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Research on the characteristics of evolution in knowledge flow networks of strategic alliance under different resource allocation

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ABSTRACT

This paper takes the four types of resource allocation (randomly oriented, relationship-oriented, cooperation oriented, and knowledge-embedded) as its premise and investigates the complex characteristics of knowledge flow network evolution in strategic alliances, taking into account the mutual variance effects of the evolution mechanism. Existing research has neglected the differences in resource allocation types, by and large employed statistical analysis methods, and identified only the linear relationships among experimental variances of cross-sectional data. The present study differs from existing research in the following ways: First, we thoroughly consider the multi-faceted nature of resource allocation. Second, we use the method of multi-agent imitation according to perspective of dynamic system evolution and the principle of phase theory, allowing the explicitly analysis of nonlinear functional logic, forms and patterns in the variance. Finally, we analyze the appropriateness of different resource allocation models. Our paper features several significant findings: (1) The evolution of the knowledge flow network of a strategic alliance can produce a bifurcation phenomenon composed of saddle-node bifurcation and transcritical bifurcation. (2) The number of nodes exhibits a logarithmic growth distribution, the connection intensity and the network gain exhibit exponential growth distributions, and the connectivity and knowledge flow frequency are mutually influential in the form of a power function. (3) Knowledge-embedded resource allocation is most effective for improving the knowledge flow rate of networks and can further supply ample impetus for evolution. (4) Cooperation-oriented resource allocation is most beneficial for quickly propelling the network into the evolution realm. (5) Relationship-oriented resource allocation can aid the network in capturing more profit. Furthermore, this research is beneficial for understanding the key problems of each resource allocation model and the evolution of strategic alliance in knowledge flow networks. Our proposed methods and framework can be more widely applied to the fields of complex networks, knowledge management, and strategic innovation.

1. Introduction

In the age of the knowledge economy, the strategic alliance has been adopted by enterprises as a new business model for understanding and dealing with murky and uncertain environments. The biggest advantage of the strategic alliance is the ability it gives alliance organizations to supplement their own capabilities and shortcomings and achieve strategic goals of mutual benefit through the multi-faceted knowledge flow networks formed by knowledge transmission and interaction (Schildt, Keil, & Maula, 2012; Zhao, Xi, & Su, 2015; Panico, 2017). In addition, considering that the differential resource allocation could influence the formation and effectiveness of knowledge flow networks, the problem of the evolution of knowledge flow networks in strategic alliances opens up the black box of the complex nature of network evolution. Therefore, research on different resource allocation models is extremely valuable for clarifying the emerging mechanism of network evolution as well as for propelling the stabilization, diversification, and continued development of the strategic alliance.

In conjunction with earlier research based on knowledge management theory (Hansen, Nohria, & Tierney, 1999; Gupta & Govindarajan, 2000; Phene & Tallman, 2014; Caner & Tyler,2015; Guan & Liu,2016; Zhang, Li, & Li, 2017; Geels,2017), recent studies have been influenced by the idea of "relationship-structure" in complex network theory. Scholars have mainly focused on the influence of network structure characteristics on the effectiveness of knowledge flow and that of network relationship characteristics

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on knowledge understanding and ties degree. Although the studies have differed in their approaches, their conclusions all showed the complexity manifested in the changes of knowledge flow networks and the uncertainty of network social relationship changes poses monumental challenges for researchers and practitioners of the strategic alliance. In fact, a number of theoretical perspectives related to the role of knowledge flow in complex networks have contributed to our understanding of strategic alliances. These theories include complexity systems, network embeddedness, resource-based views, knowledge management, strategy management, social capital, and technology innovation. However, most of the literature using these theories has been limited on three important fronts: content, method, and context.

First, in terms of research content, Sorenson, Rivkin, and Fleming (2006) noted that "while much of the knowledge networks and knowledge flow in strategic alliance research has dealt with the barriers to successful knowledge transfer and has investigated structural questions, little of the research has delved into the characteristics of networks evolution based on knowledge flow in strategic alliance." Likewise, Meier (2011) recognized that much research attention has been directed to trends in knowledge ambiguity in the strategic alliance, alliance formation, determinants of networks, the alliance network effect, and resource utilization in alliances, rather than questions related to evolution characteristics. Even, studies that focused on knowledge networks in the strategic alliance and network evolution fell short of linking emerging characteristics and evolution mechanisms. Instead, these studies turned to the role of network-specific variables such as average path length (Grigoriou & Rothaermel,2017; Paruchuri & Awate,2017; Wang et al.,2017), topological structure (Tan, Zhang, & Wang, 2015; Basole,2016), degree distribution (Graham, 2017; Baum, Calabrese, & Silverman, 2000), or organization heterogeneity (Moeen & Agarwal,2017; Lavie, Haunschild, & Khanna, 2012). However, scholars whose research focused on knowledge networks in the strategic alliance, all found that the characteristics of knowledge flow network evolution-such as bifurcation, mutation, node tie mechanism, and relationship between alliance organizations-clearly influenced the direction and effect of knowledge flow networks. And the important problem of explaining the characteristics of knowledge flow network evolution has received scant systematic attention. Beyond the analysis of the dual effect of knowledge flow, few studies have used appropriate methods to link the attribute variables (control variables) with the effect variable (state variables) to explain the characteristics of evolution.

Second, in terms of research method, much of the scholarship has focused on the theoretical aspects of conceptual research. From a holistic perspective on the network, few studies have employed computational simulation methods. Although ample research has been conducted on the knowledge management and knowledge network problem of strategic alliances, there still exists substantial research potential in quantitative fields of research. Similarly, the prevalent and foundational theory used to analyze the knowledge management problems of the strategic alliance seems to also have certain problems, as scholars have begun to realize that the most valuable and meaningful variance is often difficult to explain persuasively through theoretical analysis. Although prior researches proposed and demonstrated the hypothetical and empirical functions of such methods in the knowledge network and knowledge transfer problems of the strategic alliance, there are still shortcomings in these methods. First, the knowledge flow networks of the strategic alliance exhibit high degrees of information asymmetry, which causes many data capture and calculation deficiencies (or a lack of reliability and data loss) for researchers who employ structural equations and regression methods. Second, the knowledge flow networks of the strategic alliance are complex systems that exist within time and space-evolution occurs in continuous time and is a process that is clearly dynamic and uncertain. The existing studies that conducting statistical research through questionnaires or cross-sectional data were all conducted with the implied condition of being divorced from time, leading to a lack of precision in the analysis of the emergence traits of network evolution and a lack of reliability in their conclusions. Third, although empirical research methods with statistical analysis can indeed prove the logic behind the effects of independent and dependent variables, they cannot prove the characteristics, forms, or laws of the effects among variables, rendering practitioners unable to develop targeted and effective management policies. This study departs from theoretical speculation and empirically based on research that relies on cross-sectional samples or investigations based on a structural equation or regression approach. We use a multi-agent imitation method to investigate the evolution characteristics and principles of the knowledge flow networks of strategic alliances. The benefit of utilizing this method is that we can use a rigorous and intelligent programming language to define the rules of network evolution, to make continuous time a basic condition of a network's evolution, and to prominently feature the interdependent effects of variables.

Third, in terms of research context, among scholarship that pertains to the theoretical research of alliance networks and knowledge flow based on the resource-based view and the knowledge-based view, scholars have recognized the limited nature of resources, but they unfortunately have not considered the existing differences in the limited resource allocation and utilization methods of alliance organizations caused by differences in strategic targets and development directions (Klingebiel & Rammer,2014;Kogan, Papanikolaou, Seru, & Stoffman, 2017). This leads to the problem that scholars take one single resource allocation model only as their research context. Not only do they fail to notice the formation mechanism and influence model of multiple resource allocations, but fail to provide analysis of the effect of multiple resource allocations models on network evolution. As a result, the focus of the existing research has been entirely concentrated on the rate of alliance resource utilization, the integration of knowledge resources, and the influence of network structure on the transfer of knowledge resources, failing to investigate the potential guiding role exerted by resource allocation models on the network evolution of strategic alliances in knowledge flow. Therefore, this paper partitions the various resource allocation models that may be selected by strategic alliances according to the dual impact of knowledge flow, analyzes the knowledge flow evolution traits of strategic alliances based on these resource allocation models, and discusses the unique functions of each resource allocation model in network evolution.

To address the limitations of previous research and further our understanding of the characteristics of knowledge flow network evolution in strategic alliances under different resource allocation conditions, this paper will explain the content and function of different resource allocation models, analyze the key variables of knowledge flow networks in strategic alliances (node density, average network node degree, spatial distance, and connectivity), and, by utilizing the multi-agent imitative method, conduct analysis of the evolution traits of knowledge flow networks of the strategic alliance based on different resource allocations. This research elucidates the nature and laws of knowledge flow network evolution in strategic alliances under different resource allocation premises with limited resources as a condition and establishes a new research framework for related future research. This framework can shed light on three problems. First, different resource allocation models have different functions and levels of usability for the knowledge flow network evolution of strategic alliances. Second, under different resource parameters, the mutual effects of control factors and variable factors create special patterns for the

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