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A configurational approach to network topology design for product innovation☆

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ABSTRACT

This research exploits a novel configurational approach for technological companies to investigate the effects of network topology on innovation using the configurational theory assumptions. Network topologies attract a substantial amount of theoretical attention, and researchers envision that they can enhance creativity. The most recent studies focus on the isolated analysis of network qualities; however, this study introduces a set-theoretic approach to investigate the interdependencies of the small-world degrees of innovation. Thus, this research applies a qualitative comparative analysis to a unique dataset of 10 innovator companies with 150 smartphones between 2010 and 2015. The empirical results of this study demonstrate the role of small-world innovation configurations in fostering product innovation. Through the introduction of a configurational perspective to the network topology discussion, this study examines equifinality in small-world design and advances the theory concerning interdependencies within the network topology construct.

1. Introduction

The characterization of network anatomy is notable because structure always affects function. The topology of a network affects the spread of activities. Recent theoretical research on macro networks focuses on the properties of network topology (Watts, 1999, 2002; Watts & Strogatz, 1998; Yan & Assimakopoulos, 2008). Physicists and mathematicians expose three network topology models, *small-world*, *random-networks* and *scale-free-networks* (Newman, 2003; Watts & Strogatz, 1998), which generate considerable interest from natural and social scientists. In some types of networks, information, innovation, and technology can spread through society or vice versa. This type of famous network is a *small-world-network*, popularly researchers describe this type of network as *six-degrees-of-separation*. Interestingly, the name *six-degrees-of-separation* originates from an experiment of Stanley Milgram (1967). This experiment is a social psychological one that at first glance has nothing to do with mathematical definitions. The relevance to small-world networks is that this network makes the structure of the social network between people visible.

This study intends to explain whether product innovation requires different network topologies. In network studies, researchers should evaluate their actions not in isolation but rather with the expectation that the world will react to what they do. What are the underlying mechanisms that lead to such success or radical change? To understand the nature of the mechanisms of innovation efficiency that lead to a certain network, is innovation efficiency useful to examine the topology of the ultimately emerging network? Do researchers create links in a completely random manner (random networks), do they create precise rules (regular networks), or is a combination of randomness and certain rules (complex networks as small-world or scale-free networks)? In addition, networks not only present differences in their structure but also behave differently, depending on their different topologies.

This study examines the interaction of product innovation and network topologies with respect to the assumptions of configurational theory. The primary goals of this paper are the following: (a) to survey the recent literature on configurational theory and the analysis of network topology; (b) to illustrate the application of configurational theory to network topology through product innovation; (c) to provide insight into the implications of network topology on the creation of technological interweavement; (d) to survey the major innovations (radical changes) that require different network topologies compared with minor innovations (non-radical innovations); and (e) to analyze the network topology conducive for product innovation.

2. Configurational theory

Configuration theory aims to determine how actors should structure or form their organization to ensure their effectiveness. Meyer, Tsui, and Hinings (1993) study the configurational approach in its various forms, and their work continues to be influential. The theory has three core assumptions.

First, a relationship between organizational performance and formal organizational arrangements occurs that managers use to coordinate

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activities and exercise control over employee efforts; therefore, researchers perceive organizational arrangements as organizational designs or organizational forms.

Second, configuration theory objects the assumption of "one best way" to organize; the structural-contingency theory also asserts this assumption. However, configuration theory focuses more attention on the types and sizes of these contingencies and their nature.

Third, the appropriateness of an organizational design partially depends on contingencies, such as an organization's size, its technology, and the rate and predictability of environmental change (the same assumption that is present in structural contingency theory) but also depends on the social (institutional) processes of approval. Therefore, an organization's performance is a function of the degree of "fit" with respect to its strategy, organizational design, functional contingencies, and institutional processes.

2.1. Implementation of configurations

Configuration theory refers to a multidimensional aspect and focuses on the coherence of strategies, structures, and processes with a company's dominant problems, operational environment, and strategic goals (Sarason & Tegarden, 2003).

A high degree of configuration extends beyond the aspects of competitive strategy and includes synergy, clarity of direction and coordination, difficulty of imitation, distinctive competence, commitment to valuable resources, speed, and economy. These complexity and ambiguity lead to complex causality and nonlinear relationships in the context of an organizational system. As a result, the relationships between variables expose *asymmetric* characteristics, and *synergetic effects* replace traditional bivariate interaction effects. Furthermore, different initial conditions and a variety of different paths can take an organization to a final state called *equifinality* (Doty & Glick, 1994). According to configuration theory, different sets of strategy contexts, structures, and processes that are arranged by organizations lead to different features and outcomes. In contrast, multiple paths may lead to a given goal (Fiss, 2007).

Nonlinearity represents the variables that may be convenient in one configuration but not in another. Organizations must alter between disequilibrium and equilibrium with discontinuous changes during temporarily stable periods. Configuration theory considers change to be episodic, and changes are time-dependent. According to configuration theory, many approaches can lead to success in each type of setting, accommodating effectiveness in terms of equifinality (Meyer et al., 1993).

3. Network topology

Networks can examine many different types of relationships or connections in terms of links. Topological features such as degree distribution, clustering, and shortest path are three major concepts or patterns of connections that define each type of network model by whether they share the same number of nodes (n) and the same number of links nk / 2 (k number of ties).

Network analyses that only model the existence or absence of a connection between any two nodes assume that the mutuality of ties is one of the weaknesses of this topological model because these types of models ignore the 'strength' or 'frequency' of the connection between the actors (Assimakopoulos & Yan, 2006).

3.1. Small-world network

The idea of a small-world network is that the world appears small considering the short distance of a path of friends that connects a person to almost anyone else. Small-world networks tend to contain cliques and near-cliques that function as sub-networks with connections between almost any two nodes within them. This characteristic stems from the defining property of a high *clustering coefficient*. A clustering coefficient is a measure of an "all-my-friends-know-each-other" property, which means "the friends of my friends are my friends." More precisely, the clustering coefficient of a node is the ratio of the existing links that connect a node's neighbors to each other to the maximum possible number of these links. Second, most pairs of nodes are connectable by at least one short path, which stems from the defining property that the *mean-shortest path length is small*. Because the underlying structure of a network can be complex and because small-world networks present several other network properties.

Watts and Strogatz (1998) assert that a certain category of small-world networks constitutes a class of random graphs and argues that two independent structural features, namely the clustering coefficient and the average node-to-node distance (average shortest path length), are fundamental to the description of graphs. The authors also integrate the ideas of clustering and path length by considering the extremes of regular and random graphs. Regular graphs in which each node connects to its k nearest neighbors display high clustering and long path lengths. For example, in the case of $k = 4$, your immediate neighbors directly connect both to you and to one another. Distant neighbors, however, connect through a large number of indirect ties. Purely random graphs that are constructed according to the Erdős–Rényi (ER) model expose a small average shortest path length (which varies typically as the logarithm of the number of nodes) along with a small clustering coefficient. Watts and Strogatz (1998) demonstrate that many real-world networks have a small average shortest path length and a clustering coefficient that is significantly higher than that expected by random chance.

A small-world network is a type of mathematical graph in which most of the nodes are not neighbors of one another but in which most nodes can be reachable from every other node by a small number of nodes. Specifically, a small-world network is a network in which the typical distance L between two randomly chosen nodes (the number of steps required) grows proportionally to the logarithm of the number of nodes N in the network (Watts & Strogatz, 1998):

> "*In the context of a social network, this results in the small-world phenomenon of strangers linking by a mutual acquaintance. Many empirical graphs are well-modeled by small-world networks. Social networks such as the connectivity of the Facebook and Wikipedia exhibit small-world network characteristics*"

4. Network topology as a configuration and innovation relationship

Organizational researchers adopt formal models of network topology and assert that some types of network topology improve creativity and innovation. Researchers (Newman, 2003; Watts & Strogatz, 1998) argue these points with respect to the influences of clustering, path length and their interactions (regression, correlation analysis and structural equation models). The first problem is the identification of cases in a manner that combines their key similarities and differences. The second is the assessment of causal complexity when an outcome can result from different combinations of case properties (Fiss, 2007). The incorporation of the configurational approach into innovation and social network studies may help reduce an overwhelming mass of data into tangible theory. Although product innovation rates are a common indicator of innovation effectiveness, this indicator has a weakness because not all companies strive for high innovation rates (Gemünden, Ritter, & Heydebreck, 1996). Thus, to evaluate the influence on innovation management, the assumptions should include both product improvement and new product degrees.

Uzzi and Spiro (2005) focus on clustering and argue that a small-world network improves creativity in musical productions "because clustering promotes collaboration, resource pooling, and risk sharing." The authors add that the effect of clustering is non-monotonic because