Advancing a process theory on coevolution among networks

ABSTRACT

The extant research on network development often focuses on individual networks, thereby leaving room for theorizing how multiple networks coevolve. To fill the gap, we aim to create a conceptual framework to explain coevolution among networks. Drawing from the fields of biology, ecology and sociology and integrating them into the management literature, we propose that the basis for network coevolution is the existence of hot and cold spots–where networks are either mutually receptive to signals from each other or not –and that coevolution is driven by identity schisms. We also introduce essential mechanisms (criteria for fitness, traits change), characteristics (neither deterministic nor causal, disruption of network development process) and possible outcomes (mutation, competition, isolation, complementariness, extinction) of coevolution among networks. The contribution of the study on the extant research on social networks and networking lies in increasing our understanding of the mechanisms of network-to-network interaction at the whole network level.

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INTRODUCTION

It is well established that networks are evolutionary in the context of process change (Easton, 1992 , Halinen, Medlin and Tornroos, 2012) and structural change (Holmen, Pederson and Torvatn, 1999 , Uzzi, 1997 , Zaheer and Soda, 2009). The process of network evolution evolves through changing relationships of the parties in efforts to 'maintain, develop, change and sometimes disrupt the relationship' having a cumulative effect on the evolution of the network (Johanson and Matteson, 1988 , Benson-Rea and Wilson, 2003 , Snijders, Steglich and Schweinberger, 2005). In a similar way Powell (1998) alludes to a network lifecycle whereby collaboration speeds up innovation, which together with the experience of collaboration, changes the nature of interactions themselves.

Adopting the network perspective, scholars converge on the notion that the process of network evolution involves a coexisting dynamic of stability and change (Freytag and Ritter, 2005). Thus the lifecycle or evolution of relationships may not be congruous to the network level unless the participants have a similar goal as may be the case in temporary networks or project networks (Freytag and Ritter, 2005 , Fredriksson and Gadde, 2005). Accordingly, such considerations have led scholars more recently to focus their attention on analysing how network dynamism can be studied and what kinds of network changes can be identified, although this is still a very underdeveloped area of study (Ford and Hakansson, 2006 , Snijders, Steglich and Schweinberger, 2005). Recent studies on network dynamics suggest that the network evolutionary process is influenced by integration or substitution paths from interactions within a network that leads to network consolidation or change (Guercini and Runfola, 2012) or interlocking dynamics of choice based ties again within social networks (Stadfeld and Pentland, 2015). Others explain network evolution by linking relationship processes to network processes, alluding to a 'relational dimension' comprising business interactions and strategizing that creates new (undefined) network spaces (Tornroos, Halinen and Medlin, 2017).

While we are starting to understand network evolution whether broadly cyclical or progressive, one area that lacks sufficient theorising to date is how multiple networks evolve simultaneously, or the coevolution among networks. Network coevolution is emerging as a hot topic among network researchers at the present time (Tur and Azagra-Caro, 2018 , Arifovic, Eaton and Walker, 2015). Coevolution in network studies is normally considered as the process by which the social network activities of individuals contribute to macro level network change, which in turn affects the outcome of the individual and the network (Kossinets and Watts, 2009). Indeed from this perspective network coevolution is at the heart of the debate concerning the microfoundationals of organisational social networks (Tasselli, Kilduff and Menges, 2015). However, while the logic of understanding how individuals and networks influence each other is important, coevolution also happens among networks. However studies on this phenomena often emphasise relational interactions such as proximity (Broekel, 2015) or influences of the micro network on the meso or macro environment/field/system (Rodrigues and Child, 2003) , or comparative variables within networks such as ties and perceptions of psychological safety (Schulte, Cohen and Klein, 2012) . It is fascinating however to consider that networks are also influencing each other in a coevolutionary way even without ties (Hansen, Mors and Lovas, 2005). For example, a documentary series Designing Ireland (Brady and O'connell, 2016) the eminent architect Angela Brady details how the broad spectrum of creative industries in Ireland including architecture, fashion design, animators and product designers are primarily influenced by “how we tell stories”. Essentially in this example contemporary and historic networks both actively and passively influence one another and co-evolve without significant relationship ties to create what is called “Irish Design”.

Social identity theory might be useful to explain this as social identity theory predicts individual level behaviour as a function of group level perceptions (Hogg and Terry, 2000 , Hogg and Williams, 2000). But the phenomenon of coevolution among networks is somewhat counterintuitive to what social identity theory proposes because social identity strives to maximise differences between ingroup members and others, as outgroup members (Turner, 1975 , Hogg, 2000a). Conversely, some argument could be made for adopting the complementary signalling theory of Spence (1973)and Stiglitz (2000) to explain network to network coevolution. But while signalling theory can explain the active process of signalling and receiving of signals between two parties it cannot explain the conditions or antecedents of why and under what circumstances coevolution among networks might emerge.

We argue that a process theory of network to network coevolution is needed for management scholars to explain the process of how coevolution happens among networks. By focussing centrally on this process we suggest that scholars need to think differently about network dynamics because networks are influenced from the outside and correspondingly generate outbound influence. The role and importance of outside networks is long recognised and is now gaining traction in the management literature (Haug, 2013 , Maclean, Harvey and Kling, 2014 , Podolny, 2001 , Gulati, 1998). But outside influences do not just come from a vague space referred to as the environment or the ecosystem, they often come from other networks.

Within the management field problems of coevolution have been explained by management scholars through different theoretical lenses such as the organisational learning perspectives (Koza and Lewin, 1998), complexity theory (Mckelvie, 1999), institutional theory (Rodrigues and Child, 2003) or capabilities perspectives (Ter Wal and Boschma, 2011). The aim of this paper is to advance towards a theory of coevolution among networks that can explain more generally how distinct networks coevolve. To advance theory on coevolution among networks, we draw on important work from others on identity and signalling, but we also look outside the management field where theoretical underpinnings of network to network coevolution are quite well developed. Importantly theories of such coevolution exist in fields such as evolutionary biology (Thompson, 2005 , Gomulkiewiz *et al.*, 2007b) and sociology (Cherns, 1976 , 1987 , Jessop, 2004 , Norgaard, 2006) that may be drawn into management studies. By theorising about this, we can assist researchers in the management field explain phenomena involving altercentric (Podolny, 2001 , Gulati, 1998) or outward directed network interactions (Ellis, 2010 , Montgomery and Oliver, 2007). This may be somewhat counterintuitive to most network emphasis that is concerned with what happens inside a network and inbound interactions, but it feeds into our understanding of what scholars now recognise as the pivotal role of external networks in business (Haug, 2013 , Maclean, Harvey and Kling, 2014).

Our paper does not attempt to develop a complete theory of network to network coevolution. Rather we advance propositions that might support a different way of thinking about network dynamics and that might assist in moving towards a theory of coevolution among networks in the management field. In the following section we present our theoretical underpinnings that influence the development of eight propositions about network to network coevolution. This is followed by our discussion and conclusion section offering insights on the relevance of a framework, presenting useful domains of application and finally avenues for further study.

THEORETICAL FRAMING

A search of the management literature on networks and coevolution reveals mainly studies that deal with comparative variables within networks such as the coevolution of ties and perceptions of psychological safety within a network (Schulte, Cohen and Klein, 2012) or dependent variables on network coevolution such as the coevolution of trade agreement networks and democracy (Manger and Pickup, 2016). A small number of studies deal with network to network coevolution, but these mainly assume ties and relationships exist and coevolution is influenced by those ties (Ku, Gil-Garcia and Zhang, 2016). However, having ties (whether consistent or sporadic) blurs the boundaries of distinctive networks and this is a major challenge for researchers in understanding what happens among networks. Theoretical insight dealing with distinctive networks and explaining how and why networks coevolve (apart from the obvious of having relationship ties) is very limited. Yet in practice networks often coevolve with little or loose connections between them.

In explaining coevolution more generally and building on the works of others (March, 1991 , Levinthal and March, 1993), Koza and Lewin (1999 , 1998) advance a framework for coevolution grounded in the learning perspective. They suggest coevolution happens as a function of three morphological attributes of the structure (in their case alliance) on the behaviour (in their case the strategy) – absorptive capacity, control and identification. While this explanation is popular to explain the process of coevolution within a network, it does not explain why networks coevolve or coevolution among networks. Nevertheless the insights can in part guide our theorizing about the process of network to network coevolution.

Hence, with fractional insight from the management literature, it is necessary to explore outside of the field to understand the process of both 'how' and 'why' coevolution changes networks, and also to shed light on how these two perspectives can be integrated. In this regard, the fields of biology, ecology and sociology offer ideas that could complement the sociological nature of business networks. A theory of coevolution can be found within the field of evolutionary biology suggesting that the process of network to network coevolution requires three criteria – the existence of coevolutionary hot and cold spots, selection mosaics and trait remixing (Thompson, 2005 , Gomulkiewiz *et al.*, 2007b). This theory suggests that networks interact because of 'fitness' and offers explanation how the fitness of both species is affected (or not) by the distribution of traits in the other species.

What are 'hot' and 'cold' spots?

In the work of John N Thompson whose book 'The Geographic Mosaic of Coevolution' (2005) provides a compendium of empirical literature on interactive species whose ranges span broad and variable landscapes - the author hypothesises that a primary driver of coevolutionary dynamics are intermingled coevolutionary *hot* and *cold* spots. For a pair of interacting species, a coevolutionary 'hot spot' is a location where the fitness of both species is affected by the distribution of traits in the other species. In other words, a region in which reciprocal selection occurs (Gomulkiewiz *et al.*, 2007b , Thompson, 2005). By contrast, in a 'cold spot' the fitness of at least one of the species is unaffected by the other, meaning that reciprocal selection is absent. In evolutionary biology coevolutionary cold spots arise for many reasons including nonoverlapping geographic ranges (Nuismer, Thompson and Gomulkiewiz, 2003), the presence or absence of additional species (Benkman, Holimon and Smith, 2001), or shifting physical conditions (Hochberg and Van Baalen, 1998). These hot and cold spots can be defined relative to specific traits that might be subject to reciprocal selection in some places but not others. Also cold spots may be inferred in regions where one of the species is completely absent (Gomulkiewiz *et al.*, 2007a).

Shifting these ideas into social networks in a business domain, we know that networks may even have a resistance to interaction with other networks as an inclination and likeness for the familiar makes communication between networks hard to foster and thus less frequent (Huang, 2014). Social identity theorists are centrally concerned with this dynamic. However, if networks are focussing on inbound interactions, what influence is this having on surrounding networks? and similarly, if they are focusing outwards, possibly signalling to other networks, how does this influence network cohesion?

Process theory in part recognises the dynamic of coevolution in the management domain typifying a hybrid of combining prescribed lifecycle interplays and dialectic constructive conflict and synthesis between entities (Van De Ven and Poole, 1995 , 2011 , Greiner, 1998 , 1972). While lifecycle stages for networks cannot be as clearly typified as the organisational lifecycle in Greiner's model, we argue that driven by social identification, networks progress through stages interjected by identity crisis points on their journey. During the crisis points networks become more altercentric, focussing outwards rather than inbound and sending signals to others. When two networks are in crisis they may be mutually receptive to signals from each other, similar to the conditions of hot spots described in Thompsons (2005) theory.

Contrary to most network scholars (eg. (Uzzi, 1996 , Granovetter, 1985)) who suggest that business happens within social relations, we argue that important business also happens in the absence of ties that needs to be explained. Social identity theory predicts individual level behaviour as a function of group level perceptions (Hogg and Williams, 2000 , Hogg and Terry, 2000). While such identity occurs the salience of other identities recedes and the individual incorporates traits of the organisation into the self-concept (Hogg and Terry, 2000). Some authors push for a more triadic conception of social identity involving the individual, the organisation and the stakeholder arguing that perceptions of the stakeholder as a member of the organisation or the organisations identity orientation is collectivistic can encourage external stakeholder engagement (Korschun, 2015).

The social identity perspective is intended to be a general analysis of group membership and group processes (Hogg *et al.*, 2004). It rests on a cognitive and self-conceptual definition of the social group. Social identity theory has its origins the work of Tajfel (Tajfel, 1959 , 1972 , 1979) who first defined social identity theory as “the individual’s knowledge that he belongs to certain social groups together with some emotional and value significance to him of his group membership”. On this basis we argue that, at least in the cognitive sense, network cold spots occur when social identity is inbound but these reach crisis points when members may actively look more outwards, signalling their status and quality to other networks that may we equally reciprocal to such signals. The role of signalling as theorised by Spence (1973) and Stiglitz (2000) involving the active signalling and receiving of signals between two parties is discussed later in our theorising about the dynamics of coevolution among networks.

Proposition 1: Coevolution among networks requires hot and cold spots.

What is fitness?

When individuals have a sense of oneness or sameness with a group the salience of other identities recedes and the individual incorporates traits of the group into the self concept (Ashforth and Mael, 1989 , Hogg and Terry, 2000). In this way social identity, at least at a cognitive level, strives for similarity within groups and differentiation between groups (Hogg, 2000a). In this regard emotional and value significance is attributed to group membership (Turner, 1987).

Brewer and Gardner (2001 , 1996) argue that the collective self offers two types of social identity. The first, group based social identities equivalent to the collective self or social identity traditionally defined. The second, collective identities referring to a process whereby group members do not just share self-defining attributes but also engage in social action to forge an image of what the group stands for and how it is represented and viewed by others. In terms of collective identity, stereotyping is interestingly also an issue: you view them as being similar to one another and all having outgroup attributes (Hogg *et al.*, 2004).

Social identity motives are linked to either maintaining prestige and status of one's own group (Abrams and Hogg, 1988) or as a motive for uncertainty avoidance (Hogg, 2000b). Interestingly intergroup social comparisons do not strive toward uniformity and assimilation: instead, they strive to maximize differences between self as ingroup member, and other, as outgroup member (Turner, 1975 , Hogg, 2000a). According to Tajfel (1972), social comparisons between groups are focused on the establishment of distinctiveness between one's own and other groups. Collective self conception therefore is thus anchored in valence-sensitive social comparisons that strive for similarity within groups and differentiation between groups (Hogg, 2000a).

To understand 'fitness', sociology informs us that an important difference between coevolution and evolution is the relationship with the environment. According to Norgaard (2006) interactions and activities both inside the networks themselves and outside environmental influences contribute to the evolution of networks. However, when emphasising *coevolutionary* processes, the directionality of evolution is no longer determined by a steady advance toward perfect fitness with an unchanging environment. In coevolving groups, inward focussed identities of networks getting better and better are no longer relevant. Thus interactions of networks with their environment or ecosystem explains which selective forces are affecting the evolution of each network contributing to fitness (Norgaard, 2006) (p74).

We argue that for social networks ‘fitness’ is also about identification and an expectation that the evolution of the network will progress towards better and better with strong identification. Signals from other networks however in a network with weakening social identity change the variables that members are identifying with.

Proposition 2: collective network identities strive for similarity in traits to achieve fitness, but the criteria for fitness changes with coevolution among networks because new traits may be valued.

What are traits?

In evolutionary biology, the suggestion is that when networks are reciprocal to coevolution the fitness of both species is affected (or not) by the distribution of traits in the other species (Thompson, 2005 , Gomulkiewiz *et al.*, 2000). Norgaard’s coevolutionary paradigm (2006) suggests that species and other system components have a variety of traits that are context-specific. These traits change over time, as opposed to supposed universal characteristics. Moreover, the distribution of traits does not reproduce itself perfectly. In biological species, imperfect replication results in new traits in biological species, most of which do not prove fit, but a few of which do.   In social networks, similarly new traits identified within a coevolutionary process mix with existing traits to create new meaning and new identifications for network members.

Furthermore, the distribution of traits can become more diverse through introductions of new traits through migration of individuals from other areas and less diverse through extinctions in Norgaards theory. And the relative dominance of any particular trait is constantly changing according to changing criteria of fitness which, in turn, depend on the relative dominance of the characteristics of other system components (p71). For these reasons, coevolutionary thinking is really different from ‘cause and effect’ or ‘deterministic’ thinking of an evolutionary process.

Proposition 3: the relative dominance of any particular trait that is identified with is constantly changing according to changing criteria of fitness, thus coevolution is not deterministic.

Coevolutionary outcomes.

In view of the above, coevolutionary interactions mainly explain the nature of the relationships and not the outcome (Norgaard, 2006). In terms of trait remixing in evolutionary biology, Gomulkiewiz et al. (2007b) offer four potential processes for trait remixing: gene flow across landscapes, random genetic drift within populations, *extinction* and recolonization of local populations and *mutation*. In some respects the biological perspective on gene flow can be considered a source of local maladaptation and trait mismatching as may happen in sociological fields . In this aspect, traits shaped by selection in one community context are introduced to a different context (Gomulkiewiz *et al.*, 2000 , Nuismer, Thompson and Gomulkiewiz, 1999). They can be a creative or a destructive force.

We argue therefore that institutional and other externalised approaches to this phenomenon do little to deepen how we theorize network to network coevolution. Simple cause-and-effect relationships rely on the environment to get an effect (Hakansson, 1982). But, when networks evolve in response to changes in each other, rather than an environmental factor, all evolutionary direction is lost. Thus the traditional life cycle dynamics associated with network theories become unimportant. With more emphasis on coevolutionary processes, the directionality of evolution is no longer determined by identifying with a steady advance toward perfect fitness or a life cycle.

In this regard Norgaard (2006) suggests that coevolution requires a stress on **complex processes** rather than complex systems. He argues that entities and relationships are always changing yet they constantly reflect each other in coevolution. This change is unpredictable. Thus, a coevolutionary explanation of change goes beyond interactive (evolutionary) determinism.

Notwithstanding, coevolutionary outcomes can be broadly defined for social networks but normally the process leading to the outcome is not predetermined. The one exception may be when coevolution creates similarities between networks because common identities may increase the likelihood of sustained relationship ties and emergence. Scholars in management studies recognise some of the coevolutionary outcomes identified in other fields including competition, isolation, mutation, complementariness, extinction (eg. (Chandra, 2015 , Mckelvie, 1999 , Pollock *et al.*, 2015 , Koza and Lewin, 1999 , Rodrigues and Child, 2003)).

Proposition 4: coevolution disrupts the network evolutionary or lifecycle process.

Proposition 5: process outcomes from coevolution comprise mutation, competition, isolation, complementariness and extinction.

Proposition 6: network coevolution creating similarities leads to extinction because identifying with similar traits may result in eventual emergence.

Dynamics of coevolution among networks.

Explanations of network trajectories (Guercini and Runfola, 2012) recognize that evolution is influenced by relationship interactions which involve choices in the process. In this regard networks may work at some points with shared and common goals by network members such as a shared identity pursuing a prescribed life cycle. However this is interspersed by crisis points that we identify from the coevolution literature as 'hot spots' when two networks are in this space. Hot spots disrupt the normal evolutionary or lifecycle trajectory.

In attempting to explain the dynamics of coevolution between 'cold spots' and 'hot spots' the management literature, at least from the perspective of cognitive networks offers us some explanation. The combination of social identity group behaviours generates a wide range of intergroup behaviours (Ellemers, 1993 , Ellemers *et al.*, 1997) – for example low status groups (or their members who believe that the status quo is stable and legitimate and that intergroup boundaries are permeable) tend to disidentify from their group and pursue an individual mobility strategy of 'passing' (gaining acceptance) as members of a higher status group. They may try to gain psychological entry into a higher status group. Schisms are also likely to arise under conditions of identity threat and intolerance of diverse views within an overarching group (Sani and Reicher, 2000). We identify the conditions of movement between cold and hot spots as permeable boundaries. Possible drivers of these permeable boundaries may be status deterioration or schisms. These conditions influence members to signal or maybe forge ties with disconnected others which further creates conflicting identity demands. This view would be supported by Podolny and Baron (1997) who found that employees with ties to disconnected others were undermined by conflicting identity demands.

In the opposite direction, (Mok *et al.*, 2007) examine the relationship between bi-cultural individuals identity structure and their friendship network providing interesting insights on identity integration into a network. Weakening network identities may relate to members reflecting on other identities that may signal or allow entry or integration into another network with permeable boundaries.

Once a network is in a hot spot, signalling studies recognise the primary elements of signalling theory as a timeline of actors involving the signaller (the insider with the information) and receiver (who observes and interprets the signal) – and the signal itself that is sent to the receiver (Connelly *et al.*, 2011). Some signals of quality may be more readily detected by the receiver than other signals so management scholars sometimes suggest signals may be 'strong' or 'weak' (Gulati and Higgins, 2003 , Lampel and Shamsie, 2000). Visibility is also of interest (Ramaswami *et al.*, 2010) and signal clarity and intensity (Gao *et al.*, 2008 , Warner, Fairbank and Streensma, 2006). Another branch of signalling theory relates to countersignals which assumes that information asymmetry works in two directions as signallers need to understand what works so they can improve signal reliability (Gulati and Higgins, 2003).

Environmental distortion of signals can occur when the medium for propagating the signals (eg. media outlets, rankings, bandwagon effects) reduces the observability of the signal (Branzei *et al.*, 2004 , Carter, 2006). Signalling between multiple networks is infrequently a subject of enquiry (Ozmel, Reuer and Gulati, 2013 , Brass *et al.*, 2004 , Gulati, 1998 , Podolny, 2001). We theorise that active signalling as signalling theory suggests minimises distortion of signals between two networks. However, when passive signals are exuded as may be the case in cold spots, environmental distortion is more likely.

In particular signalling across multiple networks shows that at least in the case of new venture signals generated from given ties by one type of network weaken the effects of signals generated by another type of network (Ozmel, Reuer and Gulati, 2013). This might shed some light on the dynamics of coevolution among networks as in a temporary state of receptivity.

In the network literature, Podolny (2001) and Gulati (Gulati, 1998) recognise altercentric uncertainty whereby the value of status increases. This points to the notions of a prismatic/status perspective focused on how networks reduce altercentric uncertainty.

Proposition 7: Coevolution among networks is driven by identity schisms and disidentification together with permeable network boundaries.

Proposition 8: identity trait signals are actively managed in hotspots but risk distortion from passive signals in cold spots.

DISCUSSION AND CONCLUSION

Management scholars have generally been concerned with explaining and exploring coevolutionary problems evolving from relational interactions or within network perspectives. This paper raised the emphasis on the altercentric occurrences that occur among networks and how these can influence network to network coevolution. The aim of the paper was to create a conceptual framework for coevolution among networks that requires us to draw on other fields of influence, including biology, ecology and sociology. Our framework proposes that the basis for coevolution among networks is the existence of hot and cold spots – hot spots where coevolution happens and cold spots to create network trait identification. Coevolution is driven by identity schisms and disidentification together with permeable network boundaries which enacts the movement from cold spots to hot spots. Essential mechanisms in coevolution contain criteria for fitness and traits change. Specific characteristics of coevolution are that it is neither causal nor deterministic and that it disrupts the development process of individual networks. Possible outcomes of network coevolution include mutation, competition, isolation, complementariness, extinction.

In general, the study contributes to the extant management research on social networks and networking by increasing our understanding of the mechanisms of network-to-network interaction at the whole network level. The extant research on networks and their development both from the viewpoint of process change (Easton, 1992 , Halinen, Medlin and Tornroos, 2012) and structural change (Holmen, Pederson and Torvatn, 1999 , Uzzi, 1997 , Zaheer and Soda, 2009) has traditionally focused on individual networks. Although network coevolution has recently become an emerging hot topic among researchers (Tur and Azagra-Caro, 2018 , Arifovic, Eaton and Walker, 2015), research has particularly focused on how individuals and networks influence each other (e.g. (Kossinets and Watts, 2009); (Tasselli, Kilduff and Menges, 2015) or emphasising relational interactions (Broekel, 2015 , Rodrigues and Child, 2003 , Schulte, Cohen and Klein, 2012).To the best knowledge of the authors of this theory, although some researchers have recognized that networks influence each other in a coevolutionary way even without ties (Hansen, Mors and Lovas, 2005), no research has conceptualized the process of coevolution among networks. This study closes the gap and thereby offers a novel viewpoint to the discussions on networks and networking in management.

In more detail, the study offers five contributions to the extant management research on networks and networking. First, it introduces the concepts of hot and cold spots. The first refers to a situation where both networks are influenced by the other, and the latter refers to the situation where only one of the networks or neither network is influenced by the other. The study suggests that recognizing the existence and importance of hot and cold spots offers a basis to examine network coevolution further.

Second, the study theorises how coevolution is driven by identity schisms and disidentification (Sani and Reicher, 2000) which creates permeable network boundaries . As coevolution requires two networks the conditions of coevolution requires that both network identities are weakened (Dutton and Dukerich, 1991) and receptive to signals about the traits of the other. Identifying with these traits creates certain outcomes such as mutation or greater competition between networks.

Third, the study introduces two essential mechanisms of coevolution. Criteria for fitness refers to identification and an expectation that the evolution of the network will progress towards better and better with strong identification. However, the study proposes that network criteria for fitness changes when networks coevolve (Norgaard, 2006). Trait change builds on the idea that networks are reciprocal to coevolution for fitness and fitness of both species is affected (or not) by the distribution of traits in the other species (Thompson, 2005 , Gomulkiewiz *et al.*, 2000). These traits change over time (Norgaard, 2006).

Fourth, central characteristics of network coevolution emerge from the above mechanisms. Network coevolution is neither causal nor deterministic, as coevolutionary thinking differs from ‘cause and effect’ or ‘deterministic’ thinking of an evolutionary process. This is supported by the argument by ((Norgaard, 2006), p71) that the relative dominance of any particular trait is constantly changing according to changing criteria of fitness which, in turn, depend on the relative dominance of the characteristics of other system components. Additionally, coevolution disrupts development process of individual networks. This is because crisis points (Van De Ven and Poole, 1995 , 2011 , Greiner, 1998 , 1972) described in the coevolution literature as ‘hot spots’ disrupt the normal evolutionary or lifecycle trajectory of a network.

Fifth, possible outcomes of network coevolution include mutation, competition, isolation, complementariness, extinction which can be found in the management literature. However, it is the complex processes that need to be understood from the theory, as the outcomes are not deterministic.

We acknowledge that our paper does not develop a complete theory of network to network coevolution. We also understand that in its current form and structure, the paper does not express all aspects network coevolution might contain. These shortcomings offer bases for further research. All in all, we suggest that the propositions we identify might support a different way of thinking about network dynamics, which might assist in moving towards a theory of coevolution among networks in the management field.

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