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## **Social network and radical innovation: evidence from the U.S. pharmaceutical and biotechnology industry**

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## Summary

Innovation plays an essential role in firms' competitiveness and long-term success. It varies from different types, ranging from run-of-the-mill innovation that bring incremental changes to existing technologies to radical innovation that break from existing trajectories. The aim of this PhD dissertation is to integrate radical innovation and social network literature to broaden theoretical understanding, especially contribute to the literatures of social networks, creativity, and innovation, and inform innovation management by unpacking the drivers and effects of radical innovation.

Chapter 1 provides an overview of this dissertation, presents the research questions to be addressed in this dissertation, and the potential contributions. There are long-standing debates in the social network literature regarding which types of networks are more advantageous for innovation. Some researchers highlight the benefits of weak ties and structural holes, while others suggest advantages of strong ties and network cohesion for radical innovation. To address this question, Chapter 2 investigates how tie strength and structural holes collectively affect innovation radicalness at a location within an innovating firm. Specifically, Chapter 2 separates two faces of weak ties and structural holes: their informational advantages in accessing the diverse knowledge that is needed for radical innovation, and their relational disadvantages linked to a weaker shared understanding and trust. To test hypotheses, Chapter 2 builds a unique panel dataset consisting of 19,343 firm-location-time observations for 16,011 unique firm-locations belonging to 93 U.S. pharmaceuticals and biotechnology companies on the EU Industrial R&D Investment Scoreboard. The findings of this chapter support our hypotheses that there is a positive interaction effect between tie strength and structural holes on innovation radicalness. Structural holes weaken the negative effect of tie strength on innovation radicalness, and tie strength magnifies the positive effect of structural holes on innovation radicalness. In other words, the informational advantages of structural holes can be mobilized if there are strong ties for mitigating the relational disadvantages of structural holes. Similarly, network cohesion is needed for mobilizing informational advantages of weak ties. Chapter 2 provides a promising direction for reconciling competing theories about network effects.

Another reconcile direction is to examine different stages of the creative process.

Innovation starts from creative ideas, but not all creative ideas will turn into successful innovation that is being adopted and used by others, and it takes multiple steps to develop a creative idea into a successful innovation. One important separation is between an initial production stage where a creative idea is being generated and a latter diffusion stage where a creative idea is being adopted and used by others. Building on this line of literature, Chapter 3 investigates how social structure for producing a creative idea influences the adoption and future use of its innovations and make a novel contribution by exploring how this effect is contingent on the radical nature of the creative idea. Prior studies have highlighted the advantages of strong ties and network cohesion for idea transfer and diffusion, due to their associated higher level of trust, fine-grained information exchange, and reciprocity norms. Chapter 3 argues that these effects are likely to be contingent on the radical nature of the innovation. More specifically, these effects might only hold for incremental innovation that consolidates existing technologies and aligned with reciprocity norms. These effects turn into negative when the innovation is radical and disrupts existing technologies, because the kind of impact that radical innovation brings to network partners is not aligned with reciprocity norms and therefore sanctioned by the network. In addition, the lack of information diversity also hinders the identification of new applications for radical innovations. To test hypotheses, Chapter 3 constructs a unique panel dataset with information about firm R&D locations, their collaboration networks, and innovation outputs. Empirical results support our hypotheses. The findings in Chapter 3 highlight that different types of innovations require different network conditions for diffusion. The reciprocity norms are not always beneficial but can become a burden, and non-redundant information is not only beneficial for generating novel ideas but also for identifying new applications for radical innovation. Chapter 3 contributes to the literatures of social networks, creativity, and innovation.

In addition to contributing to this long-standing debate, this dissertation also investigates how radicalness affects the private value for the innovating firm. Studying how the radicalness predict future economic value, especially the different aspects of radicalness, is a very interesting research topic in innovation literature. However, the empirical evidence is mixed considering there are diverse approaches for conceptualizing and operationalizing innovation radicalness. Chapter 4 investigates the association between the private value of a patent for the innovation firm and its technological radicalness by differentiating between two important

dimensions of technological radicalness: destructiveness and dissimilarity. Chapter 4 argues that the private value is lower for patents that are more destructive to existing technology trajectories, because of their higher risk and uncertainty, longer road to profit, and incompatibility with existing firm capabilities. On the other hand, the private value is higher for patents that are more dissimilar to the exiting knowledge, due to the reception reward to dissimilarity and ambiguity. Furthermore, dissimilarity makes it difficult for the market to understand the patented invention and therefore weakens the negative effect of destructiveness. Using a dataset consisting of 1,066,637 USPTO granted patents, the findings support our hypotheses. Chapter 4 confirms that the different dimensions of radicalness have distinct effects on private value. More importantly, Chapter 4 provides a useful approach for making sense of the diverse and sometimes competing theories and evidence about technological radicalness. This dissertation concludes with summarizing the main findings, discussing the implications from theoretical and practical perspectives, and showing the limitations and future research prospects (Chapter 5).

