With a Little Help from Our Colleagues: A Longitudinal Study of Social Networks for Innovation

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Abstract In this paper we investigate the dynamics of networks of employees in the front end (FE) of the new product development process. So far, the literature focuses on network structure and argues that sparse networks of weak ties are optimal for idea generation. In this paper we include both network structure and network content, and we emphasize the importance of strong ties for the exchange of complex and tacit knowledge and the importance of density of networks in the further development and in the adoption of ideas. To test our assumptions, we mapped the full networks of 17 ideas for new product development projects over time in a longitudinal study in two research laboratories. For specific phases of the front end, we found confirmation of our expectations with respect to the advantage of large networks, strong ties and seniority of participants to the networks. In addition, it appeared that particularly strong ties between different subunits advance the adoption chances of ideas. The managerial implications of this latter finding is that communication with good acquaintances or friends in other subunits should be promoted in the front end of idea generation
Key words front-end, social networks, new product development, creativity

1 Introduction

An effective 'front end' of the new product development process is important for the innovative performance of firms. The front end (FE) is the process during which ideas are born and further developed, ending with the go/no-go decision for the start of a project (Khurana and Rosenthal 1998). Because of its importance, firms increasingly put effort in the organization of the front end (Kim and Wilemon 2002). Already for years Shell has its 'GameChanger' suggestion system (Hamel 1999; Van Dijk and Van den Ende 2002), recently IBM organized a dedicated InnovationJam, raising as many as 37,000 ideas (Moss-Kanter 2006) and under Jeff Immelt General Electric has included the generation of "Imagination Breakthrough proposals" in the performance measures of GE business leaders (BusinessWeek 2005). The dominant view behind most of such endeavours is that firms should collect as many ideas as possible and organize an effective review and selection process (Wheelwright and Clark 1992).

This paper deals with the influence of communication between people on the idea generation and development process. We focus on the effects of communication on the quality of ideas and on the review decisions for converting ideas into projects. The social network and creativity literatures have shown that many infrequent social relations with people outside their own social circle can provide people with unique information that, if combined, can lead to new creative insights (Burt 2004; Perry-Smith 2006). With the exception of Allen's classic work (1977) and more recently Kijkuit and Van den Ende (2007), these literatures so far have hardly studied the further development and selection of ideas in the FE. We contribute to this literature by performing an exploratory study of social networks in the FE process from idea generation until the review of ideas, including their effects on the outcome of the review process. Moreover, we specifically look at temporal networks as opposed to the stable networks considered in previous research (Burt 2004; Perry-Smith 2006). We investigate the network conditions in the first phase of idea generation, emphasizing the effects of good relations and of repeated relations between actors in an environment of uncertainty and complexity. Moreover, we investigate whether the network conditions that support idea generation are also beneficial for the further development of ideas and their adoption (Reiter-Palmon and Illies 2004). By studying the influence of social processes involved in and preceding the review process, we also contribute to the new product development (NPD) literature, which has mainly focused on the criteria applied in the review process at the end of the FE (Cooper et al. 2001; Henard and Szymanski 2001).

The practical motive behind our interest is that the current selection approach of the FE, according to which large quantities of ideas are generated and reviewed, is a costly process with potential drawbacks since many idea submitters must be disappointed. It may therefore be more attractive for firms to improve the quality of ideas than just to increase their quantity. For this purpose, we investigate

the influence of communication in the FE on the quality of ideas and on adoption decisions. In contrast to the current selection perspective on the FE, we hold an adaptation perspective, emphasizing the effects of social networks on idea quality (Hodgson 2001; Lewin and Volberda 1999).

In this paper we develop and test our social network perspective on the FE. Our unit of analysis is the network of a proposal, which is defined as the people that discuss a particular proposal with each other. We follow Kijkuit and Van den Ende (2007) by building on insights from the behavioural decision-making literature and social network literature to define a dynamic framework in which we include both elements of network structure and content and explore potential interaction effects between structure and content. Contrary to expectations that arise from the literature on idea generation, we show that strong ties and dense networks are important for the improvement and survival of ideas. We also show that this effect is not the result of lobbying or political support generated in the decision process on ideas, but of the improvement of the ideas themselves. Furthermore we provide support for the idea that network relations with friends or good colleagues outside one's own subunit are particularly important for idea improvement and survival. This also has implications for managers who not just want to stimulate the generation of large quantities of ideas, but also of high quality ideas.

In what follows we first briefly discuss the benefits of social networks in a new product development context in terms of diverse information and coordinated action. Next, we develop our hypotheses on the effects of networks in the different phases of the FE on the acceptance of ideas, distinguishing between the effects of structure and content of networks. We subsequently discuss the methodology of data collection and measurement and present the results of our empirical study. Finally, we present and discuss our findings, exploring some new avenues for theory building and future research.

2 Background

Two mutually reinforcing types of benefits of social networks are addressed in the network literature, both applying to the FE. The first and most often cited benefit concerns information (Burt 1992; 1997; Campbell et al. 1986; Coleman 1990; Granovetter 1973). The notion that diverse information, if combined, can lead to creative ideas and products is deeply rooted in the literature on innovation (Allen 1977; Schumpeter 1934) and creativity (Guilford 1967). In this study we expect not only information benefits of networks, but also the so-called 'multiple-lens' benefits, referring to receiving diverse "criticisms that allow an actor to anticipate a variety of contingencies" (Mizruchi and Stearns 2001). The second benefit of networks concerns the ability to facilitate collective action and coordination of tasks (Burt 1992; 1997; Coleman 1990; Gargiulo and Benassi 2000; Obstfeld 2005). Information and coordinated action are, as Burt (1997) notes, mutually reinforcing and cumulate over time. Where information can provide actors with opportunities, coordinated action can provide the cooperative behavior needed to explore those opportunities (Podolny and Baron 1997). We expect that coordinated action is required in the FE of the NPD process for the joint development of ideas, to decrease technological and market uncertainties and to improve company fit. Moreover coordinated action is expected to facilitate decision-making.

The network literature attributes these benefits to two elements of networks: network structure and network content. The more classic literature on network structure mainly focuses on the configuration of ties in networks and the strength of ties (Adler and Kwon 2002; Burt 1992; Coleman 1990; Krackhardt 1992). More recently, the literature on network content emphasizes the effects of organizational roles and experiences of actors (Cummings 2004; Podolny and Baron 1997; Reagans and McEvily 2003)

Prior studies on the creative act of idea generation have mainly focussed on elements of network structure, particularly the benefits of a large network of weak ties to generate diverse information (Burt 2004; Perry-Smith 2006; Perry-Smith and Shalley 2003). Diversity is assumed to result from weak ties which lead to people that are a member of different social circles and are thereby exposed to diverse information. Weak ties are expected to facilitate the creation of large networks, because they are less time consuming for an actor to maintain and can thus provide contact to even more diverse information. Lastly, weak ties leave autonomy to the individual (Burt 1997), who is expected to feel more free to generate novel and unorthodox ideas.

This literature has dedicated little attention to the effects of uncertainty and ambiguity. Perry-Smith and Shalley (2003, p. 94) even state explicitly that the levels of uncertainty and ambiguity are low. This may explain the strong reliance on weak ties in their models of the idea generation process. However, Kijkuit and Van den Ende (2007) have pointed to the NPD literature, which has explicitly highlighted

the need for people working on ideas to focus on reducing the uncertainty sufficiently to meet the review criteria (Kim and Wilemon 2002; Moenaert et al. 1995). Moreover, these authors have pointed to the behavioral decision-making literature and highlighted that ambiguity of preferences is equally important in a decision-making context such as the FE. They have advocated the need for strong ties and dense networks, which facilitate information transfer and the sense-making required for coordinated action and decision-making in a context of uncertainty. Moreover, strong ties facilitate mutual criticizing. In this paper we build on the notion that strong ties and dense networks have specific advantages in the FE.

Other reasons to favour strong ties, which received little attention in previous research on networks and creativity, are the tacitness and complexity of knowledge. Tacitness results from the context specificity of know-how and is inherent in NPD routines (Madhavan and Grover 1998). Complexity of information exchanged in NPD settings results from the novelty of theoretical scientific knowledge (Dougherty 1992; Teece 1996; Von Hippel 1994). For instance, Perry-Smith and Shalley (2003) assume that "general information about work or projects may be enough to help spark new ideas" (Perry-Smith and Shalley 2003). Strong ties facilitate the transfer of tacit knowledge.

Lastly, we posit that not only network structure affects the success of ideas, but also network content, particularly peoples' educational background and organizational experience and affiliation (Kijkuit and Van den Ende 2007). The importance of this aspect is supported by many general creativity studies, as opposed to the network specific creativity studies mentioned earlier (Kurtzberg and Amabile 2001; Mumford and Gustafson 1988). Cohen and Levinthal (1990) argue that the ability to recognize, evaluate and assimilate diverse knowledge is largely a function of the level of prior related knowledge and point to the trade-off between diversity and commonality of knowledge across individuals. While the importance of prior related knowledge and mutual understanding is not new to the network literature as such, it does supplement network studies on creativity (Burt 2004; Perry-Smith 2006; Perry-Smith and Shalley 2003) by highlighting the degree of similarity in people's experience that allows them to exchange required information through network ties.

3 Hypotheses

Our first three hypotheses refer to effects of network structure, whereas the last two refer to the effects of network content on the adoption of ideas in the FE. As we noted above, our unit of analysis is the network of a proposal, which is defined as the people that discuss a particular proposal with each other. Furthermore we distinguish three phases in the FE, namely the initiation phase, the development phase and the refinement phase. In the initiation phase the initial discussion on an idea takes place. The development phase includes further discussions of the idea until an initial first submission of a proposal to a review committee. The refinement phase is defined as the phase between first submission of the proposal and the decision of the review committee on the proposal. At its shortest, this phase only takes some days. However, in many firms this phase takes longer since the review process consists of an initial screening, a further specification period, and a final review decision (Wheelwright and Clark 1992).

Network structure

A network's size affects information benefits. Larger networks provide more, faster and more diverse information (Burt 1992), which contributes in an innovation setting to sparking creative insights (Perry-Smith 2006). Moreover, the increased amount of information and criticism resulting from larger networks (Mizruchi and Stearns 2001) can facilitate the reduction of uncertainty and ambiguity regarding technical and market feasibility. Research on top management teams corroborates that size increases the "range of perspectives" (Haleblian and Finkelstein 1993), but also shows that size creates problems of control and coordination in decision-making (Smith et al. 1994; Seashore 1977; Thomas and Fink 1963). Smaller groups allow for a form of team work, which is considered critical for coordinated action and decision-making in NPD (Ancona and Caldwell 1992). In short, we expect that large networks provide diverse insights and can reduce uncertainty and ambiguity, and are thus beneficial in the idea generation and development phases, whereas smaller networks are beneficial for decision making and consensus creation and thus critical in the refinement phase.

Hypothesis 1a: A larger size of networks of ideas in the idea generation and development phases increases the probability of proposal acceptance.

Hypothesis 1b: A decreasing size of networks of ideas from the development to the refinement phase increases the probability of proposal acceptance.

Our second element of network structure is network density, which refers to the degree to which actors within a network are tied to each other. There are two opposing views on the benefit of network density. One view advocates that in a network with low density, actors tend to be tied to diverse others, and thus are likely to receive a greater diversity of information (Burt 2004; Mizruchi and Stearns 2001; Perry-Smith and Shalley 2003). The diverse others are assumed to provide diverse experiences, unique resources and multiple thought worlds. Furthermore, low density also provides the benefit of autonomy and freedom of action (Burt 1997) and a lack of social pressure to conform, which improve creative thoughts (Perry-Smith and Shalley 2003). On the other hand, high density has been associated with faster, more accurate and more reliable information (Ibarra 1995; Granovetter 1983; Nooteboom 1999), the development of a shared language (Naphiet and Ghoshal 1998; Obstfeld 2005), psychological safety (Edmondson 1999) and increased absorptive capacity (Gilsing and Nooteboom 2005). Regarding coordinated action, high density has been associated with an increased willingness to help (Reagans and McEvily 2003) and the creation of trust (Coleman 1988) and can, therefore, help align views, resolve conflicts and mobilize support. To combine these two perspectives we follow Gilsing and Nooteboom (2005) and Kijkuit and Van den Ende (2007) with the idea of a separation in time. We expect that a network structure in an innovative setting should evolve over time from a sparse network facilitating the creation and initial development of innovative proposals, to a dense network facilitating the refinement and coordinated action needed to get a proposal accepted.

Hypothesis 2a: A lower density of networks of ideas during idea initiation and development increases the probability of proposal acceptance.

Hypothesis 2b: A higher density of networks of ideas during idea refinement increases the probability of proposal acceptance.

According to Granovetter (1973), strength of ties, a third element of network structure, consists of a combination of amount of time, emotional intensity, intimacy and reciprocal services. Previous research has generally identified two extremes: weak and strong ties. Weak ties are characterized by incidental interaction, low emotional intensity and intimacy, and multi-lateral communication; strong ties by the opposite. Weak ties can provide information or access to resources at a low cost in terms of time and effort, making it possible to maintain many ties. Hansen (1999), therefore, stressed the 'search' potential of weak ties. Furthermore, these ties also provide autonomy, which is often linked with the ability to think 'outside the box' (Perry-Smith and Shalley 2003). Strong ties, on the other hand, are considered important if one aims at transferring knowledge (Hansen 1999). Strong bonds motivate contacts to be of assistance and are more readily available than weak ties (Granovetter 1983). Furthermore, strong ties facilitate the formation of trust (Reagans and McEvily 2003), psychological safety (Edmondson 1999) and mutual understanding thereby further facilitating the transfer of information and the construction of knowledge, especially more complex knowledge (Hansen 1999; Uzzi 1999) in a context of ambiguity (Daft and Lengel 1986). Kijkuit and Van den Ende (2007) argue that specially in an innovation context, strong ties can be instrumental in facilitating a 'sensemaking' process in which both idea generators and decision makers "read and shape" their environment by creating a fit between problems and opportunities and requirements in the organization. Therefore, given the inherent uncertainty and ambiguity of the FE process and the complexity and diversity of information, we propose that strong ties are important throughout the entire FE.

Hypothesis 3: A higher average strength of ties in networks of ideas during idea initiation, development and refinement increases the probability of proposal acceptance.

Network content

As noted above, network content refers to the benefits that arise from the organizational roles and experiences of actors. In this research we consider the influence of (1) organizational membership and (2) seniority and decision-making power of actors (Cummings 2004; Perry-Smith 2006; Reagans and McEvily 2003; Reagans and Zuckerman 2001).

Network studies have looked at ties that span across organizational structures as a source of diversity (Burt 1983; 1992; Perry-Smith 2006; Reagans and McEvily 2003). These studies showed that network range, i.e. the degree that a network includes members from different organizational units, with different educational background or with different decision-making power, improved both team productivity and ease of knowledge transfer (Cummings 2004; Reagans and McEvily 2003; Reagans and Zuckerman 2001). Similar results have also been found in the NPD literature, which has abundantly stressed the importance of interdepartmental and interfunctional communication (Hoopes and Postrel 1999). We follow Cummings (2004) by focusing on two work-related sources of diversity, namely functional membership and subunit membership. A functional assignment generally creates unique

knowledge through training and experience (Bunderson and Sutcliffe 2002), and also provides access to specialized social networks, which actors build up in their specific area of expertise. Subunit membership refers to disciplinary units. A car manufacturer will for instance group its material specialists, its aerodynamic specialists, its internal combustion specialists and so on. A network with a higher range of subunits has more diversity of knowledge. The downside of network range is often not salient in the network literature relating to innovation and creativity. Decision-making research, on the other hand, has emphasized that although an increase in the range of perspectives is considered positive (Haleblian and Finkelstein 1993), it is also creates problems of coordination and control in decision-making (Seashore 1977; Smith et al. 1994; Thomas and Fink 1963). We would therefore propose that a broad network range can help in the initial phases of the FE, but can be problematic in the final phase.

Hypothesis 4a: A higher functional and subunit range of networks of ideas during initiation and development increases the probability of proposal acceptance.

Hypothesis 4b: A decreasing functional and subunit range of networks of ideas from the development to the refinement phase increases the probability of proposal acceptance.

Research has suggested that senior personnel may be better at encouraging people to take risks and identifying opportunities (Gupta et al. 1986; Moenaert et al. 1992). Empirical results show that seniority contributes to the novelty of information during the initial phases of the NPD process (Moenaert and Souder 1996) and to the reduction of uncertainty (Roussel et al. 1991). Network studies have also highlighted that contacts in the higher echelons of an organization receive more information through the formal reporting structures (Han 1996). Seniority in a network can thus provide information benefits on both opportunities and on organizational requirements with respect to those opportunities.

On the other hand, research on decision-making power has demonstrated that decision-making power will facilitate coordinated action. Studies in the NPD literature have demonstrated the importance of support from senior managers to steer innovation projects in a direction that meets company requirements (Brown and Eisenhardt 1995; Cooper 1993; Wheelwright and Clark 1992). Kijkuit and Van den Ende (2007) argue, as we noted above, that interaction with decision makers give the people working on an idea a sense of what fits within the organization and the decision makers a sense of what is possible, and thereby influences both the organizational alignment and the decision criteria and their application by decision makers.

Hypothesis 5a: A higher number of senior people in networks of ideas throughout all three phases of the FE process will positively influence the probability of proposal acceptance.

Hypothesis 5b: A higher number of decision makers in networks of ideas throughout all three phases of the FE process will positively influence the probability of proposal acceptance.

4 Method

Research design

We performed a 14 months longitudinal on-site field study during which we conducted over 200 interviews to map the networks around 17 proposals for new products as they moved from rough ideas to detailed project proposals. The on-site longitudinal design prevented retrospective and survivor biases that would occur if we did a survey after the submission of ideas (Pedhazur and Schmelkin 1991). As noted, the unit of analysis was the network around a proposal and not individual people. This data was gathered from multiple sources and included formal records and archival data allowing for triangulation of the network and attribute data. In addition to this data, we collected information on three types of control variables: (1) the initial potential of ideas (2) idea newness, and (3) the decision-making process.

Sample

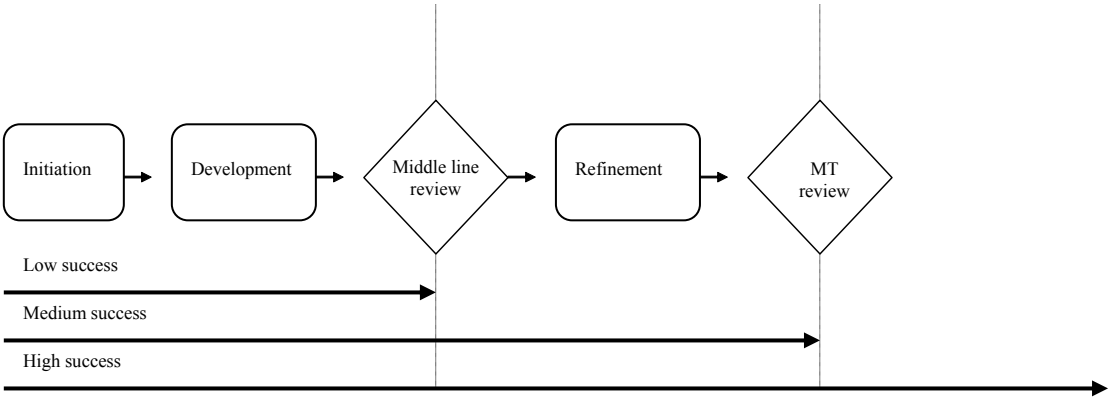
The data were collected at two central R&D labs of a large multinational in the fast-moving consumer goods industry. The labs employed around 1200 R&D scientists and were located in the UK and the Netherlands. The labs had a funnel management system in which scientists could submit proposals for new projects. The proposals were research-oriented and could for instance cover the addition of new proteins or bacteria to food in order to change their taste, texture, conservation time, health benefits etc. Our study included ideas that came up during large information sessions that the labs organized around specific topics, during regular small scale work meetings and during scientific activities. Transcripts of the information sessions, in combination with regular talks with line managers, ensured that we could contact people shortly after they had started working on a particular initiative. It became clear that R&D scientists often did a lot of ‘work’ on the proposals before submitting anything

formally. For example, two R&D scientists involved in idea development explicitly stated that they were afraid that their idea would be rejected before it was mature enough or before they could show that there was a business interest. The various sources initially provided us with data on 23 ideas. We eventually dropped 6 of those ideas from the sample, because the initiators did not have sufficient time to work on them and they were thus never submitted for review. Lastly, we included contacts with people from outside the organization in our data collection. However, their number was very small (3% of the actors) and they were fairly equally distributed across the different levels of success. Therefore we included these people in our analysis, but we did not analyze the specific influence of outside communication.

Funnel system

In the funnel system proposals had to pass two gates to be granted funding. The majority of the work on the proposals was done before the first gate. There was no funding available for this work, which meant that scientists had to do this in their 'spare' time or as one scientist said: "I'll simply include my time for this idea in my time for one of my other projects". Scientists would take between 3 to 10 months before submitting ideas for the first time, depending on their workload. The first gate consisted of a review by a group of mid-level managers. This review was more of a readiness review than a formal go/no-go decision, and was used to filter out the 'worst' proposals. Criteria included a check for overall company fit, general market potential and fit of the proposal with the lab's competences. This review could have two outcomes: the proposal was turned down or suggestions were made for revisions. In case of a revision, proposals needed additional work to, for instance, clarify technical hurdles and buy-in from a sponsor. Based on this advice, in the second phase, more detailed and supplemented proposals were prepared. This included developing more accurate estimates of required resources and risks, a more detailed plan of the technical approach, and a more detailed analysis of how the proposal would fit within the company and the existing project portfolio. The people involved in a proposal could decide to drop it in this phase, especially when they found out that the proposal could not be matched with an internal customer. The second gate consisted of a review by senior management.

In line with our definitions above, we considered the initiation phase to include the initial discussion of the idea to write a proposal on a given opportunity. We speak of 'initial discussion' since it became clear from our pre-test that ideas and proposals often built on or were linked to existing ideas or projects and were rarely the product of a single person. This finding fits with the remark made by Van de Ven (1986) that a new idea may be "a recombination of old ideas, a scheme that challenges the present order (…) or a unique approach perceived as new by the individuals involved". The development phase was the period in which the idea was specified further, ending with the middle-line review. The refinement phase covered the period between the middle-line review and the senior management review (see Figure 1).



Collection method

We used both archival and interview data. The interview data were collected through semi-structured interviews, including open-ended and structured questions. The open-ended questions' main purpose was to shed light on the causal mechanisms between the characteristics of the networks, the development of the idea, and the dynamics of the networks. Amongst others, we asked respondents to describe the nature of the discussion regarding the proposal, such as a 'coffee corner' discussion, lunch meeting or formalized appointment and the reason behind the discussion, such as specific

technical or market knowledge, a referral to another person, organizational support. We also asked them to indicate which aspects of the scientific, organizational and business were covered during the discussions.

The structured questions provided us with quantitative indicators on the networks. The questionnaire was pre-tested on 10 respondents from various hierarchical levels. The data collection regarding the networks was divided in two stages. In the first stage we mapped the initiation network and the initial further development of the idea into a proposal. The initiation network consisted of those people involved in the initiation, all of whom were interviewed. The second stage focused on further development and, if applicable, refinement of the proposal. The second stage interviews were scheduled two months after the initial interviews. During these interviews we mapped the changes, if any, in the proposals and the people that were contacted. We subsequently interviewed all people with whom the initiators had discussed the proposal longer then 30 minutes to ensure that we contacted all people that had potentially made a substantial contribution to the idea. The interviews with these people were used to check the intensity and nature of the discussion and allowed us to assess whether these persons themselves had contacted additional people. In case the second contact disagreed on the intensity or nature of the discussion, we reconfirmed the data with the original respondent. This strategy solved apparent contradictions. We only contacted the third group of people, i.e. people contacted by the second contacts, if the discussions again had lasted longer than 30 minutes. We repeated the second stage interviews until the proposal was either dismissed or granted funding. The overall response rate was around 95%. In total, we held over 200 interviews to collect the data.

In addition to the data collection relating to the networks and the proposals, we conducted interviews on the decision-making process with 10 of the 18 middle line review team members and two ideation support staff people. We asked them which review criteria they used, how the decision making procedure took place and the degree of consensus in the decisions. Moreover, for five recently reviewed proposals (no longer than two months prior to the interviews) we asked them how they had ranked the proposal, if they knew who had submitted each proposal, who else they knew was involved in the proposals, what their prior relation was with these persons and the degree to which the idea was close to their expertise. The main purpose of these interviews was to investigate the potential influence of lobbying, personal interests of members of the review committees, or status of the proposal networks on the outcome of the decisions.

Dependent and independent variables

The measures were, if possible, adopted from previous research.

Success. We distinguished between low, medium and high success. As indicated in Figure 1, low success entailed that the proposal was dismissed during the first review, medium success entailed that the proposal was rejected in the second one, and in case of high success the management team granted funding and turned the proposal into a project.

Size. Size referred to the number of people in the network in each phase.

Size convergence (0 – 1). This measure was the ratio between the size of the networks in the refinement and the size of the network in the development phase. Values approaching 0 mean high convergence and large values signal the opposite.

Density (0 – 1). The classic operationalization of density refers to the number of actual ties divided by the maximum possible number of ties, which makes this measure inappropriate when comparing networks with different numbers of nodes (De Nooy et al. 2005).

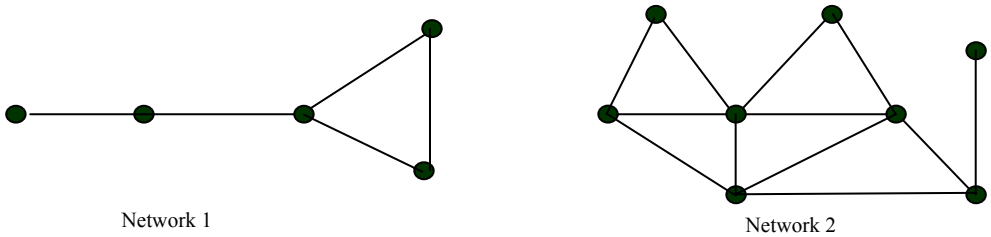


Figure 2Network density using Burt's efficiency measure

For instance, the classic density measure of Network 1 in Figure 2 is 0.50 and of Network 2 is 0.46, which does not reflect the intuitive idea that the actors in Network 2 are more interconnected than the actors in Network 1. We therefore follow Reagans and McEvily (2003) and view network density as an

indication of "strong third-party connections". We used a slightly adjusted version of Burt's (1992) "efficiency" measure designed for ego networks and used the average of the number of third party connections for each actor in a given network for density at the network level. First, we assessed the extent to which the contact j of person i is connected to any other contacts q of person i (so-called 'third-party connections'):

$$\sum_q p_{iq}, \qquad q \neq i, j,$$

where p_{iq} is the proportion of *i*'s network time invested in the relationship with *q* (interaction with q divided by the sum of *i*'s relations). (Burt 1992, 51-53). $\sum_q$ accounts for all third-party connections around the relation between person *i* and person *j*. We subsequently calculated the density of the relations of actor I by summing across all of *i*'s direct relations and dividing this by the number of relations of *i*. Finally, we summed across all *i*'s (all actors) in the network and divided this by the number of actors to arrive at the average density for a network:

$$Density = \sum_i \left\{ \left[\sum_j \left(\sum_q p_{iq} \right) \right] / N_j \right\} / N_i, \qquad q \neq i, j,$$

The value will vary from 0 indicating low density to 1 indicating high density. This formula results in scores of 0.24 and 0.43 for Network 1 and 2 respectively (assuming equal distribution of time invested in each relation by each actor), which fits much more closely with the intuitive notion. Using UciNet VI, we calculated the values by taking one minus the average efficiency scores of the dichotomized networks (Borgatti et al. 2002).

Range (0 – 1). We distinguished subunit range and functional range. Subunit range was the number of inter-subunit ties relative to the total number of ties in a network:

$$Runit_u = \sum_i^j \left(u_{ij} \right) / \sum_i^j n_{ij},$$

where n_{ij} indicates a relation between person *i* and person *j*, and u_{ij} indicates whether person *i* and person *j* are members of the same subunit. The value for u_{ij} is dichotomous, either 0 (same subunit) or 1 (different subunit). In the measure of functional range u_{ij} is replaced by f_{ij}, which indicates if people are members of the same function.

Seniority (1 – 6). For seniority we used human resource management data from the company on employees' hierarchical levels. There were six hierarchical levels 1-6 in the company. Entry level university graduates started at 1 whereas the board of directors of the entire company reached 6. Respondents from outside the company, which, as noted, accounted for only a small part of the actors, were not included in this measure. The average seniority of a network was calculated by taking the average of the hierarchical levels of the company members.

Decision-maker involvement (0 – 1). Decision-maker involvement was the ratio between the number of members of one of the review teams in the network and the total number of people in the network.

Tie strength (1 – 4). This measure consisted of two dimensions, namely past and current intensity. *Past intensity* referred to the frequency of personal communication prior to the initial discussion on a particular initiative. The options were: more than once a week, between once a week and once a month, less than once a month, and no prior contact. In the initial version of the interview we included emotional closeness as a dimension, but each respondent interpreted this dimension rather differently. This is confirmed by Reagans and McEvily (2003), who found that "individuals were emotionally close to contacts with whom they communicated more frequently" and that results for both dimensions "were substantively the same" (p. 254).

We measured the variable *current intensity* as the length of the discussion between two actors on a proposal. If they spoke several times with the same person on the same proposal, we took the total time of the discussions. Based on the results we grouped the discussions into four categories: less than 30 minutes, between 30 and 90 minutes, between 90 and 180 minutes and more than 180 minutes.

Control variables

Idea potential (1 – 5). One of the key alternative explanations for any network effect is that differences in network characteristics are caused by the unit of analysis rather than affecting the unit of analysis. For this study the most obvious alternative explanation is that 'successful' proposals had simply been more promising at their inception, and thus generated larger, denser networks with higher range. We could not consult middle-line reviewers or management team members during the initiation or development phase to ask for idea potential, because interviewing them could influence the decision process. Moreover, respondents indicated that they did not want their idea to be reviewed before "it was

ready". Outside reviews were not allowed by the company for reasons of confidentiality. We therefore asked the respondents that we interviewed in the first month after the initiation of the idea 7 questions relating to the characteristics of the idea. The questions had to be answered on a 5-point likert scale and focused on projected market opportunities, technical feasibility, competitor protection and internal funding chances. On average we had 7 respondents per proposal. We dropped one proposal from this sample, because it was not discussed prior to submission. For the other proposals initial idea potential was calculated as the average of the 7 items.

Newness (1 – 6). Some ideas may simply have been considered too incremental or too radical to be considered appropriate. We therefore asked respondents to rank the idea from 1 to 6 on a classification of newness developed by Griffin and Page (1996).

Analysis

Considering the exploratory nature of this study and the small overall sample size we opted for independent samples t-tests to make comparisons between each level of success (e.g. between low and medium success, low and high success and medium and high success). Since the size of the samples for each level of success varied, we used the pooled variance estimate t-test (Field 2000), which assumes homogeneity of variance. We tested the validity of the homogeneity of variances assumption by performing Levene's test for equality of variances (Field 2000). If Levene's test was significant we used the t-test result not assuming equal variances. In addition, we performed a series of one-way ANOVA tests for the initiation and development phases to test whether the overall differences between the means of the three different levels of success for the three success categories in these phases were significant. Finally, we again corrected, where relevant, for the heterogeneity of variances by performing the Levene's test and if necessary took the Welch F-ratio (Field 2000).

5 Results

Descriptive data

Eight out of the 17 proposals were low successful, five were medium successful, and four were highly successful. Since the low successful proposals were rejected after the development phase, there are no figures on these proposals for the refinement phase.

Table 1 Descriptive statistics on network structure and content

Phase		Variables	N	Mean (std dev)
Initiation	Structure	Size	17	2.82 (1.01)
		Density	15	0.28 (0.28)
		Current intensity	-	-
		Past intensity	15	2.22 (0.94)
	Content	Subunit range	15	0.84 (0.20)
		Functional range	15	0.22 (0.39)
		Seniority	17	2.09 (0.76)
		Decision-making power	17	0.16 (0.24)
Development	Structure	Size	17	13.47 (9.01)
		Density	16	0.14 (0.12)
		Current intensity	16	1.73 (0.21)
		Past intensity	16	2.94 (0.58)
	Content	Subunit range	16	0.63 (0.26)
		Functional range	16	0.16 (0.16)
		Seniority	17	2.11 (0.40)
		Decision-making power	17	0.09 (0.09)
Refinement	Structure	Size	9	9.22 (3.63)
		Density	9	0.32 (0.15)
		Current intensity	9	1.69 (0.29)
		Past intensity	9	3.02 (0.45)
	Content	Subunit range	9	0.65 (0.19)
		Functional range	9	0.18 (0.19)
		Seniority	9	2.38 (0.33)
		Decision-making power	9	0.22 (0.18)

Table 1 represents the descriptive data on network structure and content. It is important to note that the exact contribution of each person was difficult to determine during the initiation phase. When we asked respondents to clarify how much each person contributed to the initial idea, they most often stated that it was not possible to determine who exactly contributed how much to the idea. The respondents

repeatedly said that it was the result of "a combination of remarks by me and the others". As such, we cannot report on the 'current intensity' dimension of tie strength in the initiation phase.

Alternative explanations

We investigated three potential alternative explanations of success: (1) idea potential, (2) newness and (3) the decision-making process. The results for idea potential and newness are depicted in Table 2. The ANOVA result for the difference in overall potential between the three levels of success is not significant ($F(2, 13) = 1.45$, $p = 0.27$). The independent t-tests show that the results are only significantly different between low and high success proposals at a 10% confidence interval level. Nor the ANOVA ($F(2, 13) = 0.19$, $p = 0.83$) nor the t-tests show significant differences in newness between the three levels of success.

Table 2 Idea potential and newness [a,b,c]

Success	N	Low	N	Medium	N	High
Variables		Mean (std dev)		Mean (std dev)		Mean (std dev)
Overall potential	7	4.55 (0.24) [#]	5	4.49 (0.51)	4	4.87 (0.31) [#]
Newness	7	4.59 (0.74)	5	4.43 (0.45)	4	4.65 (0.25)

[a] The significance signs next to the label of the variable indicate the overall level of significance. We distinguish

between the following three levels of significance: [°]sig. < 0,10 ; [°°]sig. < 0,05 ; [°°°]sig. < 0,01.

[b] The significance of the differences is calculated for all three pairs, 1 & 2, 1 & 3 and 2 & 3. If the differences are

significant, this is indicated as follows:

For differences between group 1 & 2For differences between group 1 & 3For differences between group 2 and 3

[*]sig. (one-tailed) < 0.10 [#]sig. (one-tailed) < 0.10 [†]sig. (one-tailed) < 0.10

[**] sig. (one-tailed) < 0.05[##] sig. (one-tailed) < 0.05[††] sig. (one-tailed) < 0.05

[***] sig. (one-tailed) < 0.01[###] sig. (one-tailed) < 0.01[†††] sig. (one-tailed) < 0.01

[c] The figures for low successful proposals are based on 7 cases, because one proposal only involved one person who did not discuss his or her idea with anybody.

The decision-making process concerned in particular lobbying, personal interests of members of the review committees, or status of the proposal networks. To assess potential effects, we used the qualitative interviews with the middle line reviewers and the ideation support staff on the selected five proposals. These interviews showed that most middle-line team members had no prior knowledge of proposals until they were discussed during a review meeting. Reviewers were only aware of proposals prior to meetings if the submitters were subordinates of them. Reviewers were not aware of who was involved in the networks around proposals apart from the idea submitters themselves. Moreover, reviewers were only capable of recollecting the names of the idea submitters themselves for 72 % of the proposals. One middle-line review team member even admitted: "I didn't know who submitted that proposal until I looked through the submission details, when you mailed me for this interview". More interesting, reviewers were only capable of listing more than one name for 39% of the reviews, indicating that the composition of the networks had no direct effect on the decision. Finally, the reviewers were highly unanimous in their reviews of the proposals regardless of their personal interests or expertise. The interviews thus showed little reason to assume that lobbying, personal interests or status of the proposal networks played a significant role in the decision-making process. A possible explanation for the lack of 'political networking', which was considered important in other studies (Eisenhardt and Bourgeois 1988), is the small size of the proposals. These projects did not required multimillion dollar investments or result in dramatic strategic redirections.

Network structure

The results for network structure are depicted in Table 3. The results for the initiation networks support the notion that idea initiation has a strong social dimension. Table 1 showed that proposals were on average initiated by 2.8 people. Only in 2 out of 17 cases people cited themselves only. Even if we asked respondents to single out one person, they often refused and stated that it was the result of "a combination of remarks by me and the others". The ANOVA results in Table 3 show that the difference

in size between the three levels of success for the initiation phase was marginally statistically significant ($F(2, 14) = 2.75$, $p < 0.10$). Moreover, the t-test results showed that the size was significantly different between low and high successful networks ($p < 0.01$) and marginally different between medium and high success networks ($p < 0.10$).

In the development phase, the ANOVA results for the differences between the sizes of the networks of the three groups of proposals was strongly significant ($F(2, 14) = 17.27$, $p < 0.001$). The t-test results show that the networks of low success proposals are significantly smaller than those of medium and highly successful proposals ($p < 0.01$) and medium successful proposals are significantly smaller than highly successful proposals ($p < 0.05$). The networks of the different groups of ideas in the refinement phase do not show significant differences in size. It means that Hypothesis 1 is supported for the initiation and the development phases, but not for the refinement phase. The results for convergence in size from the development to the refinement phase show that the networks of both medium and high success networks converge, but that the difference between them is not significant. Hypothesis 1b is thus not supported.

Table 3 Overall network structure [a,b]

Success		N	Low	N	Medium	N	High
Phase	Variables		Mean (std dev)		Mean (std dev)		Mean (std dev)
Initiation	Size [°]	8	2.63 (0.52) ###	5	2.40 (1.52) †	4	3.75 (0.50) ###, †
	Density	8	0.25 (0.27)	3	0.45 (0.39)	4	0.20 (0.25)
	Current intensity	-	-	-	-	-	-
	Past intensity [°]	8	1.81 (0.84) ###	3	2.06 (1.05) †	4	3.15 (0.32) ###, †
Development	Size [°°°]	8	6.75 (4.13) ***, ###	5	14.80 (2.86) ***, ††	4	25.25 (8.62) ###, ††
	Density [°°]	7	0.06 (0.11) ***, #	5	0.24 (0.08) ***, †	4	0.16 (0.08) #, †
	Current intensity	7	1.69 (0.17) ##	5	1.67 (0.31)	4	1.87 (0.11) ##
	Past intensity [°°]	7	3.20 (0.52) **	5	2.42 (0.60) **, ††	4	3.14 (0.13) ††
Refinement	Size	-	-	5	8.00 (3.56)	4	10.75 (3.59)
	Size convergence	-	-	5	0.53 (0.17)	4	0.43 (0.10)
	Density	-	-	5	0.23 (0.12) †††	4	0.44 (0.07) †††
	Current intensity	-	-	5	1.64 (0.30)	4	1.75 (0.30)
	Past intensity	-	-	5	2.87 (0.46)	4	3.21 (0.42)

[a] For details on the significance signs see table 2.

[b] The figures on density, current intensity and past intensity for low successful proposals are based on 7 cases, because one proposal involved one person who did not discuss his or her idea with anybody, the figure on past intensity for medium successful proposals is based on 3 cases, because two proposals were generated by one person.

Neither the ANOVA nor the t-tests show significant differences in density of the networks of the three groups of proposals in the initiation phase ($F(2, 12) = 0.70$, $p = 0.52$). The ANOVA result for the development phase shows that the overall difference in density between the three levels of success is significant ($F(2, 13) = 4.97$, $p = 0.03$). The results for density during the development phase show an inverted U-shaped relation between success and the levels of density, as shown in Figure 3.

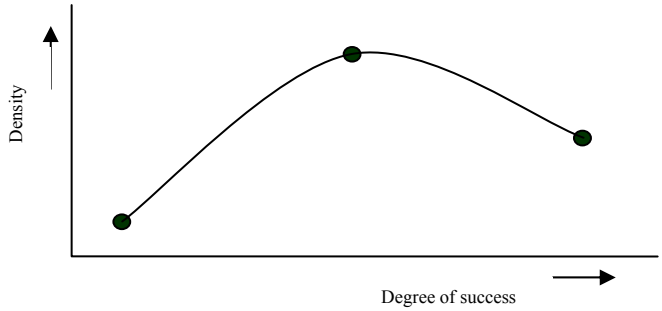


Figure 3 Success and density

The low successful networks have low density, which are significantly different from to the

medium and high success networks ($p < 0.01$ and $p < 0.10$ respectively). The networks of medium successful proposals, on the other hand, have a high density, whereas the average density of the networks of highly successful proposals is medium and is marginally significant from medium success networks. In the refinement phase this difference in density switches and is significantly lower for medium success network compared to high success networks ($p < 0.01$). In short, the results do not provide support for hypothesis 2a stating that low density in the development phase contributes to success. Instead, the results show that low density in the development phase contributes to failure, and medium density contributes to success. Furthermore, the results do support hypothesis 2b stating that high density in the refinement phase contributes to success.

As noted, we considered two dimensions of tie strength, namely current intensity and past intensity, and we were not able to measure current intensity in the initiation phase. The average current intensity of interaction per relationship was around 50 minutes in the development phase. The ANOVA result for the development phase on current intensity shows no significant overall difference ($F(2, 13) = 1.15$, $p = 0.35$). The t-tests show that the only significant difference in the development phase is between low and high success networks ($p < 0.05$). In the refinement phase, we do not find a significant difference in current intensity between medium and high success networks. We conclude that current intensity has a positive effect during the development phase and no effect in the refinement phase.

The ANOVA result for the overall difference in past intensity between the three levels of success is marginally significant ($F(2, 12) = 3{,}80$, $p = 0{,}053$) in the initiation phase. The t-test results show a significant difference between both low and medium successful networks on the one hand, and highly successful networks on the other ($p < 0.01$ and $p < 0.10$ respectively). In the development phase we see a statistically significant overall difference in past intensity ($F(2, 13) = 4.16$, $p = 0.04$). The relation is U-shaped in this phase, which entails that the scores of the medium successful proposals are low and the scores of the low and high success proposals are high. The t-tests showed that these differences are significant ($p < 0.05$). The t-test results on past intensity in the refinement phase show no significant differences. In short, the results provide some support for hypothesis 3 in the initiation phase, but show that high past intensity in the development phase contributes to the extreme outcomes, either failure or success, and that low past intensity will lead to medium success in that phase. We will go more into this effect in the discussion. In the refinement phase past intensity has no effect.

Network content

The results for network content are depicted in table 4. The ANOVA and t-tests results for the initiation phase show that the differences in subunit range between the three levels of success are not significant. The overall difference of subunit range between the three levels of success for the development phase is significant ($F(2, 13) = 6.32$, $p = 0.01$). The t-test results show that the subunit ranges of medium and high success networks are significantly higher than the subunit range of low success networks ($p < 0.01$ and $p < 0.05$ respectively). Lastly, from the development to the refinement phase we see a slight decrease of subunit range, but the t-test results do not show a significant difference between medium and high success networks.

The ANOVA result for the initiation phase shows that the overall difference in functional range between the three levels of success is not significant ($F(2, 12) = 2.60$, $p = 0.12$). The t-test results do show significant differences between low success networks and both medium and high success networks ($p < 0.05$), however, in a direction contrary to hypothesis 4a. For the development phase, the overall difference of functional range between the three levels of success is marginally significant ($F(2, 13) = 2.98$, $p = 0.09$). The t-test results show that the functional ranges of medium and high success networks are higher than the functional range of low success networks ($p < 0.05$ and $p < 0.10$ respectively). Lastly, in the refinement phase we see no significant difference between medium and high success networks. In short, the results provide partial support for hypothesis 4a, in the sense that functional range in the development phase has a positive effect on success. The results suggest that in the initiation phase functional range can better be low. An explanation may be that in a research context the complexity of knowledge is rather high and thus the combination of different types of specialized knowledge will lead to optimal ideas. The involvement of other functions than research in this phase will suffer from cognitive distance and thus a lower quality of ideas. With respect to the dynamics of the range of the networks, we see a slight decrease of the subunit range from the development to the refinement phase, but no significant difference between medium and high success networks. In short, hypothesis 4b is not supported.

Table 4 Overall network content [a,b]

Success		N	Low	N	Medium	N	High
Phase	Variables		Mean (std dev)		Mean (std dev)		Mean (std dev)
Initiation	Subunit range	8	0.90 (0.20)	3	0.83 (0.29)	4	0.75 (0.17)
	Functional range	8	0.42 (0.46) $^{**, \#\#}$	3	0.00 (0.00) **	4	0.00 (0.00) $^{\#\#}$
	Seniority	8	1.98 (0.88) $^{\#}$	5	1.80 (0.54) ††	4	2.67 (0.51) $^{\#, \dagger\dagger}$
	Decision-making involvement	8	0.06 (0.18) $^{\#\#}$	5	0.15 (0.22)	4	0.35 (0.29) $^{\#\#}$
Development	Subunit range $^{\infty}$	7	0.43 (0.23) $^{**, \#\#\#}$	5	0.76 (0.18) **	4	0.82 (0.14) $^{\#\#\#}$
	Functional range $^{\circ}$	7	0.07 (0.15) $^{**, \#}$	5	0.27 (0.17) **	4	0.21 (0.10) $^{\#}$
	Seniority	8	1.95 (0.49) $^{\#\#}$	5	2.13 (0.23) ††	4	2.43 (0.08) $^{\#\#, \dagger\dagger}$
	Decision-making involvement	8	0.07 (0.09)	5	0.10 (0.11)	4	0.11 (0.04)
Refinement	Subunit range	-	-	5	0.58 (0.21)	4	0.74 (0.13)
	Functional range	-	-	5	0.21 (0.19)	4	0.11 (0.18)
	Seniority	-	-	5	2.21 (0.33) ††	4	2.59 (0.19) ††
	Decision-making involvement	-	-	5	0.16 (0.16)	4	0.29 (0.19)

[a] For details on the significance signs see table 2.

[b] The figures on subunit range and functional range for low successful proposals are based on 7 cases, because one proposal involved one person who did not discuss his or her idea with anybody.

The overall difference between seniority of the three groups of proposals in the initiation phase is not significant ($F(2, 14) = 1.74$, $p = 0.21$). However, the t-test results do show that in this phase the level of seniority is marginally significantly higher for high success networks compared to low success networks ($p < 0.10$) and significantly higher than medium success networks ($p < 0.05$). During the development phase, there is again no overall significant difference for seniority ($F(2, 14) = 2.31$, $p = 0.14$). The t-test results show a significant difference between high success networks compared to low and medium success networks ($p < 0.05$). Lastly, for the refinement phase we again found a significant difference for seniority ($p < 0.05$). We conclude that we find marginal support for hypothesis 5a, which stated that seniority has a positive effect on success, in the initiation and development phases, and support in the refinement phase.

With respect to decision-maker involvement we find no overall significant difference in the initiation phase ($F(2, 14) = 2.37$, $p = 0.13$), but we do find a significant difference between low and high success proposals ($p < 0.05$). During the development and refinement phases, we find no significant differences. In short, the results provide no support for 5b, according to which we expected a positive effect of decision-maker involvement in all three phases.

Table 5 Network characteristics advancing idea adoption as suggested by this study

Phase	Structure				Content				Combination structure and content
	Size	Density	Current intensity	Past intensity	Subunit range	Functional range	Seniority	Dec.-maker involvement	Past intensity * inter-subunit ties
Generation	Large		(Not measured)	High		Low	High	High	High
Development	Large	Medium	High	U-shaped	High	High	High		High
Evaluation		High					High		High

6 Discussion

In this paper we studied the role of social networks during the FE of the NPD process in firms,

including both structure and content of networks. Creativity and social network research has assumed that ideas are usually generated by single persons, that large and sparse networks with weak ties support the idea generation process by providing a person with a broad knowledge base and autonomy. In this paper we extended our study of the networks of ideas during their development and refinement, and we included the effects on performance. We found that initiation networks generally consisted of more than one person, and that larger networks in the initiation and development phases facilitate idea adoption. This latter result extends the social network literature since it shows that not only large latent networks contribute to idea generation but that also large actual discussion networks contribute to the success of ideas. With respect to later phases, we found a clear decrease in size of networks of ideas in the refinement phase, highlighting the shift over time from a larger to a smaller network.

Moreover, we contribute by showing the positive effect of medium density networks in the development phase. Low density appears to contribute to failure. Medium and high densities contribute to better outcomes, but in a mixed way, since medium density contributes to success and high density to medium success. In the refinement phase, high density appeared to have a positive effect on success. These results indicate that density in an innovation context is important for its ability to increase willingness to help, to align views and to facilitate coordinated action, and to create a temporal form of psychological safety, needed for the development and refinement of ideas under uncertainty and ambiguity (Edmondson 1999; Reagans and McEvily 2003; Obstfeld 2005; Reagans and Zuckerman 2001). In most network studies, researchers look at stable working relations, which on average are at least one year old (Burt 2004; Obstfeld 2005; Reagans and McEvily 2003; Reagans and Zuckerman 2001). In those networks, high density may lead to a loss of autonomy (Burt 1997), the social pressure to conform (Perry-Smith and Shalley 2003), and forms of lock-in or even group think (Janis 1972). The temporal nature of the networks described in this study makes it unlikely that such negative effects of high density apply. This suggests that medium to high density in temporal networks can be optimal.

Tie strength appears to contribute to success in the initiation phase (past intensity) and the development phase (current intensity). This result supports the 'strength of strong ties' concept (Krackhardt 1992) as opposed to the 'strength of weak ties' argument of Granovetter (1973). It contradicts the suggestions made by, amongst others, Perry-Smith and Shalley (2003), who proposed that weak ties and sparse (low density) networks would foster the autonomy necessary for creativity. It is in line with the arguments of Cohen and Levinthal (1990) and the results of Moenaert and Souder (1996) who showed that frequent past interactions increased the effectiveness of interpersonal communication when dealing with complex R&D information.

In the development phase, we found an unexpected U-shaped relation between past intensity and success. From the interviews it was clear that for low success networks, one or two central players contacted various members from their department and only occasionally an outsider. Past intensity with these colleagues was of course high. As a consequence of the small range, the discussions focused more on the validity of the proposals than on new insights relating to the idea and as a result the idea barely changed during development. The medium success networks were large and diverse, but relatively dense and did not consist of relations with high past intensity. This seemed to cause discussions that were less fundamental and more aimed at the technical execution of the proposals. The basic idea behind the proposals did not change significantly; instead the discussions around such proposals were more aimed at refinement from the start in terms of technical specifications and market prospects. High success networks, on the other hand, were also large and diverse, but less dense and consisted of relations with high past intensity. This seems to have created more room for the fundamental discussions that took place and to have resulted in ideas that were changed more fundamentally.

To support these qualitative findings, we constructed a combined *past intensity* and *inter-subunit ties* measure *Past*Inter-subunit* to assess whether it were indeed the 'diverse friends' who made the difference. This measure was a combined structure and content measure. For each relation in the networks, we multiplied the value for *past intensity* with the dichotomous value for inter-subunit ties u_{ij}. We subsequently summed the resulting values for all relations in the network. A high value thus corresponds to a network with many diverse relations with 'close friends' and a low value corresponds to a network with few of those relations.

The results (see Table 6) clearly support the qualitative findings and are significant in all three phases, most strongly in the development phase. The ANOVA results show that the overall difference between the three levels of success is significant for both the initiation and development phases ($F(2, 12) = 3.79$, $p = 0.53$ and $F(2, 13) = 8.30$, $p = 0.01$). Moreover, the t-test results show that in the initiation phase high success networks consist of significantly more diverse friends than low ($p < 0.05$) and

medium success networks ($p < 0.10$). For the development phase, the t-test results show that high success network consist of significantly more diverse friends than low ($p < 0.01$) and medium success networks ($p < 0.05$). Also during the refinement phase high success networks consist of significantly more diverse friends ($p < 0.05$). These differences are more pronounced than the differences we found for past intensity and subunit range alone. In line with recent publications on later phases in the innovation process (Kellogg et al. 2006; Tiwana forthcoming), our data thus suggest that in a complex innovation context, it is crucial to discuss proposals relatively intensely with close colleagues or friends from different subunits to truly tap into diverse insights. However, to guarantee autonomy, this should not be in a dense clique. Moreover, the data shows that this process is important throughout the FE, from generation to refinement, thereby providing an important extension to existing insights on networks and creativity and intra-organizational innovation.

Table 6 Past intensity * Inter-subunit ties for the initiation, development and refinement phase

Success		N	Low	N	Medium	N	High
Phase	Variable		Mean (std dev)		Mean (std dev)		Mean (std dev)
Initiation	Past*Inter-subunit$^{\circ}$	8	1.40 (0.55) $^{\#\#}$	3	1.44 (0.51) †	4	2.31 (0.63) $^{\#\#, \dagger}$
Development	Past*Inter-subunit$^{\circ\circ}$	8	0.99 (0.51) $^{*, \#\#\#}$	3	1.54 (0.58) $^{*, \dagger\dagger}$	4	2.23 (0.20) $^{\#\#\#, \dagger\dagger}$
Refinement	Past*Inter-subunit	-	-	5	1.30 (0.76) ††	4	2.21 (0.48) ††

Note. The significance of the differences is calculated for all three pairs, for an explanation see table 2.

This result also sheds more light on to the search-transfer paradox of Hansen (1999). He argued that weak ties are useful for search benefits; whereas strong ties are useful for transfer benefits. Most researchers have assumed that generating ideas is identical to searching for knowledge (Perry-Smith and Shalley 2003; Obstfeld 2005). This is not corroborated by our findings. In a context where information is abundant, tacit, complex and distributed asymmetrically, only strong ties can provide added processing capacity and appropriate levels of trust and psychological safety for the successful initiation and development of ideas.

The results regarding decision-making power provided little to no support for the hypothesis. The effect of seniority, on the other hand, was notably stronger. These results show support for the notion that senior personnel are better at the encouraging risk taking and identifying opportunities as suggested by Gupta et al. (1986) and Moenaert et al. (1992) and that this is different for decision-makers. The mere fact that a senior person has decision-making power might frustrate the creation of psychological safety. Manager involvement per se seems to be positive, but if management involvement equals decision-maker involvement it may become problematic.

Summing up, this research extends and contributes to existing network research in three ways. First, we develop and find support for a dynamic network perspective, which has thus far hardly been applied in the context of creativity and innovation. Network dynamics in the FE are included in Perry-Smith and Shalley's (2003) theoretical model, but these authors focus on the career of idea generating individuals and not on the dynamics of the FE process itself. In the subsequent empirical work, Perry-Smith (2006) even explicitly mentions the need for network studies focussing on the entire process from generation to evaluation. Besides the recent theoretical work of Kijkuit and Van den Ende (2007), dynamic network studies are predominantly found outside the creative and NPD context, such as the work of Podolny and Baron (1997), Mizruchi and Stearns (2001) and Rowley et al. (2000). Second, we focus on temporal and actual discussion networks in the empirical research as opposed to the routine interactions that were studied in previous research (Burt 2004 and Perry-Smith 2006). And third, we find support for interaction effects between network structure and content highlighting the need to consider both dimensions of networks in an innovative context. This study contributes to the NPD literature by focusing on the social processes involved in decision-making on NPD projects, which has thus far hardly been addressed (Kijkuit and Van den Ende, 2007).

Managerial implications

This study has important managerial implications. Most importantly, managers acting in accordance with this framework should focus more on the quality of ideas generated in the FE than on their mere numbers. To this end, they should encourage idea generating employees to discuss these ideas with others, and particularly with good colleagues and friends from other units, before submitting the

idea for review. Moreover, they should not hesitate to give some direction to the idea with an eye on company requirements. Further actions that management can take to improve the FE process include: reconsiding recruitment policies taking social abilities into account, making more effective use of project or job rotating systems to facilitate the creation of networks of friends between different subunits, creating peer networks, and developing guidelines for proposals that stimulate networking. Improving the quality of ideas can occur through creating a mix of junior and senior people in the work environment.

Limitations and future research

This study also has various limitations. First, the longitudinal research design and time required to collect the data only made it possible to monitor a limited number of proposals, which hampered the statistical analysis. An interesting way to overcome this problem for future research is to combine or replace the interview approach with the collection of email data, which was explained in some detail by Kijkuit and Van den Ende (2007). A second limitation was that the data was collected within a single firm and within a research lab, which limits the external validity of the findings. Particularly our finding that functional range should be low in the initiation phase, may be specific for a research lab in which specialized knowledge is important. Future research could extend and validate the framework further by studying other settings. Other limitations include the measure of success and the operationalization of tie strength. With respect to the measure of success we suggest extending the investigation of networks to later phases of the NPD process and final market performance. Tie strength in this study covered intensity and duration of ties, but not aspects such as emotional closeness, reciprocity, scope (Gilsing and Nooteboom 2005; Granovetter 1973). An interesting extension concern the question what made networks grow in the front end. We would expect that strong ties to colleagues from different units also help building a network, but this has to be further investigated. A final interesting extension concerns studying the traits that add to the networking skills of employees in an NPD context.

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