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The social network among engineering design teams and their creativity: A case study among teams in two product development programs

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Abstract

Since the creative product development task requires the teams to combine and integrate input from multiple other teams, the team's structure of interaction is an important determinant of their creativity. In this study we investigate different structural aspects of social networks of such team's and their creativity within two multinational product development programs (PDPs). There are two main results. First, teams with a wider range of informational links are better to realize creative novel and feasible output. Second, in contrast to prior findings our results indicate that network efficiency and the creativity of teams relate negatively. This suggests that direct contacts contribute much more to creativity than open network structures. In managerial terms our investigation indicates that the network structure of teams in PDPs is an important issue to consider when designing such programs and that tools should be available to assist their direct interaction.

Keywords: Product development programs, Creativity; Social networks; Teams; Communication

1. Introduction

In today's knowledge-intensive environments, Product Development Programs (PDPs) are increasingly employed for executing innovative efforts (Oxley and Sampson, 2004; Smith and Blanck, 2002), especially in multinational contexts. Engineering technically advanced and complex products requires the tapping and capitalizing of knowledge concentrated in pockets of excellence around the globe (Leenders et al., 2003). Increasing product complexity often requires increasing the number of specialists involved (Hoegl and Weinkauf, 2005). For example, the number of people involved in the development of the Volkswagen New Beatle Automobile reached around 1600 and for the Boeing 777 Airplane approximately 16,800 (Ulrich and Eppinger, 2004). Researchers and practitioners unanimously agree that effective management plays a critical role in the success of such PDPs (Pinto and Prescott, 1988). Unfortunately, the knowledge and experience base of most managers refer to smaller-scale projects consisting of only a few project teams. This may be responsible for what Flyvbjerg et al. (2003) call a 'performance paradox': "At the same time as many more and much larger infrastructure projects are being proposed and built around the world, it is becoming clear that many such projects have strikingly poor performance records ...." (p. 3).

PDPs typically follow a project-management like approach with the team as the organizational nucleus (e.g., van Engelen et al., 2001). The information networks

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of these teams define the opportunities available to them to create new knowledge (e.g., Uzzi, 1996). As many scholars have argued, networks of organizational linkages are critical to a host of organizational processes and outcomes (e.g., Baum and Ingram, 1998; Darr et al., 1995; Hansen, 1999; Reagans and McEvily, 2003; Szulanski, 1996). New knowledge is the result of creative achievements. Creativity, therefore, molds the foundation for poor or high degrees of performance. The extent to which teams in PDPs produce creative ideas depends not only on their internal processes and achievement, but also on the work environment in which they operate (e.g., Amabile et al., 2004; Perry-Smith and Shalley, 2003; Reiter-Palmon and Illies, 2004). Since new knowledge is mainly created when existing bases of information are disseminated through interaction between interacting teams with varying areas of expertise, creativity is couched in interaction networks (e.g., Leenders et al., 2003; Hansen, 1999; Ingram and Robert, 2000; Reagans and Zuckerman, 2001; Tsai, 2001; Uzzi, 1996). In the present research, we build on the definitions of Amabile (1983) and Woodman et al. (1993) and extend them with the very nature of the design process itself, with the number and the considered design solutions as a precondition for novel, valuable, and useful ideas (Pahl and Beitz, 1992).In order to explore how the creative performance of teams inside PDPs depends on their embeddedness in interaction structure, we collected data on two PDPs in space industry. The first (PDP A) consists of 27 teams scattered around the globe in 17 countries. The second (PDP B) encompasses 23 teams across five countries.

Our study is explorative based on two cases, and as such, we avoid drawing explicit predictive or prescriptive conclusions about the interaction structures of teams in PDPs of their resulting creativity. However, we believe that our study offers valuable insights by integrating network theory, theories about creative performance and project-management based on a unique set of empirical data.

2. The social networks of teams in PDPs

The structural configuration of team networks in PDPs result from product decomposition into sub-components, the employed design and development procedures, and the methods of final integration into a new product (Browning, 2001). The two PDPs in our study are decomposed into 27 sub-components in PDP A and 23 sub-components in PDP B, with each component assigned to one team. Since the success of the complete product requires the creative input of all teams in a PDP, their creative capabilities are decisive to the success of the whole PDP. As we argue in this article, creativity is largely shaped by coordinated interaction among the teams. The differences in the networks of the various teams in PDP A are displayed in Fig. 1. In order to graphically illustrate distinguishable social networks we executed a *k*-core analysis of the network (Seidman, 1983). A *k*-core is a set of nodes that are more closely connected to one another than to nodes in other *k*-cores. That is, a *k*-core is one definition of a 'group' or 'sub-structure' inside an overall network. The size of the nodes in each *k*-core is proportional to the size of the *k*-core and the connectivity within the *k*-core. Graph theoretically, a *k*-core is a maximal group of teams, all of whom are connected to *k* other teams. This technique is often used to display large complex networks in a more organized manner. In Fig. 1, teams with many and very intense social contacts are characterized by larger-sized and darker nodes, whereas teams that are loosely connected with lower intensity are denoted by smaller-sized and lighter nodes. The interactions describe the exchange of product-related issues containing technical specifications, test results, technical problems et cetera, in other words problem-solving related information. The boldness of the lines indicates the strength of these interactions. From Fig. 1 it is clear that the various teams in PDP A each have very different networks. For example, team 1's network is denoted by many and strong contacts, whereas team 22 only has very few contacts and these contacts are on average less intense.

Interactions, however, are restricted by the availability of time and energy. So it may be important to reach many teams with little time and energy. Exactly this issue is addressed by the concept of 'network efficiency' (Burt, 1992). The main argument behind network efficiency is that since maintaining interactions requires time and energy an efficient distribution of contacts may make it possible to maintain more contacts and, consequently, have more access to information. Network efficiency refers to the ratio of the number of teams that can be reached and the number of contacts maintained by a team. Thus, network efficiency is high in case many teams can be reached with only a few linkages and lower when many more linkages lead to the same number of teams. For example, team 1 would need only thirteen of its current 23 links to reach all teams to which team 1 is currently connected through one (direct links) or two steps (first-order indirect contacts). The remaining ten links are redundant in the sense that they would only provide additional paths to the same teams team 1 is connected to already.

3. The social networks of PDP teams and creativity

In spite of the growing consensus that networks matter (Ahuja, 2000), the specific effects of different elements of network structure on creativity remain widely unclear. In the social network literature, a debate has arisen over the network structures that can appropriately be regarded as beneficial (Walker et al., 1997). According to one view, close networks with many strong connections linking teams are seen as advantageous (e.g., Coleman, 1988). The alternative view, however, states that advantages derive from the opportunities created by an open social structure (e.g., Burt, 1992). Teams can build contacts with multiple disconnected clusters of teams and use these connections to obtain the right information at the right time (e.g., Burt, 1992). From a theoretical point of view these arguments