Evolving innovation through office knowledge networks : mapping the ephemeral architecture of organizational creativity

DOBSON, Stephen, BRESLIN, Dermot, SUCKLEY, Louise, BARTON, Rachel and RODRIGUEZ, Liliana

Published version

DOBSON, Stephen, BRESLIN, Dermot, SUCKLEY, Louise, BARTON, Rachel and RODRIGUEZ, Liliana (2012). Evolving innovation through office knowledge networks : mapping the ephemeral architecture of organizational creativity. In: 12th EURAM 2012 : Social Innovation for Competitiveness, Organisational Performance and Human Excellence, Rotterdam School of Management, Erasmus University, Rotterdam, The Netherlands, 6th - 8th June 2012. (Unpublished)

Repository use policy

Evolving innovation through office knowledge networks: Mapping the ephemeral architecture of organizational creativity

Stephen Dobson, Dermot Breslin,
Louise Suckley, Rachel Barton and Liliana Rodriguez

Abstract

This paper explores positive conditions for the evolution of creative innovation through informal social networks in the office. By drawing on both Social Network Analysis (SNA) and the abstracted evolutionary mechanisms of variation, selection and retention, a multi-level conceptualization of the evolutionary processes underpinning the emergence and development of ideas within an organization is put forward. In this way SNA is used to visualize not just the connectivity of individuals within the company who offer 'expert advice' and 'new ideas' in the development of these products, but also the role of mediators in this process at a digital media company, Dataco.

Keywords: Evolutionary Approach, Innovation, Social Network Analysis

Introduction

Over the past few decades a number of scholars have adopted what might be broadly labelled as 'evolutionary approaches' in the study of a wide range of fields including linguistics, psychology, economics, economic geography, management and culture (Aldrich, 1999; Arthur, 2009; Boschma and Frenken, 2011; Boschma and Martin, 2007; Cavalli-Sforza, 2001; Dawkins, 1983; Dennett, 1995; Durham, 1991; Essletzbichler and Rigby, 2005; Nelson and Winter, 1982; Plotkin, 1994; Richerson and Boyd, 2005; Tooby and Cosmides, 1992). A number of these researchers have used the abstracted evolutionary mechanisms of variation, selection and retention to describe the evolution of key units of analysis over time (see Breslin, 2011). In biology the mechanisms can be used to describe the evolution of genotypes through the selection of phenotypes, where the genotype represents information inherited by an individual from its parents (i.e. genes), and the phenotype is the developmental expression of the genotype in a particular environment, as manifest through the physical characteristics of the organism. Some evolutionary researchers in the social sciences have also adopted this genotype-phenotype distinction when looking at their particular domain of study. In this manner they have adopted the abstracted concepts of 'replicator' and 'interactor', instead of the genotype and phenotype (Dawkins, 1976; Hull, 1988), where the replicator is defined as anything in the universe of which copies are made such as genes in the biological world. Interactors on the other hand, are defined as entities that interact as a cohesive whole with their environment in a way that causes differential replication of these elements (Hull, 1988). However the use and interpretation of these two concepts has differed widely between disciplines and researchers.

In evolutionary studies of innovation different units of analysis have been proposed. Basalla's (1989) account of technological evolution focuses on the changing nature of technological artefacts (e.g. tools). Drawing from wider literature on the diffusion of innovation (Rogers, 1995), others have focused more on the evolution of the knowledge behind the production of

these artefacts (Fleck, 2000; Murmann, 2003; Pelikan, 2003; Vanberg, 1992). Jablonka (2000) argues that whilst it might be easier to analyze the evolution of the phenotypic expression of technologies through artefacts, a true understanding of the detailed mechanisms of selection can only be gained through an analysis of the psychological and social context of the diffusion of innovations themselves (Fleck, 2000; Jablonka, 2000). In this way Murmann (2003) distinguishes between the notion of the replicator as represented by ideas and knowledge, and the manifestation of that knowledge in physical artefacts, whilst Mokyr (2000) proposes that the technique behind the technology be the interactor as opposed to the artefact. In this way the diffusion of innovation has been identified as a core subject for study using a Generalized Evolutionary approach, with a focus of analysis on evolving artefacts and/or the knowledge behind these technologies (Ziman, 2000). Many of the features described in Rogers' (1995) model of innovation diffusion parallel the evolutionary mechanisms of variation, selection and retention as the knowledge behind the new technology evolves over time. In this way individuals make choices to *select* innovations for use and following positive feedback new technologies are eventually *retained* within the routines of the organization (Rogers 1995). Socio-political factors strongly influence this process, as collective understandings of the technology are developed through dialogue, negotiation and compromise, with the innovation being *varied* in the process to suit the specific circumstances of the group and organization (Ansari et al., 2010; Kennedy and Fiss, 2009; Rogers, 1995; Rice and Rogers, 1980). Acts of negotiation and compromise may be explicitly formalised in the processes of product development or, perhaps more frequently, are tacitly held through ongoing and informal dialogue and relations. A review of this literature shows that past studies of innovation that have used an evolutionary approach have tended to focus on the ecology of artefacts, or end products of the innovation process. Few have focused on the details of the evolutionary process itself, and how this might lead to an evolving ecology of ideas. To address this gap, this exploratory research looks behind the evolving ecology of ideas, at the behavioural, cognitive and socio-political forces influencing this evolutionary system.

These descriptions of knowledge diffusion share many similarities with evolutionary accounts of organizational change, using the mechanisms of variation, selection and retention as the starting point, and drawing on related literature from learning and behaviour to develop specific theoretical explanations (Aldrich, 1999; Breslin, 2011). In these latter accounts, individuals also communicate and negotiate with each other as they make choices and reconcile differences in opinion and interpretation in the variation, selection and retention mechanisms. Over time, coalitions (Cyert and March, 1963) are formed as a collective knowledge becomes established and retained through routines. What differs between these various accounts is the notion of replicator and interactor. Evolutionary accounts of organizational change (Aldrich, 1999) and learning (Levitt and March, 1988) view components of knowledge, as the focus on analysis, as they spread and evolve independently of the individuals within whose heads they (sometimes temporarily) reside. Whilst Rogers clearly describes the development and diffusion of knowledge, he does not explain the relationship between this spread of knowledge and the outward manifestation of that knowledge through actions or artefacts. Therein lies an opportunity to develop a conceptualization which explicitly focuses on the multi-level processes through which knowledge and the manifestation of that knowledge through artefacts. This study seeks to address this gap, by drawing on both Social Network Analysis (SNA) and the abstracted evolutionary mechanisms of variation, selection and retention, to develop a multi-level conceptualization of the evolutionary processes underpinning the emergence and development of ideas within an organization. By making explicit the relationship between

replicators and interactors, and how these evolve through individuals and groups within the organization, the study seeks to make the link between the diffusion of knowledge and the resultant emergence of artefacts through innovation.

Specifically this paper is concerned with exploring positive conditions for the evolution of creative innovation through informal social networks in the office. The focus of research is a digital media company, who develops web-based products for clients, referred to here as Dataco. SNA is applied here to visualize not just the connectivity of individuals within the company who offer 'expert advice' and 'new ideas' in the development of these products, but also the mediators; i.e. those with high levels of betweenness. Where new ideas are closely related to expert advice we might conclude that innovation derived from this structure is driven predominantly by those expert individuals. However, truly open innovation will benefit from a more evolutionary approach; an ecology of influences which includes interaction and transformation as well as replication of thought processes. Here mutation and change might be deemed to occur whilst spanning boundaries between groups in the organization. A key component of such an ecology is that a mediator (Latour 2007) - someone who translates and contextualizes - essentially changes knowledge through the act of passing this on to others. The network is constructed through a web-based questionnaire to establish broadly who an individual would go it if they needed expert advice or new ideas to solve a problem, as outlined below.

Innovation through a Network of Actors

SNA is a key methodological approach for emphasising the 'global' overview of social relations thus illustrating the embedded nature of actors within a wider network of interactions (Hanneman, 2001). Organizational research in this area emphasises a 'relational perspective' on organizational learning and idea formation. Rather than focusing upon a single relationship or set of relationships SNA is concerned with the generalization of all relations. As such it may be used to construct a model of the relational framework, the architecture, which is formed from social relations. The structure, or topology, of this architecture will differ depending upon the nature of the relationships under scrutiny, such as; innovation (Dilk et al., 2008; Dooley and O'Sullivan, 2007; DeBresson and Amesse, 1991), social capital (Borgatti and Foster, 2003; also see, Portes, 1998; Lin, 2001; Adler and Kwon, 2002), or knowledge management (Cross and Borgatti 2004; Agranoff, 1991; Alter and Hage, 1993; Jennings and Ewalt, 1998; O'Toole, 1997; Provan and Milward, 2001). As recent research illustrates (Smith, 2011), dynamic often tacit boundaries can create and disperse over time; thus creating a fluidity of emergent and informal collaborations. Smith illustrates how coalitions formed through collective knowledge, for example, form boundaries based upon ‘like-mindedness’. Breslin (2012) underlines how this might be reinforced through the performance of routines. Innovation networks are identified by DeBresson and Amesse (1991) as being particularly characterised by their loose, informal, and often implicit nature. These are cultural boundaries and are reinforced through stereotyping and a degree of prejudice about individuals or groups perhaps in other teams or organizations. In essence such boundary formations, which may be multi-layered and span organizations, create ‘natural’ social boundaries formed out of interaction and therefore can be self-reinforcing (Cross and Borgatti 2004). Mapping the ephemeral pathways for communication and social relations within and between boundaries is the subject of this study. Where idea forming is predominantly produced ‘within boundary’ we might consider that retention may be more likely than variation.

Opportunities for variation often occur externally, through customer feedback or perhaps periodic external assessment. However, where idea formation involves the spanning of boundaries between groups those points of contact will also be sources of variation; where actors transform knowledge and ideas in an attempt to communicate them to people outside of the collectively held beliefs and systems/routines within their coalition. The fluid and emergent nature of social networks, within and between organizations, thus form boundaries characterized by Nonaka (1994) as "communities of interaction", "communities of practice" (Brown and Duguid, 1991). These inter- and/or intra-organizational coalitions of interactions may be grouped around projects, common interests or other areas of shared objectives. The structures of these are rarely explicitly defined by the organizations; especially as such definitions would be at risk of quickly becoming as redundant as the organizational chart:

> "Put an organizational chart in front of most any employee and they will tell you all the boxes and lines only partially reflect the way work gets done in their organization." (Cross et al., 2002, p. 26).

In an innovation network, knowledge is then not just transferred it may also be transformed and so we might consider that knowledge is invariably subject to both replication and variation through the act of communication. In an organizational setting, ideas and responses to problems rarely, if ever, wholly embody the thoughts of just one individual; without influence of the ideas of others. The co-constructed nature of such knowledge means that it is unlikely to be conceived without having been subject to multiple iterations and influences on multiple levels. These ideas and responses therefore are independent of each individual since they represent co-creation. Within an organizational setting this may be reflected at the relatively transient and micro social interaction level of two colleagues chatting over coffee to the longer term, macro level interactions of many people and groups over a more substantial period of time. SNA is a valuable means for the researcher to visualize and map these informal and formal social relations and so the aims of such studies are generally; "to describe patterns of relationships among actors, to analyze the structure of these patterns and discover what their effects are on people and organizations" (Martinez *et al* 2003). Keast and Brown (2005) suggest that "the virtue of network analysis is that unlike conventional analytical approaches it does not focus on the attributes or characteristics of particular individuals or cases, but on the relationships between entities" (2005); i.e. "the quality of relationships binding a network together" (Cross and Borgatti, 2004, p.137; see also Monge and Contractor, 2000; Adler and Kwon, 2002).

Adopting an evolutionary approach, the abstracted mechanisms of variation, selection and retention can be used as a starting point for developing theory to explain the process of innovation. Auxiliary theories can be used in this development of theory specific to the domain of study, (Stoelhorst, 2008), and in this way SNA can provide a means to model the ecology of social relations which emerge as ideas shift and transform between actors. Whilst Davies states that "the starting points within network analyses are populations of actors who connect to and interact with each other" (Davies, 2005, p.145) we might consider these as sampling points rather than the subject of study per se; each pair of actors defining two sides of a communication relationship from which co-constructed cultural artefacts are formed. Through the lens of Actor Network Theory (ANT) Latour (2007) illustrates this as a form of 'social inertia'. The example is used of a team of builders making a wall. The team part company "only after the wall is completed. But while the wall is being built, there is no doubt that they are connected" (2007, p.75). These non-human, but evidently social, artefacts are considered from an ANT perspective as equally important actors within the network

assemblage. ANT studies are therefore not solely confined to considering human actors but essentially consider any entity with the power to influence the social realm as an active actor (actant). Latour describes actants as displaying the characteristics of either an intermediary or mediator; an intermediary being an entity which transparently passes on information, whereas a mediator will steer the application of knowledge into a new area; a mediator might translate, contextualize, and transform knowledge. Within an organization we might consider that knowledge communicated within a social boundary of like-minded colleagues (i.e. coalitions formed through routines) is more likely to be passed unmediated for it requires little translation; however as boundaries are spanned between alternative groups, information and knowledge has a greater likelihood of requiring translation, mediation, the reconciliation of differences and therefore ultimately - transformation. This leads to a significant source of variation and therefore the conditions for the evolution processes of creativity and innovation.

In summary, most evolutionary studies of innovation, and more generally organization studies and economics, tend to focus on the population as a level of analysis. In so doing studies can overlook the multi-level processes driving these macro-level changes. Drawing on SNA, this exploratory study seeks to put forward a conceptualization which captures the multi-level complexity of the innovation process. This approach has implications not only for the study of innovation, but wider aspects of organisational and socio-cultural change. In order to develop a conceptualisation of the evolution of ideas using an evolutionary approach, the replicator and interactor need to be defined. As noted above, some evolutionary studies have identified the innovative product as the focus of attention, while others have focused more on the evolution of the knowledge or ideas behind the production of these artefacts (Fleck, 2000; Murmann, 2003; Pelikan, 2003; Vanberg, 1992). Hull (1988) defined the interactor as an entity that interacts as a cohesive whole with their environment in a way that causes differential replication of these elements. However it can be argued that ideas (as replicators) interact with the external world through their expression in words and actions. In other words the interactor is the expression of these ideas as individuals interact and communicate. This conceptualization of a collection of ideas interacting with the external world through their expression in words and actions requires a disconnection with biological analogies, and a further level of abstraction in the use of an evolutionary approach (Breslin, 2011). Therefore in this study the replicators might be defined as ideas which are expressed through communication, discussion and actions of individuals. The emergence, development and dissemination of these ideas occurs at multiple levels through the mechanisms of variation, selection and retention, as noted above.

Research Method

The construction and analysis of SNA sociograms are well documented (Cross and Borgatti, 2004; Cross et al., 2002; Scott, 2000; see also Rogers, 1995; Granovetter, 1973), but briefly, the process involves establishing through questionnaire analysis who is connected in some way to whom and representing these connections in lattice form. A simple check box web interface was used in this study to enable the staff members of Dataco identify their most significant connections in the workplace for a number of scenarios. They were asked to identify which of their colleagues they would be most likely to go to in relation to the following:

1. completing everyday work processes
2. developing new ideas
3. discussing social topics

4. discussing everyday working practices
5. seeking expert advice
6. making decisions

For the purpose of this study, 'seeking expert advice' and 'developing new ideas' are focused upon as key for innovation and creativity. The results were compiled as a case by case adjacency matrix (see Scott, 2000) and processed through the SNA software package yEd (yWorks[1]). SNA data relations may be classified as either Symmetrical (non-directional) or Asymmetrical (directional) (Scott, 2000). For example, if actors A and B share an affiliation such as working together or are friends we might consider this an equal relationship, shared by both, and so symmetrical. Asymmetrical relations however are directional and so are perhaps more indicative of power or advice structures e.g. actor A may line manage actor B however actor B does not line manage actor A; or, actor B may help/mentor/gives advice to actor C whilst this may not be reciprocal. The data processed in this study was asymmetrical since one actor may seek new ideas, for example, from another actor but the opposite may not necessarily be the case. The connection modelled in this network thus represented a group perspective on the flow of new ideas and expert advice within the company which might lead to innovation and product development.

Referring to Granovetter (1973), Cross and Borgatti (2004) argue that new or innovative information is more likely to be gained through brief contact with more disparate parts of the network ('distance' between one actor and another) - ie the weaker ties. Stronger and closer connections, on the other hand, are suggested to favour extensive support or the transference of complex knowledge (Hansen, 1999) or the sharing and reinforcement of commonly-held beliefs. For these reasons, analysis focused upon both the connectivity and also the betweenness of actors in the network as potential opportunities for selection and variation. Connectivity is a measure of how many times an individual is referred to as a key source in any of the given scenarios. A high level of connectivity in relation to 'expert advice', for example, would indicate that this person provides such advice to a large number of people within the workplace. Betweenness is a measure of the mediating, connecting role that an individual may have between individuals or teams/groups. Someone with a high level of 'expert advice' betweenness may be someone who contextualises the information, translating it into a more understandable or locally relevant form for another group or team. These individuals are the brokers or mediators in a network and therefore are key components in the transformation and variation of information.

Finally, the staff were asked to indicate how frequently on a one to five scale (daily to never) they had face-to-face and virtual (e.g. telephone, email) interactions with each of their colleagues. The results of this part of the survey (appendices 1 and 2) helped to indicate the nature and quality of social relations based on frequency and the predominant means by which communication tended to be carried out by the individual. Frequent communication (i.e. daily) for example is regularly carried out via virtual means by many of the participants (e.g. actor 'E' physically carried out daily communication with 27.3% of their colleagues but communicated through virtual means, at this frequency, with 72.7%). This information was gathered to help frame recommendations to the managers about how to maximise communication channels in relation to spatial layout.

[1] http://www.yworks.com/en/products_yed_about.html

Findings

Dataco are a small UK based company, comprising of 12 staff, which design and build consumer websites with an online portfolio covering motoring, finance, insurance, competitions and lifestyle; they deliver email marketing on behalf of clients or sell data to clients for their own use. There are two company directors who also act as team leaders covering both the general administration and marketing for the company (Actor M) and also the technical development (Actor D) which is a strong component of the products they produce.

Relationship category: Expert Advice

Within the organization, colleagues will seek advice from each other in order to solve problems or to progress the development of a product. Mapping the most likely flows of these relations helps us build a conceptual model of the ephemeral architecture relating to expert advice. Actors M and D are the directors of Dataco with D heading up the technical team (A, B, C, D, I, J). Most expert advice is formed around these two actors although we can see (Fig 1) that a number of the technical team provide advice as these display high connectivity; this is displayed by darker, larger boxes. Actors H, K and E are administrative and support staff and are not considered significant sources of expert advice; M being the key source of expert advice over non-technical company matters.

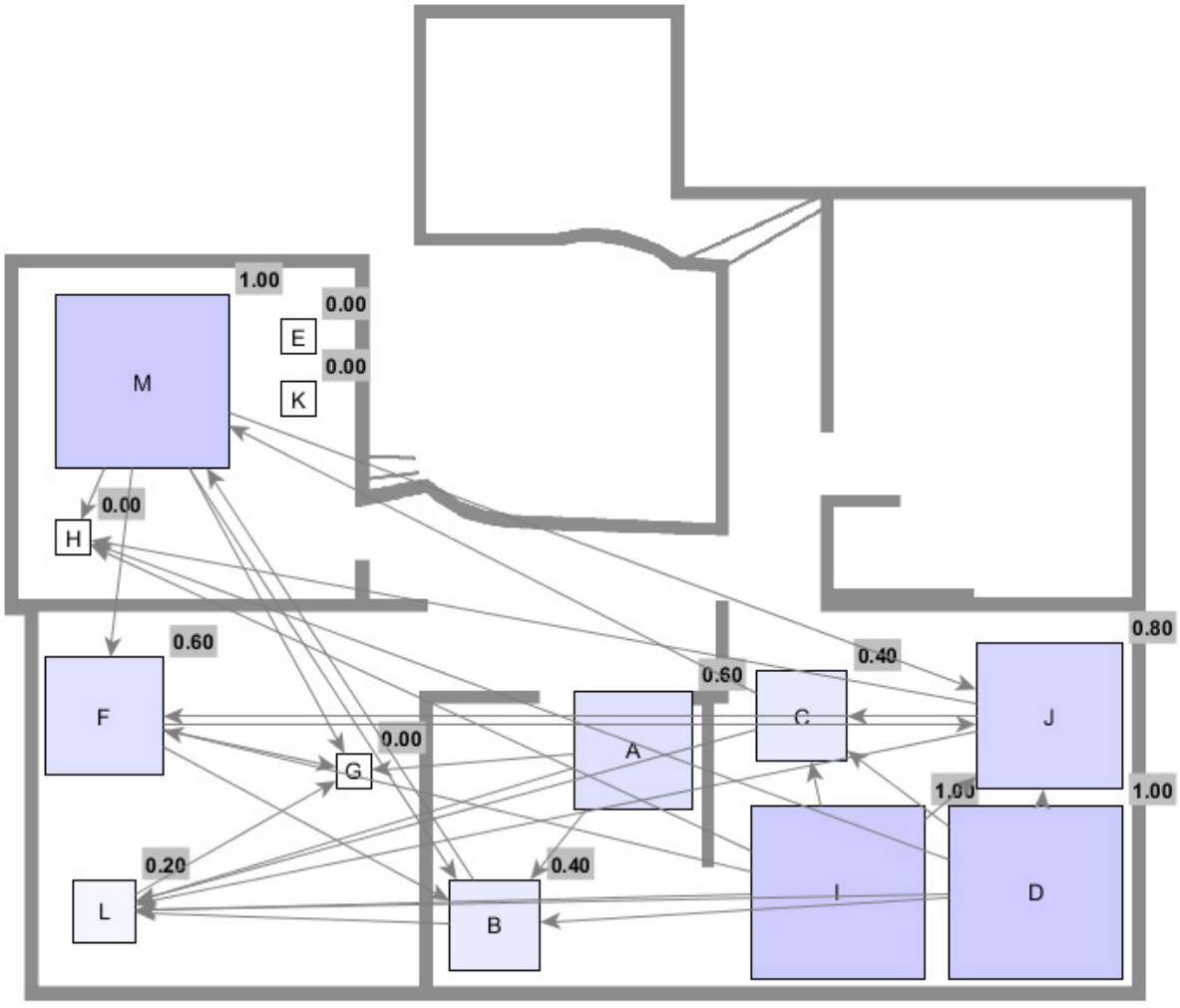

Figure 1: 'Expert Advice' – Connectivity

Considering the general directional flow of expert advice amongst the key actors and their nearest neighbours, as head of the technical team and a co-director for the company, D emerges as an obvious source. D does not define any actor as being someone to whom they seek expert advice from but is defined as a source by others (Fig 2).

J is the most significant recipient of expert advice from D in terms of their high level of connectivity indicating that they in turn are also someone to whom colleagues refer to on these matters. The nearest neighbours to J (Fig 2) indicate that M, D and also I are key sources of expert advice. J in turn disperses advice to L, H, F, and C however we see that there is a two way relationship with F who is involved with the marketing and client side of product development and indicates a key point for iterative variation and external interaction through customer feedback. J is a new member of the technical team and their position between receiving expert advice from technical and managerial staff and dispersing this to non-technical staff indicates that they display high connectivity, but also betweenness (Fig 3), thus mediating information between the technical and non-technical staff. This is potentially a source of variation as the information/product being developed may need transformation through compromise to match the needs of both groups. Through post-survey discussion with the company directors, J was identified as having made a key breakthrough in solving a technical problem which the rest of the technical team had been unable to resolve. In this case, J had continued to listen to the feedback outside of the technical team to persevere with the issue. As a new member of staff they also had not yet fully adopted the routines and commonly held beliefs of the others in their team. Maintaining such opportunities for interaction and influence on idea development, both internally (illustrated through betweenness) and externally (via newly held perspectives), is therefore an important characteristic of variation.

C has the lowest level of expert advice connectivity in the team (0.40) and also does not display the highest level of betweenness (0.19). However, by examining their neighbourhood (Fig 2) their strategic relevance becomes more evident since they are cited by the other company director M as a key source of advice. Actor M's immediate neighbourhood also reinforces the significant position C plays in the provision of expert advice. Whilst C is only cited by two actors as a source of expert advice, the seniority of M suggests that C does indeed present an important source of idea variation. However, since the accuracy of their advice is not necessarily tested by a wider group we might conclude that copying errors from J, D and I through C to L and M may exist without being easily or immediately identified.

The immediate neighbourhood for Actor I indicates that whilst they are seated closely to both D and B in the office space layout, neither of these actors feature as either sources or recipients of expert advice for I. This may be through lack of communication or, perhaps more likely, a high level of shared knowledge and expertise i.e. a coalition of similarity.

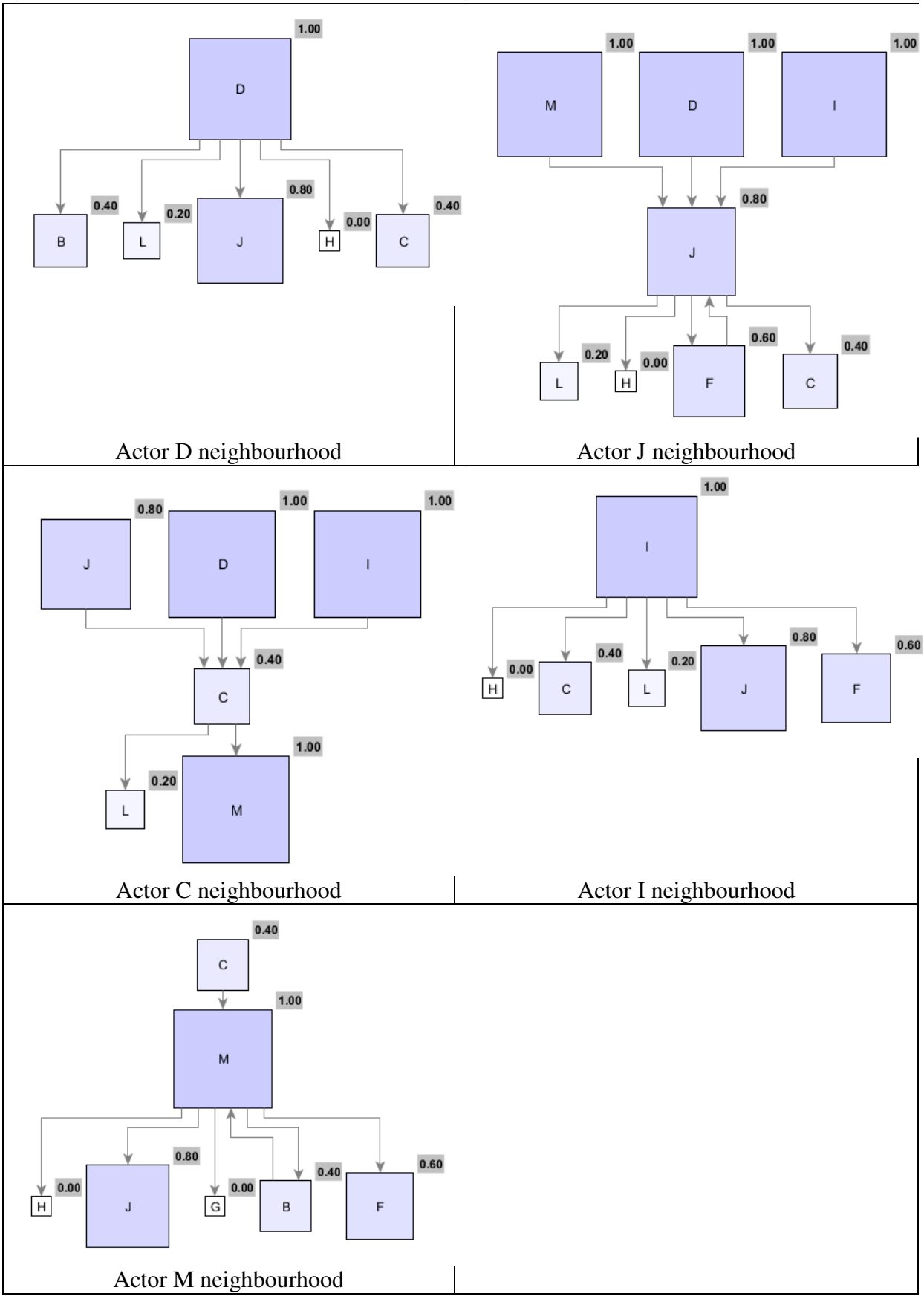

Figure 2: 'Expert Advice' Connectivity Sub-diagrams

Considering betweenness (Fig 3) we see that there are three actors who appear to adopt a key mediating/brokering role for expert advice, these are M, B, and J. Whilst M connects with all groups (rooms) we see that, of the technical team, B and J are the predominant mediators and communicators of technical issues. In post-analysis discussions with the company directors it was confirmed that J was indeed considered the most approachable and able to contextualize the technical nature of the team's work. This act of communication to other groups was also the main stage at which technical development might interact with non-technical considerations; where technical development might influence the work and understanding of others and, in turn, where these might influence new technical challenges.

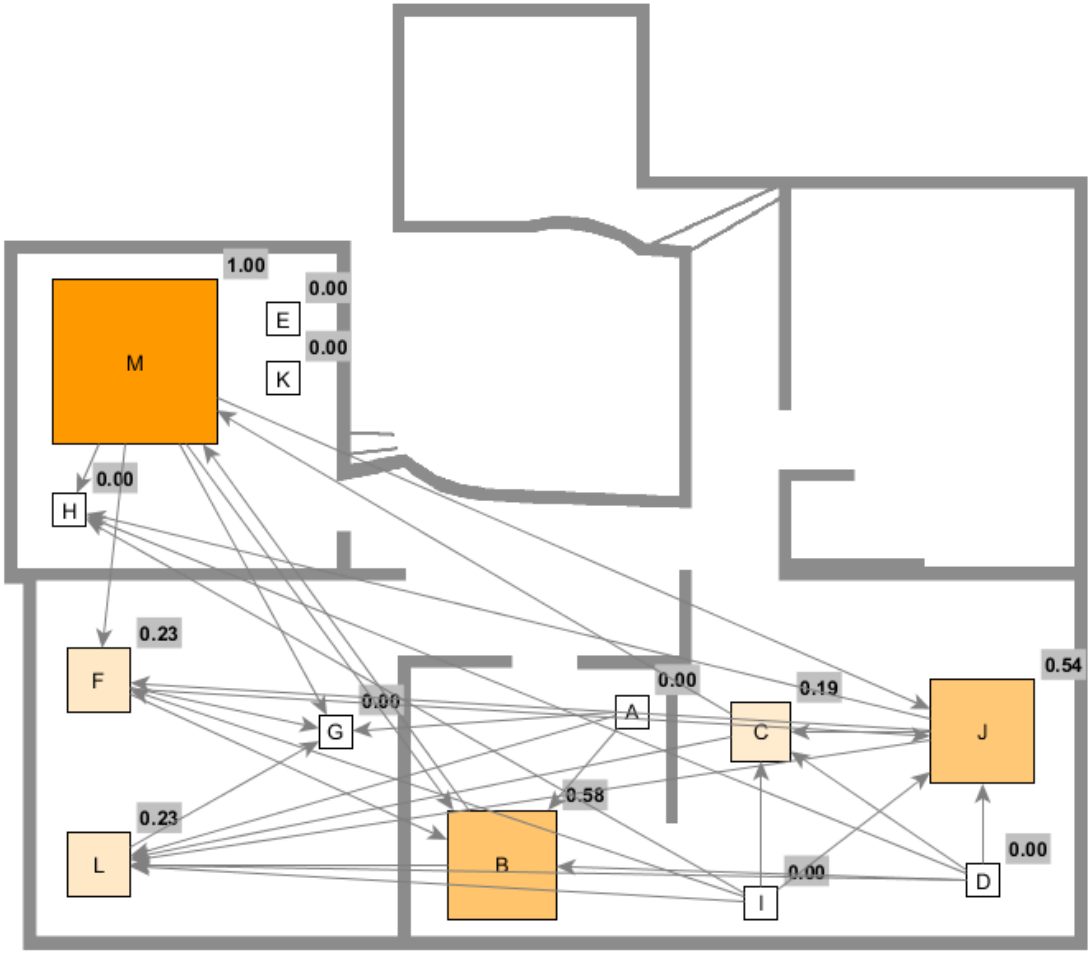

Figure 3: 'Expert Advice' - Betweenness

Relationship category: New Ideas

Whilst many of the key actors for expert advice are the same as those identified as sources of new ideas H emerges as displaying greater level of significance in this category (Fig 4). Whilst H may not be considered 'expert' they are obviously still acknowledged as influential to idea building. Figure 6 also indicates the relatively high level of betweenness (0.48) displayed by H. By examining H's neighbourhood, we see that H considers C, J, and I as key sources of new ideas. It is interesting to note that H has a two-way relationship in this category with all three of their recipients of new ideas; significantly co-director M is one of these.

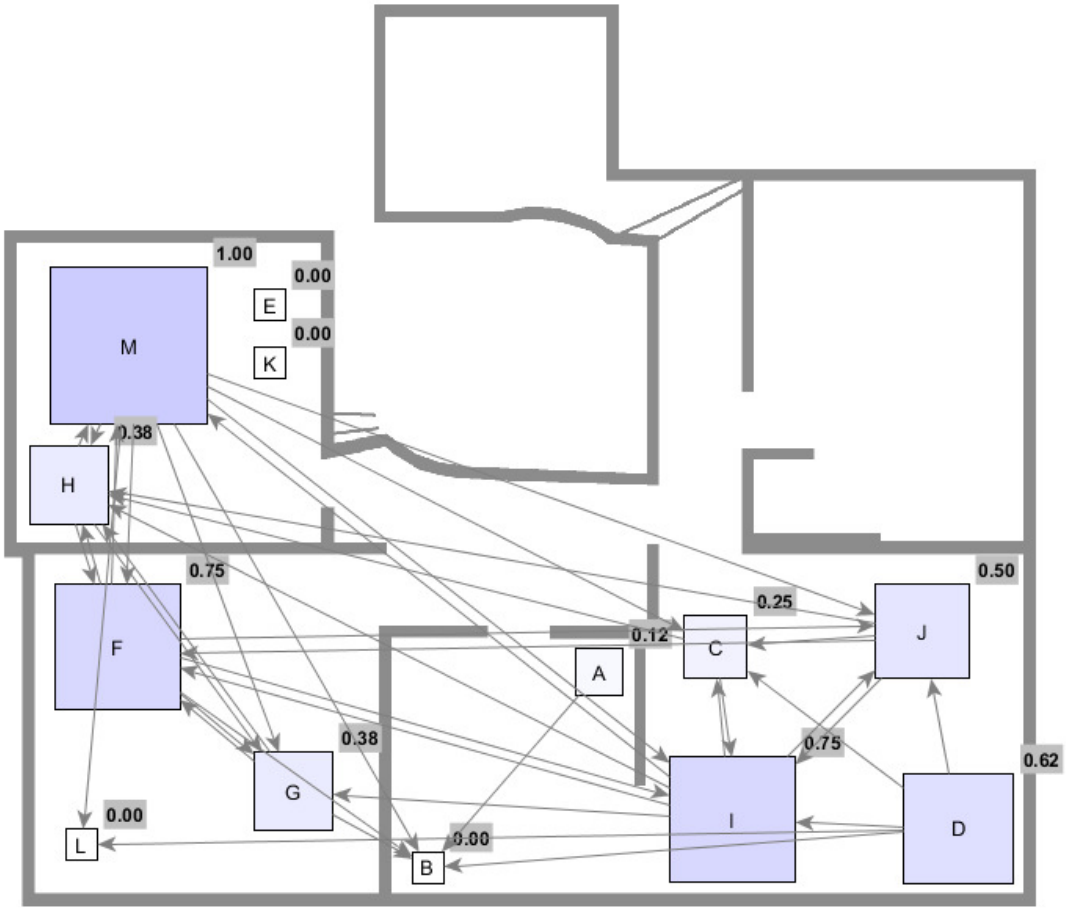

Figure 4: 'New ideas' - Connectivity

Examining the neighbourhood for M in relation to new ideas (Fig 5) demonstrates the strategic importance of H in this process. Actor M emerges as a key source of new ideas, especially reinforced through their position of power in the company, illustrating the influential nature of any idea development with Actor H on trajectories of innovation and creativity. If we compare this with the neighbourhood of D (the other company director) it is evident that D does not consider any other member of staff to be a significant source to them for new ideas (Fig 5). This may indicate that D's focus may be purely on quite specific and highly technical challenges. With the exception of L, the recipient's of D's new ideas are completely within the technical team which again supports the assumption that D may be focussed on creative challenges of a highly technical nature.

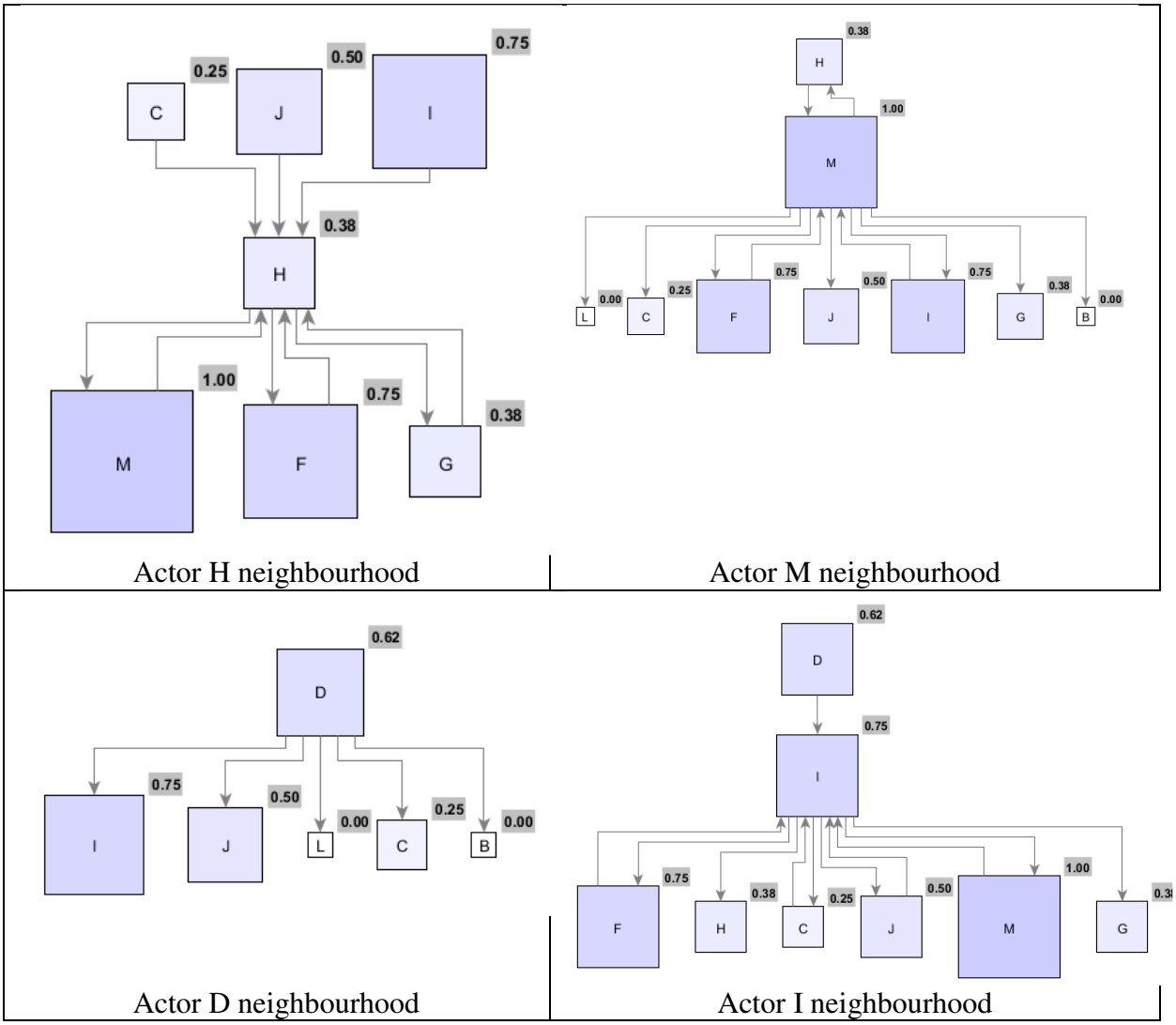

Figure 5: 'New Ideas' Connectivity

Each of the key groups has a person who appears to act as a broker or mediator, connecting the teams; these are M, F and I. It is particularly interesting to note that within the technical team, J was considered highly connected and also a commonly used source of 'expert advice' (Fig 1), however it is Actor I who is considered by most as a significant source of 'new ideas' between groups with high levels of connectivity (Fig 4) and betweenness (Fig 6). Figure 5 illustrates that Actor D is a highly influential source of ideas for I. The level of dispersal of these to others demonstrates the importance of Actor I as a communicator and mediator.

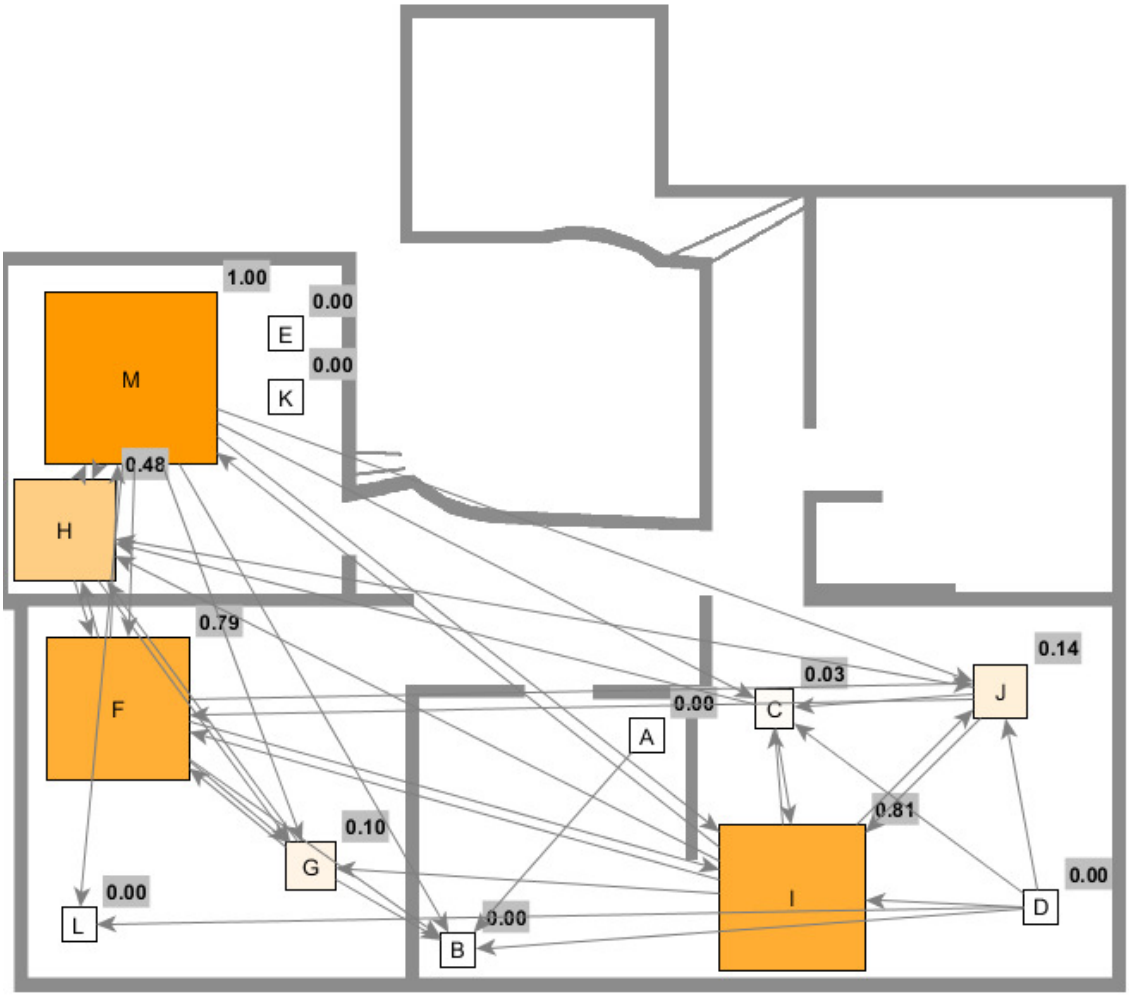

Figure 6: 'New ideas' - Betweenness

The sociograms and neighbourhoods illustrated here obviously do not aim to represent specific events or scenarios but instead are models indicating the group's perception of tendency. Any single act of conceptual or product development may deviate from the routes and flows constructed here but, over time, we might consider that such routes represent commonly trod pathways through which ideas are replicated or transformed. This model of creative exchange therefore does not represent a single act – but the culmination of many such acts in daily working practice and which culminate to form the ephemeral architecture of organizational innovation. This may resemble, but can never be completely defined by, the social networks presented here.

Discussion

These findings reveal a rich pattern of connectivity and betweenness within the group of individuals at Dataco. As noted above an evolutionary approach might be taken to interpret these findings with a view towards shedding light on the process through which they emerge over time. In this manner, the evolution of ideas between individuals within the organization might be conceptualized using the mechanisms of variation, selection and retention as follows (shown in figure 7):

- *Variation*: Individual M for example puts forward a new idea to the group. Individual M is considered to be a key source and generator of new ideas, as shown in figure 4. Likewise most ideas within the group occur through individuals M, F, D, I and J (see figure 4). The importance of these individuals as a source of variation is shown by the bold variation arrow in figure 7.
- *Selection*: Individual M 'selects' this idea as a possible solution, using a mental representation of the external selection environment. Given the expertise this individual holds (or alternatively receives principally from Actor C), he/she believes this mental model is 'accurate'. Individual M, then expresses this idea to others within the group through words, narratives, schematics etc. The recipients of the idea, e.g. individual I, will also use interpretive frameworks to assess the 'attractiveness' of the idea. However this interpretation is influenced by the strength of the signal conveying the message. This signal (or interactor) is clearly influenced by the power of sender (including expert and role power); the degree to which the expression of the idea is convincing and the compatibility of this idea with previous understandings of individual I. In this manner individual I is more likely to select ideas coming from individual M if they 'fit' with his/her mental model and received from the right sender (i.e. someone with high expert power) as indicated by the bold arrow in figure 7. The strength of the expert advice of the various actors is shown above in figure 1.
- *Retention*: Having selected the idea, an interpretation of this idea is retained by individual I. It is important to note that this interpretation may differ from, 1) that intended by Actor M; 2) that conveyed to M by Actor C, and; 3) the interpretation made by C of advice given to them from J, D and I. Such acts may lead to further variation of the idea or advice as it is diffused through the group. As noted above Individual I is an individual with a high level of betweenness in the diffusion of ideas (see figure 6), so any variation introduced here might have a greater impact on the subsequent spread of M's idea to say individual F.

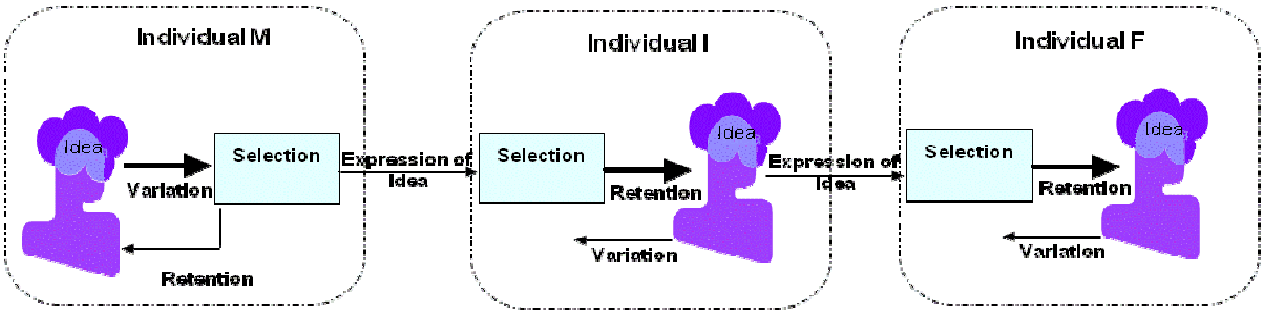

Figure 7: Interaction between individuals and the emergence of ideas

This process continues for each new idea or variation on the idea. As ideas are passed between individuals 'copying errors' occur as they are deliberately or accidentally made to fit with the interpretations and understandings of the receiver and mediator. In this sense the replicators are the ideas, or mental representations of the products/services. The interactors are the manifestation/representation of those ideas to the outside world, through narratives/product design etc. The difference between the two is a key part in unpacking the evolutionary process followed by ideas over time.

In light of this discussion and examining in detail the findings from the study, we can see that the generation of new ideas was made chiefly in response to customer demands. As shown in figure 4, the key generators of new ideas were individuals M, F, I, J and D. However, as

noted above, individuals receiving these ideas are more likely to select them, if the sender has high expert power (namely, individual M, I, D, and J) or, importantly; if the ideas are transformable so as to achieve compromise. Of this group of ideas generators, this meant that only individual F lacked the expert power (relative to the M, I, D and J) to influence selection of his/her ideas within the group. The spread of ideas occurred mainly through the key sub-group mediators individuals, F, I and M. In a sense these individuals facilitated the selection mechanisms outlined above by improving the expression of the idea, and the interaction/spread of the ideas among the group and beyond. As a result these individuals could vary ideas (as noted above), to fit with their interpretative system. Both individuals M and I were generators of ideas, and exhibited high expert power, and as such we might expect that ideas would vary little as they were diffused through these agents. However individual F was seen to have relatively weak expert power (0.6, see figure 1), and so we might expect higher variation as ideas were diffused. Indeed as noted above individual F was the key customer contact, and as a result might have a closely, "more accurate" understanding of customer needs. Finally all individuals within the organisation were involved in the retention of ideas, once selected as noted above.

Co-Evolutionary Systems

Analysing the findings through an evolutionary lens, might have some interesting implications for the management of the innovation process within the organisation. One might ask whether the design of the physical spaces within the organisation facilitated or constrained the evolutionary process of variation, selection and retention? The generation of new ideas will be encouraged by critical discussion and differences between individuals within the business. The more these individuals work closely together, the more they tend to develop collective mental models, and the less they will question the ideas put forward by colleagues. In this regard the physical separation of the generators of ideas is important, providing that they meet/communicate regularly to discuss ideas (which appears to be the case looking at Appendices 1 and 2). While M is located at a distance from I, J and D, the latter three are not (see figure 4). It might be interesting to see, whether the mechanism of variation would therefore increase, if I, J and D were also physically separated into different rooms.

The selection and dissemination of ideas is facilitated by individuals M, F and I, who in a sense facilitated the creation of interactors which might gain better acceptance, and so selection, by others. Clearly the mediator needs to 'speak the language' of both the sender and eventual recipients, and in this regard, it would appear to make sense that they would be located close to each generator or ideas and also eventual recipients. This appears to be the case as shown in figure 6. However, what would be interesting to investigate further is the extent to which an individual acts as both the sender and mediator of ideas, and whether this results in more or less variation over time. For example, it is seen above, that both individuals M and I (and Actor D to a lesser degree) are core generators and mediators of ideas. While a key role of the mediator is to 'spread' the idea, by facilitating the expression of replicators through interactors. The interpretation of the latter by others can be a source of further variation and refinement of the idea. If the mediator is also the generator or ideas, opportunities for differences in interpretation might be lost. If the company is driven to be creative, perhaps the roles of mediator and generator of ideas should be separated behaviourally (if not physically).

These findings lead onto other interesting areas for further investigation and research. For example, does a high level of cognitive betweenness result in more or less variation? How does this influence selection and retention? Individuals working closely together might develop a shared cognitive interpretation of 'what might work'. This might result in higher levels of acceptance/selection of ideas, and subsequent 'accurate/faithful' retention (and as a result lower levels of variation). Individuals with very different interpretative systems, might generate more variation, as they challenge each other's viewpoint, and in the process generate more ideas. So a closer match between individuals might result in higher selection/retention, but lower variation. Whereas lower shared interpretations might reduce selection/retention but increase variation. In parallel with this 'cognitive betweenness and difference', the physical proximity of individuals might also be studied. Does a closeness of cognitive processes develop with close proximity of co-workers? If so, could the location of individuals be altered to suit the creative needs of the business (i.e. move individuals around to increase variation. Keep them together to increase selection/retention). What about experts? If their ideas prove successful it might pay to reduce levels of variation. Or, would the threat of challenge from others improve the evolutionary process? Therefore future research should be directed at exploring the relationship between the connectivity and betweenness of individuals with the group, and the resultant evolutionary process. This might be pursued through further in-depth longitudinal studies of innovation processes within organisations. In parallel with these studies, agent-based models based on the conceptualisations given above might be used to simulate the co-evolutionary process.

Conclusions

As noted above, many evolutionary studies on innovation focus on evolving ecologies of artefacts within organizations or industries. At such a macro-level the innovation process might even be viewed as a population of competing ideas. However a macro perspective can miss the multi-level, non-linear complexity of macro-level interactions underlying this process. In this sense macro-level studies might view innovation in terms of competing acts of creative expression which accumulate as unbounded and indistinct 'clouds'; passively drifting through organizational time. Viewed at a distance these impressions fail to convey the turbulent and non-linear complexity of interacting particles 'inside' the cloud. Perhaps the boundaries of these expressions however become even more difficult to capture as one moves closer to the field of study.

> "The sky has no surface and is intangible; the sky cannot be turned into a thing or given quantity. And landscape painting begins with the problem of painting sky and distance." (Berger, 1972, p.105)

What we are presenting here is a means to attempt to map these social network structures, the ephemeral architecture of innovation and creativity. Doing so helps to highlight where opportunities might exist for variation and retention ensuring that the office environment contains a balance of both. Price (2012) refers to organizations as ecologies containing populations of individuals who carry particular 'modes of thought'. This is a perspective acknowledged in evolutionary approaches as focusing upon the cultural entity as the object of sociological study rather than the people themselves. Breslin (2011) highlights the disagreement of the unit of analysis – evolution of knowledge behind the artefact, or the artefact itself. The latter being a focus on 'materialized' culture such as that referred to by Basalla (1989). An evolutionary approach considers that simply passing information from one person to the next will not provide the conditions for evolution; this also requires interaction

through boundary spanning where information must be able to pass *between* different types of individuals or groups. In summary this study has aimed to make more tangible the implicit network architecture which supports the conditions of variation, selection and retention required for the evolution of innovation and creativity. This is likely to be of most value to managers looking for strategic tools to help shape and influence the relational interaction in the workplace to maximize these conditions.

References

Adler, Paul, S. and Seok-Woo Kwon 2002 'Social Capital: Prospects for a new concept *Academy of Management Review* **27**(1): 17-40

Agranoff, Robert 1991 'Human Services Integration: Past and present challenges in public administration' *Public Administration Review* **51**(6), 533-542

Aldrich, Howard, 1999, *Organizations Evolving*. London: Sage Publishing.

Alter, Catherine and Jerald Hage 1993 *Organizations Working Together* Newbury Park, CA: Sage Publications

Ansari, Shazad, Peer Fiss and Edward Zajac, 2010, "Made to fit: How practices vary as they diffuse". *Academy of Management Review*, **35**(1): 67-92.

Arthur, Brian, 2009, *The Nature of Technology: What it is and How it Evolves*. London: Penguin Books.

Basalla, George, 1989, *The Evolution of Technology.* Cambridge: Cambridge University Press.

Benoit, Morel and Ramanujam Rangaraj, 1999, "Through the Looking Glass of Complexity: The Dynamics of Organizations as Adaptive and Evolving Systems". *Organization Science,* **10**(3): 278-293.

Berger, John 1972, *Ways of Seeing* London: Pelican Books

Borgatti, Stephen P. and Pacey C. Foster 2003 'The Network Paradigm in Organizational Research: A review and typology' *Journal of Management* **29**(6): 991-1013

Boschma, Ron and Koen Frenken, 2011, "The emerging empirics of evolutionary economic geography". *Journal of Economic Geography*, **11**: 295-307

Boschma, Ron and Ron Martin, 2007, "Constructing an evolutionary economic geography". *Journal of Economic Geography*, **7**: 537–548.

Breslin, Dermot, 2011, "Reviewing a Generalized Darwinist Approach to Studying Socio-Economic Change". *International Journal of Management Reviews,* **13:** 218-235.

Breslin, Dermot, 2012, "Spaces and the Co-evolution of Practices within a UK Metallurgical Equipment Supplier". In Keith Alexander and Ilfryn Price (Eds.), *Managing Organizational Ecologies: Space, Management and Organizations,* New York: Routledge.

Brown, John Seely and Paul Duguid, 1991, "Organizational Learning and Communities-of-Practice: Toward a Unified View of Working, Learning, and Innovation". *Organization Science*, **2:** 40-57.

Cavalli-Sforza, Luigi, 2001, *Genes, Peoples and Languages*. London: Penguin books.

Cross, Rob and Stephen P. Borgatti, 2004, "The Ties that Share: Relational Characteristics that Facilitate Information Seeking". In Marleen Huysman and Volker Wulf (Eds.) *Social Capital and Information Technology* MIT Press, pp. 137-159

Cross, Rob, Stephen P. Borgatti and Andrew Parker 2002 'Making Invisible Work Visible: Using social network analysis to support strategic collaboration' *California Management Review* **44**(2): 25-46

Cyert, Richard and James March, 1963, *A Behavioural View of the Firm*. 2nd Edition, Oxford: Blackwell.

Davies, Rick J. (2005) 'Scale, Complexity and the Representation of Theories of Change, Part II' *Evaluation* **11**(2): 133-149

Dawkins, Richard, 1976, *The Selfish Gene*. New York: Oxford University Press.

Dawkins, Richard, 1983, "Universal Darwinism". In Derek Bendall (ed.), *Evolution from Molecules to Man*, Cambridge: Cambridge University Press, pp. 403-425.

DeBresson, Chris and Fernand Amesse, 1991, "Networks of innovators: a review and introduction to the issue". *Research Policy,* **20**(5): 363-379.

Dennett, Daniel, 1995, *Darwin's Dangerous Idea*. New York: Simon and Schuster.

Dilk, Christoph, Ronald Gleich, Andreas Wald, and Jaideep Motwani, 2008, "State and development of innovation networks". *Management Decision,* **46**(5): 691-701.

Durham, William, 1991, *Coevolution: Genes, Culture and Human Diversity*, Stanford, California: Stanford University Press.

Dooley, Lawrence and David O Sullivan, 2007, "Managing within distributed innovation networks". *International Journal of Innovation Management* 11(3): 397-416.

Essletzbichler, Jurgen and David Rigby, 2005, "Competition, Variety and the Geography of Technology Evolution". *Tijdschrift voor Economische en Sociale Geografie*, **96**(1): 48–62.

Fleck, James, 2000, "Artefact – Activity: the coevolution of artefacts, knowledge and organization in technological innovation". In John Ziman (ed), *Technological Innovation as an Evolutionary Process*, Cambridge: Cambridge University Press, pp. 248-266.

Granovetter, Mark S. 1973 'The Strength of Weak Ties' *American Journal of Sociology* **78**: 1360-1380

Hanneman, Robert A. 2001 *Introduction to social network methods* Riverside: University of California

Hull, David, 1988, *Science as a process.* Chicago: The University of Chicago Press.

Jablonka, Eva, 2000, "Lamarckian inheritance systems in biology: a source of metaphors and models in technological evolution". In John Ziman (ed), *Technological Innovation as an Evolutionary Process*, Cambridge: Cambridge University Press, pp. 27-40.

Jennings, Edward T. and Jo Ann G. Ewalt, 1998 'Interorganizational Coordination, Administrative Consolidation and Policy Performance *Public Administration Review* **58**(5): 417-428

Keast, Robyn and Kerry Brown 2005 'The Network Approach to Evaluation: Uncovering patterns, possibilities and pitfalls' *Paper presented at the Australasian Evaluation Society International Conference, South Bank, Brisbane, 10-12 October 2005*

Kennedy, Mark and Peer Fiss, 2009, "Institutionalization, framing, and diffusion: The logic of TQM adoption and implementation decisions among U.S. hospitals". *Academy of Management Journal*, **52**(5): 897-918.

Latour, Bruno 2007 *Reassembling the Social* Oxford: Oxford University Press

Levitt, Barbara and James March, 1988, "Organizational Learning". *Annual Review of Sociology*, 14: 319-340.

Lin, Nan 2001 *Social capital: A theory of social structure and action* Cambridge: Cambridge University Press

Martínez, Alejandra, Yannis Dimitriadis, Rubia, B., Gómez, E. and de la Fuente, P. 2003 'Combining qualitative evaluation and social network analysis for the study of classroom social interactions' *Computers and Education* **41**: 353-68

McKelvey, Bill, 1999, "Avoiding Complexity Catastrophe in Co-evolutionary Pockets: Strategies for Rugged Landscapes". *Organization Science*, **10**(3): 294-321.

Mokyr, Joel, 2000, "Evolutionary phenomena in technological change". In John Ziman (ed), *Technological Innovation as an Evolutionary Process*, Cambridge: Cambridge University Press, pp. 52-65.

Monge, Peter R. and Noshir S. Contractor 2003 *Theories of Communication Networks* Oxford: Oxford University Press

Murmann, Johann Peter, 2003, *Knowledge and Competitive Advantage: The Co-evolution of Firms, Technology and National Institutions*. New York: Cambridge University Press.

Nelson, Richard and Sidney Winter, 1982, *Evolutionary theory of economic change*. Cambridge, MA: Bellknap.

Nonaka, Ikujiro, 1994, "A Dynamic Theory of Organizational Knowledge Creation".

Organization Science, 5(1): 14-37.

O'Toole, Lawrence J. 1997 'Treating Networks Seriously: Practical and research-based agendas in public administration' *Public Administration Review* **57**(1): 45-52

Pelikan, Pavel, 2003, "Bringing institutions into evolutionary economics: another view with links to changes in physical and social technologies". *Journal of Evolutionary Economics*, **13**: 237-258.

Plotkin, Henry, 1994, *Darwin Machines and the Nature of Knowledge*. Cambridge, MA.: Harvard University Press.

Portes, Alejandro 1998 'Social capital: Its origins and applications in modern sociology' *Annual Review of Sociology*, **24**: 1–24

Price, Ilfryn 2012, "Organizational ecologies and declared realities". In Keith Alexander and Ilfryn Price (Eds.), *Managing Organizational Ecologies: Space, Management and Organizations*, New York: Routledge.

Provan, Keith, G. and Brinton Milward 2001 'Do Networks Really Work? A framework for evaluating public-sector organizational networks' *Public Administration Review* **61**(4): 414-423

Rice, R and E Rogers, 1980, "Reinvention in the Innovation Process". *Science Communication*, **1**: 499-514.

Richerson, Pete and Richard Boyd, 2005, *Not by Genes Alone: How Culture Transformed Human Evolution.* Chicago: The University of Chicago Press.

Rogers, Everett, 1995, *Diffusion of Innovations*, 4th Edition, New York: The Free Press.

Rosenkopf, Lori and Atul Nerkar, 1999, "On the Complexity of Technological Evolution". In Joel Baum and Bill McKelvey (eds), *Variations in Organization Science, In Honor of Donald T. Campbell*. New York: Sage, pp. 169-183.

Scott, John 2000 *Social Network Analysis: A hand book,* London: Sage

Smith, Pernille, 2011, "The Evolution of Boundaries in Inter-organizational R&D". *Paper presented at the European Academy of Management (EURAM) 2011 1st-4th June, Tallinn*

Stoelhorst, JanWillem, 2008, "The Explanatory Logic and Ontological Commitments of Generalized Darwinism". *Journal of Economic Methodology*, 15(4): 343-363.

Tooby, John and Leda Cosmides, 1992, "The Psychological Fundations of Culture". In Jerome Barkow, Leda Cosmides, and John Tooby (eds), *The Adapted Mind: Evolutionary Psychology and the Generation of Culture,* Oxford: Oxford University Press, pp 19-136.

Vanberg, Viktor, 1992, "Innovation, cultural evolution, and economic growth". In Ulrich Witt (ed), *Explaining process and change: approaches to evolutionary economics*, Ann Arbor: The University of Michigan Press, pp. 105-121

Ziman, John, 2000, “Selectionism and Complexity”. In John Ziman, (ed), *Technological Innovation as an Evolutionary Process*, Cambridge: Cambridge University

Appendices

Appendix 1: Communication frequency - physical

Please indicate how frequently you meet with each person. This includes both pre-arranged meetings and impromptu meetings such as visits to peoples' desks. Please select an answer for each of your colleagues.

					answered question	**11**
					skipped question	**0**
	Daily	**Couple of times a week**	**Weekly**	**Monthly**	**Not at all**	**Response Count**
Actor M	**60.00%**	30.00%	10.00%	0.00%	0.0% (0)	10
Actor E	27.30%	18.20%	**36.40%**	0.00%	18.2% (2)	11
Actor H	**40.00%**	**40.00%**	20.00%	0.00%	0.0% (0)	10
Actor G	20.00%	**50.00%**	20.00%	0.00%	10.0% (1)	10
Actor F	30.00%	**50.00%**	20.00%	0.00%	0.0% (0)	10
Actor L	**36.40%**	27.30%	18.20%	9.10%	9.1% (1)	11
Actor A	45.50%	9.10%	**54.50%**	0.00%	0.0% (0)	11
Actor B	20.00%	30.00%	**40.00%**	0.00%	10.0% (1)	10
Actor I	**40.00%**	30.00%	20.00%	10.00%	0.0% (0)	10
Actor J	**54.50%**	18.20%	18.20%	9.10%	0.0% (0)	11
Actor C	**50.00%**	0.00%	40.00%	10.00%	0.0% (0)	10
Actor D	**40.00%**	**40.00%**	20.00%	0.00%	0.0% (0)	10
Actor K	**36.40%**	27.30%	27.30%	0.00%	9.1% (1)	11

Appendix 2: Communication frequency - virtual

Please indicate how frequently you communicate with each person virtually, i.e. via telephone, email, skype etc. Please select an answer for each of your colleagues.

					answered question	**11**
					skipped question	**0**
	Daily	**Couple of times a week**	**Weekly**	**Monthly**	**Not at all**	**Response Count**
Actor M	**70.0% (7)**	20.0% (2)	0.0% (0)	10.0% (1)	0.0% (0)	10
Actor E	**72.7% (8)**	27.3% (3)	0.0% (0)	0.0% (0)	0.0% (0)	11
Actor H	**36.4% (4)**	9.1% (1)	18.2% (2)	0.0% (0)	**36.4% (4)**	11
Actor G	**50.0% (5)**	40.0% (4)	0.0% (0)	0.0% (0)	10.0% (1)	10
Actor F	40.0% (4)	**60.0% (6)**	0.0% (0)	0.0% (0)	0.0% (0)	10
Actor L	27.3% (3)	**36.4% (4)**	0.0% (0)	9.1% (1)	27.3% (3)	11
Actor A	**36.4% (4)**	27.3% (3)	9.1% (1)	9.1% (1)	18.2% (2)	11
Actor B	30.0% (3)	**40.0% (4)**	0.0% (0)	0.0% (0)	30.0% (3)	10
Actor I	**60.0% (6)**	20.0% (2)	20.0% (2)	0.0% (0)	0.0% (0)	10
Actor J	**60.0% (6)**	30.0% (3)	10.0% (1)	0.0% (0)	0.0% (0)	10
Actor C	**40.0% (4)**	**40.0% (4)**	20.0% (2)	0.0% (0)	0.0% (0)	10
Actor D	**50.0% (5)**	40.0% (4)	10.0% (1)	0.0% (0)	0.0% (0)	10
Actor K	**45.5% (5)**	27.3% (3)	9.1% (1)	9.1% (1)	9.1% (1)	11