedents affect a firms' choice to engage in interorganizational relationships at all. Ahuja (2000) elaborates on the resource dependency argument by illustrating how a firm's probability of linkage formation is a function of its inducement and opportunity to form linkages. (Stuart, 1998) underlines the notion of opportunity as firms possessing a prestige of valuable resources, are favoured by other firms to form alliances with.

Besides interdependence, the level of embeddedness also influences a firm's choice to form additional alliances. The exposure to other's acquisitioning activities (Gimeno, 2004; Haunschild, 1993) ignites imitating behaviour, and the amount of network resources available to firms influences the proclivity to form new relations (Gulati, 1999). Social embeddedness thus seems to stimulate the development of relationships in two directions: it increases access to valuable partners as well as confronts firms with partnering activities of rivals.

The propensity of a firm to invest in an alliance in developing a technological standard is according to Axelrod et al. (1995) a function of the alliance size and the presence of close rivals. Size is used as an indication of the viability of the technological innovation, and the presence of close rivals is seen as an ecological threat for own survival.

Other authors found the adoption and dominance of technological innovations as independent variables for network development. Burkhardt and Brass (1990) illustrate how the adoption of new technologies can influence network centrality and thereby the relationship formation of a firm. On the other hand, the acceptance of a technological standard can enhance firm entry (Kogut, Walker, & Kim, 1995). Accepting the adoption of technological innovation as a successful 'mental' variation, the formation of relationships can be regarded as a way in which this mental idea is established and retained.

Different authors researched the antecedents of network stability as a result of firm exit. Besides instrumental reasons like performance and the presence of alternatives (Olk & Young, 1997), or complementarity and value distribution (Rowley, Greve, Rao, Baum, & Shipilov, 2005) a firm's choice to either stay in or leave a network seem to also be a consideration of to what extent it feels related to (Rao, Davis, & Ward, 2000) or feels attracted to (Rowley et al., 2005) the group identity. This culturally bonding therefore seems to be an antecedent of network stability.

### **Partner selection**

A total of nine papers are found to discuss partner selection, generally addressing the question with whom organizations form relationships. The results from this analysis can be found in table 2.

--- table 2 here ---

Gimeno (2004) introduces the concept of partner accessibility. When a rival's alliance is a form of co-specialization, organizations are excluded from a relation with that specific alliance partner. As an alliance results in unique valuable assets, organizations tend to restrain rivals from access to this competitive advantage. Rivals react by building countervailing relations.

The works of Gulati (1995; with Gargiulo, 1999) emphasize the role of social embeddedness in the selection of partners. Prior partners and information from the social context result in the (close) reproducing of the network structure. A similar argument was produced by Walker, Kogut and Shan (1997), who found partnership formation patterns inline with social capital arguments than with structural hole arguments. Close relations with many actors are preferred over unique relations with distant others, thereby reproducing the network structure with its existing clustering.

Different authors focus on the effect of uncertainty on partner selection. Hoetker (2005) combines three theoretical arguments, concluding that with increasing uncertainty socially closer partners are preferred over capability arguments, thereby extending the conclusions of Podolny (1994). However, when uncertainty is more closely looked at, different forms of uncertainty result in difference in preference for relationship partners. Firm-specific uncertainty leads to the formation of new relationships (or: exploration), whereas increasing

market-level uncertainty leads to the formation of additional ties to existing partners (or: exploitation) (Beckman, Haunschild, & Phillips, 2004) in line with above authors on uncertainty.

Finally, the preference for specific inter-organizational partners may be guided by other motivations than those at the organizational actor-level. Lower level motivations can play significant roles in network structures as e.g. the ascertaining of intraorganizational power selecting interorganizational partners (Zajac & Westphal, 1996).

### **Network evolution**

Nine papers were found useful in understanding network dynamics as they describe different aspects of structural dynamics from a more holistic network perspective, addressing issues like the antecedents of network centrality, stability and organization. An overview of these papers can be found in table 3.

--- table 3 here ---

According to Burkhardt and Brass (1990) early adopters of a new technology achieve a higher degree of centrality in the network. Decreasing centrality of firms within a network also is the co-evolutionary result of individual strategic decisions (Davis & Mizruchi, 1999). Powell et al. (2005) show that organizations with diverse portfolios of well-connected collaborators are found in the most cohesive, central positions. Network centrality thus seems to be a multidimensional phenomenon, resulting from a complex function of things like strategy, the possession of valuable characteristics and richness of fruitful activities, in a continuous interaction with the environment.

Powell et al. (Powell et al., 2005) also point out that centrality is subject to path dependency as central actors play a dominant role in network development, resulting in network stability. Central actors will stimulate structure-reinforcing events in contrast to structure-loosening events (Madhavan, Koka, & Prescott, 1998). This effect of stability is also found for clusters of highly interconnected firms (Kogut & Walker, 2001). Finally a collectivistic focus of individual firms also tend to contribute to network stability (C. Jones, Hesterly, Fladmoe-Lindquist, & Borgatti, 1998). These studies show that although IONs are exposed to different factors triggering dynamics, they possess preserving mechanisms developing stability.

However, a individualistic focus of individual firms tends to develop promiscuous networks, which requires a governance system to develop stability (C. Jones et al., 1998). The type of

market resulting from the technology maturity also affect the network organization; mass markets of mature technologies are less heterogeneous, concentrated and hierarchical in relation to markets of emergent technologies (Darr & Talmud, 2003) as they require the communication of other forms of knowledge. Doz, Olk and Ring (2000) focus on the differences between emergent and engineered networks in this perspective. This suggests that network organization and evolution may result from different sources (need for stability, maturity or level of intent).

**(THE NETWORK EVOLUTION-PART ABOVE IS NOT YET WORKED OUT IN THE DISCUSSION/CONCLUSION BELOW, and I doubt if it ever will be...)**

## Evolutionary perspective

Based on the literature review, a cautious evolutionary analogy on interorganizational network dynamics can be developed. Each article and explaining theoretical mechanism is carefully reviewed and analogous mechanisms from evolution theory were developed. The last two columns of the three tables presenting the overview of the literature review, contain alternative explanations analogous to the evolution theory perspective. Below these perspectives will be presented corresponding to the previous section.

### **Linkages formation**

In both interorganizational literature and evolutionary theory, there is an obvious parallel for the formation of linkages as both accept the notion of resource scarcity and thus, the struggle for existence. In both perspectives this mechanism plays a fundamental role.

Variations in assets among organizations result in process of selection of those organizations with the highest assets. The survival in the environment (e.g. the institutional environment, or the market) bears similarities with natural selection and the accompanying struggle to survive. The partnership selection between organizations resembles sexual selection, in which suitable partners are selected on the basis of valuable variation for the production of viable offspring.

As a consequence of variation among organizations, a deficit in resources increases the necessity to form linkages with other actors in order to acquire these resources (resource dependency argument). This also implies that on the other side, firms with high levels of resources are attractive partners for other actors. This is in line with the findings for

relationship formation of Ahuja (2000) and Stuart (1998) and that of firm exit of Olk and Young (1997).

Gimeno (2004) and Haunschild (1993) both pointed out that imitation resulting from an embedded position, also initiates the formation of linkages. From an evolutionary perspective, imitation is previously pointed out as the retention of a selected routine (e.g. Feldman, 2000; Hodgson & Knudsen, 2004). Alliance formation however, may not pass for a routine. Therefore closer attention has to be given to the unit of selection, which more likely is characterized as an idea. This discussion will be fed later.

Gulati (1999) expands the consequences of embeddedness by adding that the information from the network provides valuable information on potential partners, a grant advantage as firms have to be selective in investing in relations as their resources are scarce and investments relatively high, an argument found in evolution theory related to the choices female animals often have to make as they have to be more selective in mating as their investment is very high.

This argument of selective investment in partnering also plays a part in joining alliances of developing technical standards. Firms use cues to estimate relative benefit of a technological alliance (e.g. viability of the standard and presence of rivals) to judge which alliance to join to develop the highest fitness (Axelrod et al., 1995). The early adoption of technological innovations (a variation) however enhances firms centrality and will increase its popularity as a potential partner (Burkhardt & Brass, 1990). The establishment of a dominant variation (a technological standard) attracts the entry of new firms (Kogut et al., 1995) as the established variation increases the fitness of those who can benefit from this variation.

The presence of a cultural identity and the development of cultural proximity among members (Rao et al., 2000; Rowley et al., 2005) adds to network stability as a result of kin selection: actors will not defect on others with whom they feel connected in kinship. Rowley et al. (2005) adds to this the importance of complementarity which creates a co-evolution atmosphere among actors increasing network fitness.

### **Partner selection**

As already introduced above, from an evolutionary perspective can the formation of linkages be viewed as 'mating' and the selection of a partner is a process analogous to the concept sexual selection in biology.

Several arguments were presented for the role of social embeddedness in selecting partners. Social embeddedness increases cultural kinship, which is preferred over distant partners

(Walker et al., 1997). The process of female choice is simplified by social embeddedness as it provides extensive information about potential partners (Gulati, 1995; R. Gulati & M. Gargiulo, 1999).

In periods of market uncertainty, firms tend to prefer social proximate partners (Beckman et al., 2004; Hoetker, 2005; Podolny, 1994), in line with the kin selection mechanism. When uncertainty is firm-specific (Beckman et al., 2004), the firm goes out to explore partners which can increase their fitness (sexual selection). This continuous preference for kin selection results in a highly stable and combative network (Walker et al., 1997), a concept in line with the probability paradigm that large populations are stable.

When two partners can develop a unique asset through a co-specialized alliance, the one-happy-family-embeddedness tendency is over and we are reminded of the ecological struggle for existence hosting this play. Both partners are dedicated to the investment in their product as they both have large benefits at stake and will therefore protect their mutual offspring from exogenous interference by realising mutual exclusive access to the alliance. Other actors then have to search for similar alliance partners in a countervailing reaction (Gimeno, 2004).

Interesting about the Zajac and Westphal paper (1996) is that they introduce a multi-layer notion, a characteristic feature of evolution theory. Action on the organisational level may be guided by a lower personal strategy.

## Discussion

The developed alternative explanations from an evolutionary perspective provide refreshing understanding of ION dynamics. The development of relationships is largely trusted by the need to acquire additional resources in order to survive. However, networks differ from pure markets in which the ecological argument of instrumental dependence is used more often (e.g. Hodgson, 2000; e.g. R. R. Nelson & Winter, 2002). Networks however, also apply interdependency by co-operation in order to achieve a higher mutual fitness. Not mere exchange of resources but the combination of them. Relationships thus may be instrumental by gaining access to needed resources (ecology), but on the other hand also form a direct opportunity to develop retention (or: survival) by co-developing additional value (variation).

The choice of partners is a process of sexual selection. Variation in organizational characteristics (e.g. stocks of technological capital) among organizations, results in a selection process as certain organizations are more desirable than others. Interesting to note is that organizations seem to apply both 'male' as well as 'female' positions in sexual selection.

Male competition for the access to alliances as is noted in the empirical literature, as well as the careful consideration (female) choosing to invest in a relationship. In biology, the different sexual strategies between male and females is a result of the level of competition for quantity (male) versus investment in quality (female) resulting from their sex. Organizations seem to be confronted with both dilemma's and thus adopt 'hermaphroditic strategies' as partners are more or less sexually equal. This has implications for the considerations and decisions organizations make when selecting a partner for mating, especially for value-creating relationships.

The ION dynamics literature already suggested that dynamics were the result of multi-level processes (e.g. Davis & Mizruchi, 1999; Zajac & Westphal, 1996) in which apparently minor choices may result in network level effects. This example of Coleman's bathtub is typical in evolution where all changes have far going consequences (complexity theory).

But evolution also provides stabilizing factors. The probability paradigm shows how the size of populations correlates with the stability, a function recorded in some studies (e.g. C. Jones et al., 1998; Madhavan et al., 1998; Powell et al., 2005).

The most intriguing question however, is the search for the "gene" in IONs. What is the underlying, selfish, guiding concept? A lot of 'kin' selection and social proximity effects seem to play a central role in ION dynamics. In biology altruistic behaviour is related to kinship to the favoured organism, as it represents genetic similarity to the altruist. In IONs we see 'kin selection' in times of uncertainty, favouring social proximate partners (e.g. Hoetker, 2005; Podolny, 1994). These social proximate partner 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 the role 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 imposes itself as a probable replicator in the evolution of ION dynamics.

Memes can be defined as self-replicating elements of culture, passed on by imitation. Memes are ideas, behaviours or skills passed on from person to person by imitation. Ideologies, fashion, catch-phrases are examples 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). Memes as the replicating elements of culture which evolves and survives through the cooperation and struggle among members and in the existence of a network being able to spread culture.

When this acceptance of memes as the central replicator in network dynamics is taken even one step further, it could mean that long suggested economic motivation for organization and networking is not the ultimate goal but only providing means for the memes to struggle for existence, hence the evolutionary discussion of genotype and phenotypes.

(Other topics to be integrated in the discussion at a later instance: three simultaneous selection processes at work (natural -, sexual -, kin selection) and the consequences hereof; the skipping of dynamics of relationship content; the limited reliability of this research and its value as a suggestion for a meta-theory analogy; ...)

## Conclusions

(to be written, including: implications for our knowledge on IONs, directions for future research)

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## Appendix: selection of ISI ranked journals

### Sorted by: Journal Title

Abbreviated Journal Title	ISSN	2004 Tot. Cit.	Impact Factor	Imm. Index	2004 Art.	Cited Half-life	Full name
ACAD MANAGE J	0001-4273	6033	2.647	0.411	56	9.6	Academy of Management Journal
ACAD MANAGE REV	0363-7425	5317	3.717	0.862	29	>10.0	Academy of Management Review
ADMIN SCI QUART	0001-8392	5181	3.405	0.000	8	>10.0	Administrative Science Quarterly
AM ECON REV	0002-8282	12494	1.655	0.343	143	>10.0	American Economic Review
AM J SOCIOL	0002-9602	5600	2.121	0.519	27	>10.0	American Journal of Sociology
AM SOCIOL REV	0003-1224	6775	2.855			>10.0	American Sociological Review
BRIT J MANAGE	1045-3172	367	1.051	0.333	24	6.0	British Journal of Management
BRIT J SOC PSYCHOL	0144-6665	978	1.394	0.091	33	9.9	British Journal of Social Psychology
BRIT J SOCIOL	0007-1315	625	0.855	0.261	23	8.7	British Journal of Sociology
CALIF MANAGE REV	0008-1256	1247	1.345	0.107	28	8.1	California Management Review
ECON SOC	0308-5147	656	1.069	0.296	27	8.9	Economy and Society
EUR J SOC PSYCHOL	0046-2772	1444	1.146	0.224	49	9.5	European Journal of Social Psychology
GROUP ORGAN MANAGE	1059-6011	422	0.865	0.000	27	8.7	Group & Organization Management
HARVARD BUS REV	0017-8012	4161	1.148	0.240	104	>10.0	Harvard Business Review
HUM RESOURCE MANAGE	0090-4848	883	2.040	0.217	23	8.1	Human Resource Management
J ACAD MARKET SCI	0092-0703	1165	1.417	0.069	29	7.5	JOURNAL OF THE ACADEMY OF MARKETING SCIENCE
J BUS	0021-9398	1363	1.400	0.043	46	>10.0	JOURNAL OF BUSINESS
J INT BUS STUD	0047-2506	1884	1.286	0.581	31	>10.0	JOURNAL OF INTERNATIONAL BUSINESS STUDIES
J LAW ECON ORGAN	8756-6222	867	1.025	0.238	21	>10.0	JOURNAL OF LAW ECONOMICS & ORGANIZATION
J MANAGE	0149-2063	2112	1.241	0.209	43	>10.0	JOURNAL OF MANAGEMENT
J ORGAN BEHAV MANAGE	0160-8061	93	0.105				JOURNAL OF ORGANIZATIONAL BEHAVIOR MANAGEMENT
J POPUL ECON	0933-1433	308	0.740	0.143	35	5.9	JOURNAL OF POPULATION ECONOMICS
LEADERSHIP QUART	1048-9843	553	1.769	0.351	37	5.9	LEADERSHIP QUARTERLY
MANAGE SCI	0025-1909	8565	1.934	0.225	129	>10.0	MANAGEMENT SCIENCE
MIT SLOAN MANAGE REV	1532-9194	173	1.013	0.040	50	3.1	MIT SLOAN MANAGEMENT REVIEW
ORGAN BEHAV HUM DEC	0749-5978	3292	1.473	0.167	36	>10.0	ORGANIZATIONAL BEHAVIOR AND HUMAN DECISION PROCESSES
ORGAN SCI	1047-7039	2550	2.295	0.583	48	8.6	ORGANIZATION SCIENCE
ORGAN STUD	0170-8406	1006	0.882	0.117	60	8.1	ORGANIZATION STUDIES
ORGANIZATION	1350-5084	361	0.929	0.132	38	4.9	ORGANIZATION
PUBLIC ADMIN	0033-3298	529	1.139	0.119	42	6.7	PUBLIC ADMINISTRATION
Q J ECON	0033-5533	6617	4.412	0.725	40	>10.0	QUARTERLY JOURNAL OF ECONOMICS
REG STUD	0034-3404	1154	1.652	0.300	60	5.9	REGIONAL STUDIES
RES ORGAN BEHAV	0191-3085	1197	1.312			>10.0	RESEARCH IN ORGANIZATIONAL BEHAVIOR
RES POLICY	0048-7333	2006	1.536	0.097	93	6.8	RESEARCH POLICY
SOC NETWORKS	0378-8733	431	0.947	0.118	17	>10.0	SOCIAL NETWORKS
SOCIOL THEOR	0735-2751	310	1.025	0.029	34	9.9	SOCIOLOGICAL THEORY
SOCIOLOGY	0038-0385	841	1.047	0.208	53	9.0	SOCIOLOGY
STRATEGIC MANAGE J	0143-2095	5826	1.980	0.463	67	9.2	STRATEGIC MANAGEMENT JOURNAL
SYST DYNAM REV	0883-7066	188	0.833	0.176	17	7.4	SYSTEM DYNAMICS REVIEW

# Appendix: exclusion and inclusion criteria

## Exclusion criteria

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<i>No.</i>	<i>Criteria</i>	<i>Reason for exclusion</i>
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

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## Inclusion criteria

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

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## Appendix: selection criteria for lists A, B and C

### **List A**

Articles of particular relevance that had interesting empirical approaches. Describe and/or explain dynamics in true inter-organizational (whole) networks or suggest complex effects for the whole network.

### **List B**

Articles of some relevance, or where there may have been some question over the value of the empirical work, or which provide indirect suggestions for network dynamics.

(e.g. network startups, network-based businesses, pure dyadic processes, focus on network management, etc.)

### **List C**

Articles that were either of little relevance or which were predominantly conceptual, and articles that may provide interesting material for a discussion.

(e.g., purely social or personal networks, network statistics, etc.)

**Table 1: Linkage formation**

<i>Author(s)</i>	<i>Focus of study / ION dynamic</i>	<i>Description of network</i>	<i>Longit.</i>	<i>Given theoretical mechanism</i>	<i>ET mechanisms</i>	<i>Evolutionary analogy</i>
Ahuja, G. (2000b). <i>Strategic Management Journal</i> , 21(3)	Linkage formation as a function of a firm's inducement and opportunities.	Technical collaborative linkages in the global chemicals industry. (1979–91)	Y	(A: opportunity) The greater a firm's stock of technical and commercial capital, the greater the firm's collaboration opportunities; (B: inducement) However, when both capitals are high, the inducement to form linkages decreases as the need for resources decreases and competitive strength is high; (C: both) Highly embedded firms (with no inducement) and least embedded firms (with no opportunities) will form few linkages relative to moderately embedded firms; (D: alternative) A firm's creation of an important invention provides an additional path to linkage formation for firms that lack the three tenure-based advantages.	(A) Sexual selection (female choice); (B) Ecology (selfish gene); (C) Interplay between female choice and ecology; (D) Variation through mutation.	(A) Firm's with high level of capital (high fitness) are preferred by potential partners increasing it's opportunities to form linkages; (B) When there is no need to acquire resources (or: develop variation) as the organism has higher survival chances on its own, the best survival strategy is that of a selfishness; (C) Firms with no need or no chance to form linkages, form less linkages than mediocre firms; (D) A self developed highly innovative concept (variation) may suddenly increase attractiveness (sexual selection).
Stuart, T. E. (1998). <i>Administrative Science Quarterly</i> , 43(3)	Linkage formation as a function of a firm's technological position.	Alliances in semiconductor firms (six year period)	Y	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; Probability theory	Access to resources/partners (crowded positions) and fitness (prestige) increases desirability of a potential partner and thus its opportunities to form linkages. And crowded populations increase stability (probability theory).
Gimeno, J. (2004). <i>Academy Of Management Journal</i> , 47(6)	Linkage formation as a result of a firm's exposure to rival's alliancing activities.	Global airline industry (1994-98)	Y	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).	Ecology / co-evolution; Male competition; Retention;	In order to sustain its survival chances (ecology), the focal firm initiates action, resulting in a co-evolutionary process of trying to establishing a countervailing alliance (male competition). When the rival's alliance comprehends a unique value adding cooperation (co-specialization) enhancing a competitive advantage, both alliance partners are more committed to protect their memetic offspring (retention) from external interference by excluding the focal firm to participate. At the same time, the idea (meme) of this specific alliance is reproduced (again: retention) by the co-evolutionary process.
Haunschild, P. R. (1993). <i>Administrative Science Quarterly</i> , 38(4)	Linkage formation as a result of the exposure to a firm in its embedded position.	Acquisitions in medium and large-sized firms listed in 4 industries. (Compustat 1981-90)	?	Acquisitions activities are influenced (imitated) by the exposure to the acquisition activities of other firm's in which managers take place in their board (embeddedness through directorship).	Retention	The idea of acquisitioning (a memetic variation) is spreaded (retention through imitation) within the population through proximate relationships (mating).
Gulati, R. (1999). <i>Strategic Management Journal</i> , 20(5).	Linkage formation as a result of firm's embeddedness.	Alliances in three worldwide sectors.	Y	Proclivity of firms to enter new alliances is influenced more by the amount of network resources (informational advantages obtained through the network) available to them, then by alliance forming capabilities.	Female choice	Firms are selective in their partnerships as they require a considerable investment of resources. Therefore their selection of a partner is based on a wide range of cues telling them something about the fitness of a potential partner (female selection). Through network resources this information is easily available.
Axelrod, R.,	Firm entry into	Alliances to develop	N	Utility of a firm to join a standard-setting alliance increases with alliance	Female choice;	Firms choose their partner carefully (see Gulati 1999 analogy).

<i>Author(s)</i>	<i>Focus of study / ION dynamic</i>	<i>Description of network</i>	<i>Longit.</i>	<i>Given theoretical mechanism</i>	<i>ET mechanisms</i>	<i>Evolutionary analogy</i>
Mitchell, W., <i>et al.</i> (1995). <i>Management Science</i> , 41(9).	standard setting alliances.	and sponsor technical standards		size and decreases with presence of (close) rivals in the alliance. Result is based on a Nash equilibrium: a final configuration in which no single firm has an incentive to switch to another alliance.	Male competition	Alliance size is a cue for viability (chances of survival) of the technical standard (memetic offspring). Close rivals in the alliance may cost more resources (male competition), in which case joining another alliance may have a better total pay-off (Nash equilibrium).
Burkhardt, M. E., & Brass, D. J. (1990). <i>Administrative Science Quarterly</i> , 35.	Linkage formation as a result of technological innovations.	Federal agency	Y	Results show that early adopters of a new technology increased their network centrality to a greater degree than do later adopters.	Sexual selection of highest fitness	The centrality in population is determined by the attractiveness of (newly) adopted technologies (variation) which indicate higher fitness.
Kogut, B., Walker, G., & Kim, D. J. (1995). <i>Research Policy</i> , 24(1).	Firm entry as a result of centrality of technological innovations.	Semi-conductor industry	N	Certainty of established standard/dominant technology (indicated by a high centrality) correlates with entry of (start-up) firms.	Probability theory	When a certain (memetic) variation becomes dominant, its abilities to procreate (infecting new firms) increases (probability theory).
Olk, P., & Young, C. (1997). <i>Strategic Management Journal</i> , 18(11)	Firm exit	U.S.-based R&D consortia	N	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.
Rowley, T. J., Greve, <i>et al.</i> (2005). <i>Academy of Management Journal</i> , 48(3).	Firm exit as a function of social similarity and cohesion.	Canadian investment bank cliques	Y	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....
Rao, H., Davis, G. F., & Ward, A. (2000). <i>Administrative Science Quarterly</i> , 45(2).	Firm exit as a function of social identity	Firm exits from NASDAQ to NY Stock Exchange	N	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.

**Table 2: Partner selection**

<i>Author(s)</i>	<i>Focus of study / ION dynamic</i>	<i>Description of network</i>	<i>Longit.</i>	<i>Given theoretical mechanism</i>	<i>ET mechanisms</i>	<i>Evolutionary analogy</i>
Gimeno, J. (2004). <i>Academy Of Management Journal</i> , 47(6)	Partner selection in reaction to rivals' alliancing activities	Global airline industry (1994-98)	Y	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).	Sexual selection	An alliance partner is selected on the basis of additional value in creating offspring with the highest possible fitness (sexual selection).
Gulati, R. (1995b). <i>Administrative Science Quarterly</i> 40(4).	Partner selection resulting from social structures.	Three worldwide sectors (new materials, industrial automotion, automotive products)	Y	Prior chosen partnerships shape partnerships in the future; firms base their partnership selection on the context emerging from prior alliances and considerations of strategic interdependence.	Sexual selection; Female choice; Kin selection	Partners are chosen on the basis of their additional value (sexual selection). Due to the investment of limited resources, firms are selective in their relationship (female choice). Prior relations reflect a certain cultural closeness (memetic (social?) proximity) which is favoured through kin selection.
Gulati, R. and M. Gargiulo (1999). <i>The American Journal of Sociology</i> 104(5)	Partner selection resulting from social structures.	Three worldwide sectors (new materials, industrial automotion, automotive products)	Y	Probability of new alliances between specific orgs increases with their interdependence and with social embeddedness aspects (defined as their prior mutual alliances, common third parties, and joint centrality). Differentiation of the emerging network mitigates the interdependence effect and enhances the social embeddedness aspects	Sexual selection; Kin selection	Partners are chosen on the basis of their additional value or: interdependence (sexual selection). Partners with memetic (social?) proximity are preferred (kin selection).
Walker, G., Kogut, B., & Shan, W. J. (1997). <i>Organization Science</i> , 8(2)	Partner selection based on structural hole arguments and social capital arguments	Biotechnology network	?	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.
Hoetker, G. (2005). <i>Strategic Management Journal</i> , 26(1)	Partner selection in different levels of uncertainty	Supplier-relations in notebook industry (1992-8)	N	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	With increasing uncertainty, firms decline decision making on the basis of efficiency and start pampering memetic close ones (kin selection).
Podolny, J. (1994). <i>Administrative Science Quarterly</i> , 39	Partner selection under market uncertainty	Investment banking relationships in debt markets (1981-7)	Y	The greater the market uncertainty, the more organisations engage in exchange relations with whom they have transacted in the past and with those of similar status.	Kin selection	High market uncertainty leads to uncertainty about individual survival chances. Therefore it becomes more important to invest in relationships with one's closest partners (kin selection) as they represent similar cultural beliefs/ideas/concepts/etc. Prior relationships (a) withstanded prior tests of proximity, (b) already developed communal ideas/concepts (memetic proximity).
Beckman, C. M., Haunschild, P. R.,	Partner selection under	Interlock and alliance networks for 300	?	Whether networks are stable or changing depends on the type of uncertainty experienced by firms.	Ecology; Kin selection	In order to increase their chances of survival, organizations team up with partners with additional beneficial resources (female choice) in

<i>Author(s)</i>	<i>Focus of study / ION dynamic</i>	<i>Description of network</i>	<i>Longit.</i>	<i>Given theoretical mechanism</i>	<i>ET mechanisms</i>	<i>Evolutionary analogy</i>
& Phillips, D. J. (2004). <i>Organization Science</i> , 15(3)	different types of uncertainty	largest U.S. firms (1988-93)		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).		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)..
Zajac, E. J. and J. D. Westphal (1996). <i>Administrative Science Quarterly</i> 41(3)	Partner selection as a function of lower level processes	largest U.S. corporations over a seven-year period	Y	Variation in CEO-board power relations accross 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).	Co-evolution; Selfish Genes	Lower level strategies (personal power strategies) have consequences for higher levels (network relationships), indicating the concept of Selfish Genes.
Li, S. X., & Rowley, T. J. (2002). <i>Academy Of Management Journal</i> , 45(6).	Partner selection as a function of...	U.S. investment banking industry	?	Inertia as well as several evaluation criteria (incl. reciprocity, experience, prior performance) influence partner selection.		

**Table 3: Network evolution**

<i>Author(s)</i>	<i>Focus of study / ION dynamic</i>	<i>Description of network</i>	<i>of Longit.</i>	<i>Given theoretical mechanism</i>	<i>ET mechanisms</i>	<i>Evolutionary analogy</i>
Burkhardt, M. E., & Brass, D. J. (1990). <i>Administrative Science Quarterly</i> , 35	Network centrality as a result of technology adoption	Federal agency	Y	Results show that early adopters of a new technology increased their network centrality to a greater degree than do later adopters.	Co-evolution; Multi-level effects; Complexity theory	As a result of individual choice, network structure alters (multi-level effects and complexity theory)
Davis, G. F., & Mizruchi, M. S. (1999). <i>Administrative Science Quarterly</i> , 44(2)	Network centrality as a function of individual strategy.	Board connections of banks with large nonbank corps (1982-94)	Y	Network structure evolves as centrality of banks declines as executives of major (central) corporations join bank boards at a lower rate, due to strategic choice of the bank: returns on major corps declined, so less recruitment of central directors.	Multi-level effects; Complexity theory	As a result of individual choice, network structure alters (multi-level effects and complexity theory)
Powell, W. W., White, D. R., Koput, K. W., & Owen-Smith, J. (2005). <i>American Journal of Sociology</i> , 110(4)	Network stability as a result of path-dependency	Biotech life sciences industry	Y	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.
Madhavan, R., Koka, B. R., & Prescott, J. E. (1998). <i>Strategic Management Journal</i> , 19	Network stability as a result of industry effects	Global steel industry	Y	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.
Walker, G., Kogut, B., & Shan, W. J. (1997). <i>Organization Science</i> , 8(2)	Network stability as a function of individual partner proclivity	Biotechnology network	?	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.
Kogut, B., & Walker, G. (2001). <i>American Sociological Review</i> , 66(3)	Network stability as a function of external factors and	German firms in three industries (1993-97)	N	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.

<i>Author(s)</i>	<i>Focus of study / ION dynamic</i>	<i>Description of network</i>	<i>of Longit.</i>	<i>Given theoretical mechanism</i>	<i>ET mechanisms</i>	<i>Evolutionary analogy</i>
Jones, C., Hesterly, W. S., Fladmoe-Lindquist, K., & Borgatti, S. P. (1998). <i>Organization Science</i> , 9(3), 396-410.	Network stability and organization as a function of firm's focus	unknown	N	Due to the focus of individual firms, promiscuous (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?)
Darr, A., & Talmud, I. (2003). <i>Organization Studies</i> , 24(3)	Network organization	Markets for emergent technologies and mass markets in consumer electronics industry.	N	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 heterogeneity, higher concentration and more hierarchy relative to mass markets in which rich communications is less necessary. (social embeddedness argument)	Memetic proximity	In emergent markets a mutual understanding have to be developed...? (RELEVANT?)
Doz, Y. L., Olk, P. M., & Ring, P. S. (2000). <i>Strategic Management Journal</i> , 21(3)	Forms of network organization	R&D consortia	N	Two options for network formation: (1) an emergent process: networks develop as a reaction to changes in the environment and the development of common interest and similar views among potential members. (2) an engineered process: a triggering entity (firm) actively recruits potential members to join the consortium	Natural selection versus artificial selection	(RELEVANT?)