A Simulation Model for the Main Factors Affecting Business Innovation Performance

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***Abstract*—Building on previous research, this study develops a research simulation model for the main factors affecting business innovation performance. It links the properties of knowledge obtained from outside network, firm's absorptive capacity and the features of a firm's knowledge network topology to predict innovation performance. We use VB.NET 2005 programming languages to develop simulations to conduct tests of the propositions developed in the model. We find that the interaction between absorptive capacity and network topology has significant, positive effects on business innovation performance. This study will provide a tool that may help decision makers of those types of businesses to effectively turn knowledge into actions by matching their firms' knowledge network topology to the particular properties of the knowledge that is going to be communicated.**

***Index Terms*—properties of knowledge, network topology, absorptive capacity, business innovation performance**

I. INTRODUCTION

With the rapid development of network economy, the majority of companies all around the world are seeking to improve business innovation performance by taking part in existed firm relation network or establishing firm-self relation network. Recently, scholars have drawn on network literature to highlight the importance of external knowledge resources available to the firm through its networks [1, 2]. The network perspective avers that the embeddedness of firms in networks of external relationships with other organizations provides firms with access to knowledge with different properties and holds significant implications for business innovation performance [3]. In this article we focus on networks and how firms acquire useful knowledge through their positions within networks. Our interest is in knowledge acquisition, how diverse knowledge transfer between network members occurs, and what role firms' network topology and absorptive capacity play in the transfer.

The primary motivator for us was a theoretical gap in the research where the key concepts of properties of knowledge, network topology, and absorptive capacity intersect. This gap is the result of three interconnected theoretical research threads operating at an organizational level. First, Many researchers recently have argued that access to new sources of knowledge is one of the most important direct benefits of firm networks [4]. Second, in the network area there is increasing interest in understanding how the structure of networks in which firms are embedded influences their innovation behavior and performance [5]. Third, absorptive capacity has been identified as an important concept that can add value to the study of knowledge transfer processes [6-8].

In examining these three conceptual threads, it became apparent to us that a systematic theoretical analysis of the relationship between properties of knowledge, network topology and business innovation performance did not exist. Although various variables that affect knowledge exchange and transfer have been posited, much less attention has been focused on the process of gaining knowledge access [9]. It is important to consider whether different properties of knowledge and firm's absorptive capacity have an effect on innovation performance. Similarly, it is also important to consider whether capable firms with superior network structural will gain a further stimulus from the manner in which their innovation performances are enhanced by network topology [1].

This paper argues that a firm's absorptive capacity to improve its innovation performance will depend on sound management of its available outside network knowledge. Consequently, this study develops a research simulation model that links the properties of knowledge obtained from outside network, firm's absorptive capacity and the features of a firm's knowledge network topology to predict innovation performance. First, this paper synthesizes research on properties of knowledge and integrating it with the literature on characteristics of knowledge network topology and absorptive capacity. Second, this study develops a new model completed at the outset of the research to inductively derive predictions that go beyond the existing literature. Finally, this research uses VB.NET 2005 programming languages to develop simulations to conduct tests of the propositions developed in the model. Simulations have important advantages [10]: they let researchers replicate the organization's behavior and therefore tackle complex problems that are not directly solvable without human intervention [11, 12].

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II. Theory Development

Inside an interorganizational network, learning involves the transfer of knowledge among different organizations. Such knowledge transfer occurs in a shared social context in which different firms are linked to one another. They are embedded in a network coordinated through processes of knowledge transfer and resource sharing [1, 2]. Such a network ties enables firms to gain critical competencies that contribute to their innovation performance.

Network ties are an important part of a learning process in which firms discover new opportunities and obtain new knowledge through interacting with one another. The importance of network ties has been documented in the strategy literature. Prior research has frequently argued that an organization's knowledge network structure has a great impact in the effectiveness of knowledge transfer [12]. They also considered the effect of network ties, particularly their pattern or structure, on business innovation performance [13]. For example, Burt's classic work argues and demonstrates that firms occupying the favored network position of bridging structural holes are likely to perform better because of their superior access to information [14]. Despite the considerable focus on the role of network structure in explaining business innovation performance, some researchers have acknowledged that a network of ties merely gives the focal firm *potential* to access the knowledge of its contacts [1]. The value the firm actually derives from its contacts may also be a function of the knowledge controlled by those contacts, the ability of the firm to exploit those knowledge, and the pattern of the network topology binding the firms together.

To begin with, it is well known that a firm's innovation performance depends not in the knowledge that the firm may accumulate but on its abilities to turn that knowledge into action. The ability of a firm to identify the value of knowledge, absorb it and use it to its advantage can enhance firm's innovation performance [15]. But to turn knowledge into actions firms may need to understand the main characteristics of their knowledge. The structure of the knowledge network needs to match the specific properties of the knowledge that is going to flow all over the network [16]. In order to design an adequate knowledge network structure the designer needs to have a good understanding of the particular properties of the knowledge that is going to flow through the network. Consequently, the most important properties of knowledge need to be considered.

Knowledge can be analyzed by studying its three main characteristics [11] of tacitness, ambiguity and complexity. Polanyi (1967) classified knowledge into two categories: explicit and tacit [17]. Explicit knowledge consists of facts, rules, relation ships and policies that can be faithfully codified in paper or electronic form and shared without need for discussion. By contrast, tacit knowledge defies recording. This kind of knowledge underlies personal and groups' skill, and its transfer requires face-to-face contact or even apprentice ship [18]. In the context of information technology, knowledge can be a stand alone piece or a part of a system. Hansen (1999) stated that a stand alone piece like a software module can be easily transferred [16]. Yet, when the software module is dependent or is a part of a bigger system its transfer is more complex. This added complexity is mainly due to the need to understand the way that the knowledge transfers from one organization to anther. Ambiguity as an important property of knowledge refers to uncertainty regarding the causes of efficiency differences among corporations. Ambiguity prevents would-be-imitators from knowing exactly what to imitate or how to go about it [19]. When the knowledge to be communicated has high causal ambiguity its interchange is more problematic because of the difficulty in understanding the whole concept. In the following model, we expect that common knowledge (with low degree of tacitness, ambiguity, and complexity) will ease the transfer of knowledge.

Further, an organization's knowledge network structure has a great impact in the effectiveness of knowledge transfer [12]. An optimal transfer of knowledge will need a knowledge network structure that matches the particular properties of the knowledge that is going to be communicated [16, 20]. However, in order to design a knowledge network structure appropriate for the knowledge to be transferred the designer may need to understand the main characteristics of knowledge network topology. The three critical features of a knowledge network topology that impact the outcome of knowledge management initiatives are tie strength, density and centrality of the network [11].

Tie strength is a measure which captures people interactions within the network. Specifically, a strong tie could ease the transfer of complex knowledge because it is more likely than a weak tie to be embedded in a dense network [20]. A firm has strong tie with other members in its interorganizational network is likely to produce more innovations. Density describes the overall level of interaction of various kinds reported by network members. In general those networks that have good connections among all its members have a better innovation performance. Centralization reflects the extent to which interactions are concentrated in a small number of individuals rather than distributed equally among all members. Conversely, when the variance in the number of network ties per group member is high, some members have proportionately more ties and therefore are more central than other group members [21]. A firm occupying a more central position in its interorganizational network is likely to produce more innovations.

Finally, a large number of recent absorptive capacity studies found that firms themselves vary widely in their capability to develop, understand, or use innovation and knowledge [15]. A key factor enhancing the firm's ability to utilize and benefit from externally acquired knowledge is its absorptive capacity [15], which is often reflected in the firm's innovativeness and its ability to exploit new knowledge [8]. Without such ability, firms cannot learn or transfer knowledge from one network member to another. Consequently, we need to consider a firm's innovativeness, or its own capability for innovation, to explain its performance [1].

In summary, we extend previous research on interorganizational learning by conceptualizing properties of knowledge as consisting of tacitness, ambiguity, and complexity and by relating these three components of network topology to the acquisition of knowledge. We suggest that absorptive capacity also occupies a prominent role in facilitating knowledge acquisition and assimilation for business innovation performance (see Fig.1). In our model, properties of knowledge have direct and indirect effects on business innovation performance. Improving the level of innovation performance will need a reasonable network structure that matches the particular properties of the knowledge that is going to be communicated. Firms with a high level of absorptive capacity have more abilities to moderate the effects of properties of knowledge on business innovation performance.

The model formulates three propositions:

Proposition 1: A firm's innovation performance is sensitive to variations in knowledge properties.

Proposition 2: A firm's knowledge network topology is positively related to its innovation performance and will mediate the impact that knowledge has on the firm's innovation performance.

Proposition 3: A firm's absorptive capacity is positively related to its innovation performance and will moderate the impact that knowledge has on the firm's innovation performance.

III. Research Methodology

To test these propositions this study will use simulation output. This study's simulation model will be based on the canonical Garbage Can (GC) model [22, 23] and the modification of it [11, 24]. The study of organization's knowledge network topology that best fits the knowledge properties for an optimal knowledge transfer has peculiar characteristics that can be addressed using the GC model. Olson et al. (2006) summarizes three main characteristics that are present in this study. "First, organizations operate on the basis of a variety of inconsistent ill-defined preferences. Second, it operates on the basis of trial-and-error procedures. Third, the boundaries of the organization are uncertain and changing." Romelaer and Huault (2002) posit that when these three conditions hold the use of a similar approach to the one used by the GC model is valid [11].

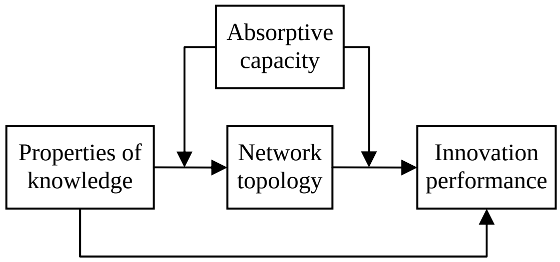

Figure 1. Theoretical model for the main factors affecting business innovation performance.

A. Research Design

Simulation modeling provides a powerful methodology for advancing theory and research on complex behaviors and systems [25]. It can be a tool that decision makers can use to better understand management issues. The manipulation of external variables and the observation of how these variables affect the organization's innovation performance may allow executives to deal with the constraints inherent to this complex problem. Specifically, simulation or computational modeling has unique advantages in analyzing firm innovation process under dynamic situation [26].

1) Simulation Design

This research's simulation model will be based on the canonical GC model [22]. The main reason for us employed GC model as our research plan is that the GC model's relationship between decisions and load assessed over a combination of organizational situations is similar in many respects to this research's main quest (the study of knowledge network topology that best fits the knowledge properties for an optimal knowledge transfer and better innovation performance) [11].

There are three differences of the canonical GC model with the model developed in this study. The first is that the GC model fixes the net energy load of the organization to three levels: light load, moderate load, and high load and varies other parameters to assess organizational performance [11]; this study, however, links the concept of energy load of the organization to the concept of knowledge properties. Therefore, the energy requirements to solve a specific problem will depend on the specific combinations of knowledge properties. Second, the main constructs of the GC model (access structure, decision structure and energy distribution) are matched to the firm's knowledge network topology particular characteristics (tie strength, centrality, and density). And third, in our model we add an Absorptive Capacity Coefficient between [0, 1] which operates on the potential innovation energies (effective energy) realized during any given time period.

2) Model Development

Four basic variables are considered (Innovation Platforms, Innovation Projects, Absorptive Capacity

Coefficients, and Stream of Energy from Participants) where each one is a function of time.

Innovation Platforms: Some fixed number, “m” innovation platforms are assumed and each one is characterized by (a) an entry time, the calendar time at which that platform is activated for innovation project to enter, and (b) an innovation platforms joining structure, a list of participants eligible to participate in joining that innovation platform.

Innovation Projects: Some number, “w” innovation projects are assumed and each one is characterized by (a) an entry time, the calendar time at which that project is activated for participate to enter, and (b) an energy requirement, energy needed to fully develop an innovation project, and (c) an access structure, list of innovation platforms to which the project has access.

Absorptive Capacity Coefficients: In our model, the coefficient, ranging between 0 and 1, which operates on the potential innovation energies to determine the effective energy actually realized during any given time period is specified. Here, for the sake of simplicity, we assume that when the absorptive capacities are low, middle and high, the coefficients are 0.3, 0.6 and 1.

Stream of energy from participants: It is assumed that there is some number, “v”, of participants. Each participant is characterized by a time series of energy available for innovation projects. Thus, in each time period, each participant can provide some specified amount of potential energy to the project.

Table Ⅰ shows the set of fixed parameters which do not change during the entire simulation. The entry times for innovation platforms are two sets of five randomly generated sequences of entry times. One innovation platform will enter per time period over the first five times periods. And the entry times for innovation project are two sets of ten randomly generated sequences of entry times. Two project s will enter per time period over the first five times periods (Table Ⅱ).

TABLE I.
FIXED PARAMETERS ASSIGNED DURING THE SIMULATION [a]

Parameters	Values Assigned
Number of time periods	10
Number of innovation platforms	5
Number of innovation project participants	10
Number of innovation projects	10

[a] Sources:Cohen et al. (1972), Bendor et al.(2001) and Bustamante (2007).

TABLE II.
SETS OF ENTRY TIMES FOR INNOVATION PLATFORMS AND PROJECT [a]

Set	Entry Times for Innovation Platforms	Entry Times for Innovation Projects
A	5，2，4，1，3	8，6，7，3，2，9，4，1，5，10
B	3，1，5，4，2	4，3，5，2，1，6，8，7，10，9

[a] Sources: Cohen et al. (1972), Bendor et al.(2001) and Bustamante (2007).

3) *Access Structure for Innovation Platforms*

This research links the access structure for innovation platforms with network tie strength. Three pure types of organizational arrangements are considered in the access structure (the relation between innovation projects and platforms).

Access structure: high tie strength. This structure is represented by an access array in which any active innovation project has access to any active innovation platform.

$$NT_H = \begin{bmatrix} 1&1&1&1&1\\ 1&1&1&1&1\\ 1&1&1&1&1\\ 1&1&1&1&1\\ 1&1&1&1&1\\ 1&1&1&1&1\\ 1&1&1&1&1\\ 1&1&1&1&1\\ 1&1&1&1&1\\ 1&1&1&1&1 \end{bmatrix}. \qquad (1)$$

Access structure: mixed tie strength. In this structure both innovation projects and innovation platforms are arranged in a hierarchy such that important projects, those with relatively low numbers, have access to many innovation platforms, and unimportant projects, those with relatively high numbers, are accessible only to important innovation platforms. The structure is represented by the following access array:

$$NT_M = \begin{bmatrix} 1&1&1&1&1\\ 1&1&1&1&1\\ 0&1&1&1&1\\ 0&1&1&1&1\\ 0&0&1&1&1\\ 0&0&1&1&1\\ 0&0&0&1&1\\ 0&0&0&1&1\\ 0&0&0&0&1\\ 0&0&0&0&1 \end{bmatrix}. \qquad (2)$$

Access structure: low tie strength. In this structure each project has access to only one platform and each platform is accessible to only two projects, that is, platforms specialize in the kinds of projects that can be associated to them. The structure is represented by the following access array:

$$NT_L = \begin{bmatrix} 1&0&0&0&0\\ 1&0&0&0&0\\ 0&1&0&0&0\\ 0&1&0&0&0\\ 0&0&1&0&0\\ 0&0&1&0&0\\ 0&0&0&1&0\\ 0&0&0&1&0\\ 0&0&0&0&1\\ 0&0&0&0&1 \end{bmatrix}. \qquad (3)$$

4) Access Structure for Innovation projects

Bustamante (2007) links the access structure for innovation projects with network centrality [11]. Three similar pure types are considered in the access structure for innovation projects (the relation between innovation project participants and projects).

Access structure: high network centrality. In this structure any decision maker can participate in any active choice opportunity. Thus, the structure is represented by the following array:

$$NC_H = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}. \quad (4)$$

Access structure: mixed network centrality. In this structure both innovation project participants and projects are arranged in a hierarchy such that important projects. Low numbered projects must be made by important participants and important participants can participate in many projects. The structure is represented by the following array:

$$NC_M = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}. \quad (5)$$

Access structure: low network centrality. In this structure each participant is associated with a single project and each project has a single participant. Participants specialize in the projects to which they attend. Thus, we have the following array:

$$NC_L = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}. \quad (6)$$

As in the case of the access structure, actual structures will require a more complicated array. Most firms have a mix of rules for defining the legitimacy of participation in network innovation projects. The three pure cases are, however, familiar models of such rules and can be used to understand some consequences of access structure for innovation processes.

5) Energy Distribution of Innovation Project Participants

Bustamante (2007) links the energy distribution with network density [11]. The energy distribution structure provides the relationship between participants and their energy allocations. The distribution of energy among innovation project participants reflects possible variations in the amount of time spent on innovation projects by different participants. Three different variations in the distribution of energy are considered.

Energy distribution: important participants – high energy. In this distribution important participants, that is participants defined as important in an innovation project, have high energy. The specific energy distribution is indicated as follows:

$$E_H = \begin{bmatrix} 1 & 1.0 \\ 2 & 0.9 \\ 3 & 0.8 \\ 4 & 0.7 \\ 5 & 0.6 \\ 6 & 0.5 \\ 7 & 0.4 \\ 8 & 0.3 \\ 9 & 0.2 \\ 10 & 0.1 \end{bmatrix}. \quad (7)$$

The total energy available to the participant each time period is 5.5.

Energy distribution: equal energy. In this distribution there is no internal differentiation among participants with respect to energy. Each participant has the same energy (0.55) each time period. Thus, there is the following distribution:

$$E_M = \begin{bmatrix} 1 & 0.55 \\ 2 & 0.55 \\ 3 & 0.55 \\ 4 & 0.55 \\ 5 & 0.55 \\ 6 & 0.55 \\ 7 & 0.55 \\ 8 & 0.55 \\ 9 & 0.55 \\ 10 & 0.55 \end{bmatrix}. \quad (8)$$

The total energy available to the innovation project each time period is 5.5.

Energy distribution: important participants – low energy. In this distribution energy is distributed unequally but in a direction opposite to that in E_H. Here the participants defined as important by the access structure for innovation projects have more energy. The distribution is indicated by the following:

$$E_L = \begin{bmatrix} 1 & 0.1 \\ 2 & 0.2 \\ 3 & 0.3 \\ 4 & 0.4 \\ 5 & 0.5 \\ 6 & 0.6 \\ 7 & 0.7 \\ 8 & 0.8 \\ 9 & 0.9 \\ 10 & 1 \end{bmatrix}. \qquad (9)$$

B. Model Description and Model Validation

The model and the simulation are going to be used to test this study's three propositions. The use of programming languages to develop simulations has important advantages because it lets the researcher to replicate the organization's behavior and therefore tackle complex problems that are not directly solvable without human intervention [11]. However, those simulation's advantages comes with the necessity that simulation models need to be validated. The simulation model in this study is the direct implementation of the conceptual model. It is based on knowledge management theory, knowledge properties theory, absorptive capacity theory and knowledge network topology theory. The visual basic net code of this research is based on the FORTRAN code created by Cohen et al., (1972) and VB.NET code created by Bustamante (2007). Validation of the visual basic net code against the original values published by Cohen et al., (1972) was conducted. The validity of the model is established by comparing results. Tables III from the 1972 study are given below.

IV. Research Results

This simulation assimilates the concept of "energy needed to fully develop an innovation project" as a function of knowledge properties. GroupFactor is the parameter that relates the three levels of Tacitness, the three levels of Ambiguity and the three levels of Complexity, as in

$$GroupFactor = Tacitness \times 3 + Ambiguity \times 2 + Complexity \,. \quad (10)$$

TABLE III.
Reproduces table in page 9 of Cohen et al. (1972)

		Access Structure			
		All	Unsegmented	Hierarchical	Specialized
Load	Light	0.55	0.38	0.61	0.65
	Moderate	0.30	0.04	0.27	0.60
	Heavy	0.36	0.35	0.23	0.50
	all	0.4	0.26	0.37	0.58

TABLE IV.
Relationship between GroupFactor and the dependent variable Energy (Coefficients [a])

Model		Unstandardized Coefficients		standardized Coefficients	T	Sig.
		B	Std. Error	Beta	B	Std. Error
1	(Constant)	0.954	0.089		10.741	0.000
	GroupFactor	0.206	0.013	0.953	15.649	0.000

[a] Dependent Variable: EnergyForProject

TABLE V.
Relationship between GroupFactor and the dependent variable Energy (ANOVA [a])

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.738	1	10.738	244.878	.000(a)
	Residual	1.096	25	.044		
	Total	11.835	26			

[a] Predictors: (Constant), GroupFactor; Dependent Variable: EnergyForProject.

The relationship between GroupFactor and the dependent variable Energy to fully develop an innovation project is a strong one. Table IV states that the expected energy needed to solve a problem is equal to

$$0.206 \times GroupFactor + 0.954 \,. \quad (11)$$

About 90% of the variation in the energy required to solve a problem is explained by the relationship (R square is 0.907). Furthermore, Table V says that since the significance value of the F statistics is less than 0.05 the variation explained by the relationship is not due to chance.

For comparison, this research ran 27 simulation models for which the energy required to fully develop an innovation project has its values in the range [1.09 – 3.30]. The 8748 records were obtained by running the simulation 27 times (using different parameters). Each run of the simulation creates 324 records of which 81 are light, 81 are moderate, and 81 are heavy. Fig.2 shows that the average values of the variable innovation performance drops significantly as GroupFactors rise. It is clear that the variable innovation performance values dropped between 9% and 50% on average after the "energy needed to fully develop an innovation project" increased from the values of the base model through the values of model E27. Those results support this research to point out that Proposition 1, a firm's innovation performance is sensitive to variations in knowledge properties, is supported at the 95% confidence interval of the difference in the variables' values.

1) Simulation Outcomes in Network Topology

The Paired-Samples T Test procedure was used to test the hypothesis of no difference between variables for the three degrees of tie strength, density and centrality when the "energy needed to fully develop an innovation project" increased from the values of the base model through the values of model E27. The results of the 648

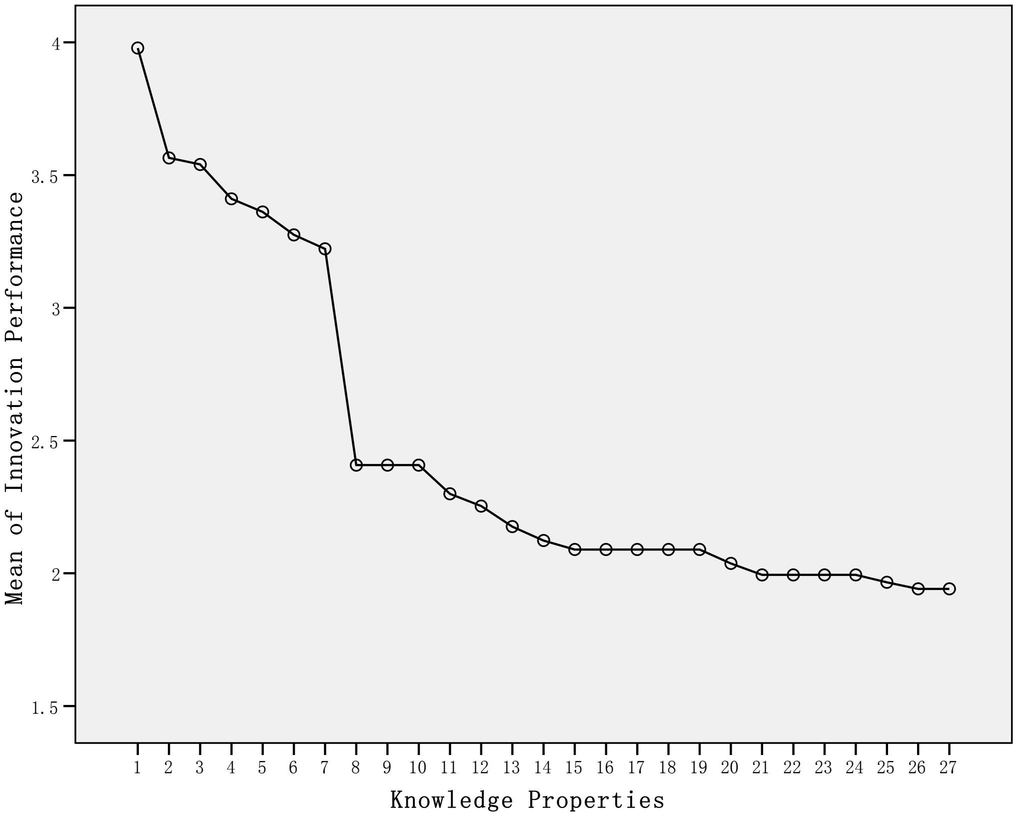

Figure 2. Average values of the variable innovation performance (model E1-E27).

Paired-Samples T Test for the three variables are generally significant. Simulation outcomes show that in average after the "energy needed to fully develop an innovation project" increased from the values of the base model through the values of model E27 the number of developedProject (the average values of the variable innovation performance) decreased for the three types of network's topology. Proposition 2 is supported at the 95% confidence interval of the difference in the variables' values.

2) Simulation Outcomes in Absorptive Capacity

Similarly the Paired-Samples T Test procedure was used to test the hypothesis of no difference between variables for the three degrees of absorptive capacity when the "energy needed to fully develop an innovation project" increased from the values of the base model through the values of model E27. The results of the 72 Paired-Samples T Test for this variable are generally significant. Simulation outcomes show that in average after the "energy needed to fully develop an innovation project" increased from the values of the base model through the values of model E27 the number of developedProject decreased for the three types of absorptive capacity.

We use moderated multiple regression (MMR) to test the hypothesis of the moderate effects of absorptive capacity on business innovation performance. Table VI shows that some interaction coefficients for absorptive capacity is positive and significant (e.g., Interaction of Ambiguity and Absorptive capacity: $\beta = -0.019$, $p < 0.05$), indicating that a firm with high absorptive capacity is likely to have good innovation performance. Proposition 3 is partly supported.

V. DISCUSSIONS AND CONCLUSIONS

This study explores and develops ways in which specific properties of knowledge can be associated to a particular knowledge network topology and absorptive capacity to optimize innovation performance. The output generated by the simulation allows observation of the relationship between the properties of knowledge obtained from outside networks and its knowledge network topology as well as the impact that different combinations of this link will have in the firm's ability to develop an innovation project. When the "energy needed to fully develop an innovation project" is incremented

TABLE VI.
RESULTS OF MODERATED MULTIPLE REGRESSION ANALYSIS

	Beta	ΔR^2
ZKT×ZAC[a]	-0.066(***)	0.166(***)
ZKA×ZAC	-0.019(**)	0.141(**)
ZKC×ZAC	-0.005	0.603

* $P < 0.1$, ** $P < 0.05$, *** $P < 0.01$

[a] ZKT=Standardized value of Tacitness (standardized Zscore); ZKA=Standardized value of Ambiguity; ZKC=Standardized value of Complexity; ZAC=Standardized value of Absorptive capacity.

from the base model through model E27, the variable developedProject values dropped between 9% and 50% on average. This result is consistent with prior research [11, 16], providing further empirical support that innovation performance is sensitive to variations in the firm's knowledge properties. In addition to extending prior research, the result is consistent with prior research also provides a level of confidence that experimental manipulations are effective.

When the "energy needed to fully develop an innovation project" is incremented from the base model through model E27, the variable developedProject values decreased for the three types of network's topology. This result is again consistent with prior research [27]. First, a well established type of network topology can promote the transfer of external knowledge. Because a firm with high network density can gain a lot of information, it will have a high level of innovation performance. While a firm with low type of network density will have a low level of innovation performance. Second, by occupying a central network position, a firm is likely to access useful knowledge from other network members. And then a firm's innovation performance is significantly increased by its centrality in the interorganizational network, which provides opportunities for shared learning, knowledge transfer, and information exchange. Farina (2010) also finds that actors operating in the investment banking industry enhance performance by having a central position in their network [28]. Finally, Strong tie strength could ease the transfer of complex knowledge. A firm has strong tie with other members in its interorganizational network is likely to produce more innovations. More importantly, when the firms' knowledge network topology matches the particular properties of the knowledge that is going to be communicated firm's innovation performance will be optimal. For example, this study found that a combination of network's centrality dependent and interdependent will perform better than the independent type of network's centrality. Uzzi and Lancaster (2003) suggest that a specific kind of knowledge network topology needs to be implemented to optimize its communication depending of the particular characteristics of knowledge [29]. This study analyzed this effect on business innovation performance and confirmed their view.

Similarly, when the "energy needed to fully develop an innovation project" is incremented from the base model through model E27, the variable developedProject values decreased for the three types of firm's absorptive capacity. A firm's absorptive capacity determines the extent to which it can absorb new knowledge from other firms. High absorptive capacity is associated with a better chance to successfully acquire, assimilate, transform and exploit new technical knowledge. This research also shows the moderate effects of absorptive capacity on innovation performance. A firm may be able to access knowledge through its network links but may not have sufficient capacity to absorb such knowledge [30]. Hence, the better a firm can access other network members' knowledge, the higher the absorptive capacity the firm should have.

By examining the pattern of interorganizational knowledge transfer, this study provides further evidence that firm's networks and absorptive capacity play an important role in shaping innovation performance. This research has significant implications for the growing body of research on networks. A firm's network topology and absorptive capacity represent its ability to leverage useful knowledge residing in other parts of its networks. A firm's network topology reveals its relative strength in gaining access to new knowledge, a corporation's absorptive capacity reveals its ability to replicate or apply such new knowledge [9]. The influence of both network topology and absorptive capacity should be studied simultaneously. Investing in absorptive capacity while building special network topology are critical to the success of firms in learning new knowledge that eventually leads to better innovation performance.

Like all methods, our theory development using simulation has weaknesses. The experimental setting of this study is a computer-based laboratory experimentation. A primary weakness of our study is external validity. Simulation eliminates complexity in order to focus on the core aspects of phenomena and so uses computational representations that are often stark, such as representing an organization by a 0/1 bit string, or no disadvantages to being a second mover [31]. So when laboratory research entails giving up the richness of context to obtain control, it should not be automatically assumed to be nongeneralizable. Future research may focus on integrating the findings of this computer-based laboratory experimentation with field experiments [11] and analyze how different firm's characters affect innovation performance [32].

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