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Research Article

Simulation Research on Risks of Entrepreneurship Platform Organization Complex Network

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The risks of entrepreneurship platform are considered one of the most significant factors that affect regional economic development. However, the complexity of the constitutive relationship and the dynamics of the research process have made it difficult for studies to analyse the evolution and risks from the quantitative perspective. According to the analysis perspective of complex networks, this study determined the coupling relationship between the entrepreneurship platform network structure and complex network model. With the results studied and described in the paper, this study had constructed a platform structure model portraying the evolution process of the platform structure under two types of risks by using the simulation method. Three main conclusions are being drawn from the study: Firstly, endogenous and exogenous risks showed substantial results in affecting the changes in microentities and network relationship of enterprises within the platform, causing the robustness of platform to risk to differ significantly. Secondly, based on exogenous risks, the robustness distribution scaling from highest to lowest among three types of platforms studied is hub-and-spoke > mixed > market. Lastly, based on endogenous risk, the robustness distribution scaling from highest to lowest among the three types of platform studies is market > mixed > hub-and-spoke.

1. Introduction

As a new form of network formation being generalised and commonly used by the majority in the market, platform organizations have now become a potential economic mover for resource integration and optimization [1–4]. Moreover, cluster entrepreneurship platform helps in enhancing the value of products by leveraging on its powerful sharing effects for building networks, speeding up the formation and growth of the organizations, reflecting on the influencing values of platform networks and organizations [5–7]. The Alibaba Group that pioneered the e-commerce industry in China has created a remarkable and sustainable success in leveraging the power of network formation by creating and managing a strong entrepreneurship platform for its users to utilise their respective business organizations within the platform itself. The company has enhanced the communication for business arrangements in B2B e-commerce market with simplified resource management processes and monetary transaction, and created a breakthrough in transforming the traditional trading business model. However, as entrepreneurship platform produces positive results in network formations, it also increases the network risks in the system. For example, the bike-sharing industry in China is encountering decline in profitability and growth due to several frequent problems in platform-type enterprises, as evidenced by Ofo, Mobike, Wukong Bicycle, and Xiaoming Bike as representatives. In the Sino-US trade war, Huawei's 5G technology is a potential systematic risk in both global and domestic information technology industries, which might create uncertainties in the growth of industrial development. As such, it is necessary to conduct a comprehensive research investigation on the risks in entrepreneurship platform organizations and network, as there are lots of platforms available in the market today. This is to advocate a healthy development of sustainable industrial economy and markets.

Platform organization allows multiple connections to be built between users within a platform, fulfilling the user's needs and promoting more interactions among users that

create the much needed influential values. Theoretically, while entrepreneurship platform organization facilitates bilateral networking results and instant resources matching and business matching effects [5, 8–10], it also mirrors certain negativity as well. It may restrict businesses in a constraint relationship of vested interest, or prevent the enterprise from seeking a more effective external partner, thereby causing a certain measure of risks [3, 10–13]. Most of the studies inferred platform risk based on the external environment of platforms, such as macropolicies and market environment, and the internal environment of platforms (management risk, innovation risk, etc.). Unfortunately, scholars of these studies focused only on singular influencing factor to lay out potential platform risks in their evaluation. This is due to, firstly, the relationship structure among enterprises differing among platforms, and thus, the platform structures demonstrate significant differences. In addition, the complexity of the influencing factors in reality makes it difficult for researchers to extract general models and perform empirical studies on the overall network structure of the platform. Secondly, the structural growth of the platform network is a dependent variable of time, resulting in having more uncertainties to take place in real-time situation and unpredicted statistics to be shown. Due to the limitations in the existing research methods, it is challenging for researchers to produce accurate risk analysis from a quantitative perspective.

Organization network should be the structural basis of platform organization [5, 8]. Additionally, it also reflects on the internal structure of the platform organization as well as the relationship between businesses through network connection and contact referrals [3, 9]. Based on the abovementioned studies, this paper regarded the platform network structure as a complex network structure as discovered by Lee et al. [14]. Through the construction of a complex network structure model and simulation using computers, the robustness of distribution of platform risks can be obtained, in order to verify relevant propositions.

2. Platform Network Structures and Platform Risks

2.1. Three Types of Platforms and Their Network Structures. The current literature related to entrepreneurial platforms mainly includes corporate entrepreneurship and platform-based organizations. Corporate entrepreneurship refers to innovative behaviours such as the development of new services, technologies, and products that are carried out within the firm [15]. Platform-based organizations are easy to achieve rapid business growth and scale up and can respond to the environment and market with agility, and high-speed innovation behaviours are done through low-cost trial and error, giving the company to develop new competitive advantages [16]. The concept of entrepreneurial platform is closely related to the more developed literature on the entrepreneurial ecosystem. The two concepts both try to explain how system conditions influence actors' entrepreneurial agency to create value [17]. Markusen [18], who had studied the industrial districts of various countries, proposed that

industrial platforms can be divided into four different types: marshallian, hub-and-spoke, satellite, and state-anchored platform. Years later, when more researches had been conducted, Evans [19] divided it into market-makers, audience-makers, and demand-coordinators However, in today's urbanised society, reality has proven that platforms can be a hybrid of centralised types, or they may now belong to one and over time become the other. For the use of metricsm, this paper used two indicators as the criteria for categorizing platform functions: "reciprocity" was used to depict the network effect for value cocreation within the platform network achieved through bilateral/multilateral cooperation, whereas "heterogeneity" was used to depict the equivalence of enterprise cooperation within the platform. In several literatures, it can be found that Jacobides et al. have also used similar indicators to depict platform characteristics [1, 20–22]. It is viable then that we explore based on the internal network structure of the platform, specifically categorising them based on the standards laid in the references mentioned; the theories and research description have been concluded and reviewed accordingly, leading us to study in this paper, on platforms with three respective types: market-based [19, 23], hub-and-spoke [24, 25], and mixed platforms [26].

For market-based entrepreneurship platform, each enterprise uses peer-to-peer partnership to cocreate value through horizontal connections, to achieve bilateral/multilateral win-win. The heterogeneity is low, and therefore, the equivalence of enterprise within the platform is high; the overall network effect of the platform is relatively weak.

For hub-and-spoke entrepreneurship platform, this platform is established using platform-type enterprise as the core and other enterprises as the periphery. Platform-type enterprise is the resource agglomeration point and a central position, whereas the other enterprises are peripheral and mainly obtain resources like platform fund, professional technology, or dedicated information service through the platform. The enterprise–platform-type enterprise cooperation within this platform has high stability and strong network effect.

For mixed entrepreneurship platforms, this platform is between the market-based and hub-and-spoke platforms thus having the characteristics of both platforms. The enterprise heterogeneity within this platform is moderate; moreover, the multilateral characteristic of its platform enterprise partnership is significant, and the equivalence and network effect are moderate.

A comparison between the types of entrepreneurship platform structure is given in Table 1.

2.2. Offensive Nature of Two Entrepreneurship Platform Risks. The main types of entrepreneurship platform risks include endogenous and exogenous risks [27]. The endogenous risk refers to the risk accumulated by the internal forces of the platform such as network risks [11–13, 27]. It takes the organization and network built within the platform and the collection of such data as research subject, or in simpler terms, it takes the relationship between enterprises and businesses in the platform as the research subject, and

TABLE 1: Comparison of three types of entrepreneurship platform network structure.

Indicator	Platform type		
	Market-based entrepreneurship platform	Hub-and-spoke entrepreneurship platform	Mixed entrepreneurship platforms
Heterogeneity	Low	High	Moderate
Reciprocity	Low	High	Moderate

TABLE 2: Characteristics of the two platform risk types.

Risk type	Characteristics		
	Properties	Object of action	Mode of action
Endogenous risk	Microscopic entities	Platform-type enterprise	Specific
Exogenous risk	Macroscopic population	Platform enterprise	Random

studies the microscopic entities so as to particularly understand further the risks exist from within the platform. For example: Jing and Benner [28] believed that a negative effect of the network organization in platforms would be generated during the development and expansion of platform due to restrictive and limited use of information and other resources, affecting the business collaboration and cooperation within the platform [29] and surfacing higher and more risks in general. As we observed in recent research reports, research on endogenous risks is giving much focus to the cyber risks caused by microindividuals, especially those caused by platform-based companies, which often referred as "self-fertility." Concrete evidence would be this: the risks of platform enterprises such as the Zhonghuatai Automobile, Lifan Automobile, Zhongtai Automobile, etc. have led to the rise of the new energy vehicles (NEV) risks. This is in addition to the quake of the Chinese photovoltaic industry caused by the collapse of the Suntech platform photovoltaic company in Wuxi back in 2013.

Exogenous risk refers to the risk caused by external forces of the platform, including structural and periodic risks [30]. Exogenous risk is caused by the external forces that affect the overall progress and performances of the platforms, which include the economic and political changes termed as cyclical risks. Not to forget that the life cycle of platforms is the structural risk that is part of the consideration as the commonly faced by enterprises within the platforms are important information to the study in order to objectively analyse the overall platform risks truthfully. Fritz et al. studied the risk caused by periodic fluctuation in the external economy, while Wu and Han [31] studied the platform risk caused by changes in macropolicies. Taking the integrated circuit and television industries in Japan as an example, Zhu [32] studied the problem of the decline of the industrial competitiveness due to changes in the lifecycle of platform core technology in the industry. The characteristics of the two platform risks are as listed in Table 2.

As we understood from the recent literature, it can be clearly seen that exogenous risks are paying much concern on the overall risks of cluster entrepreneurship platforms, especially network risks caused by cluster entrepreneurship platform system risks that occur after the overall macroimpact. For instance, the financial crisis that happened in 2008 has led to the decline of the textile industry in Shaoxing

County of Zhejiang, China. Looking at the cluster size of such industry, the total output value of the textile industry in Shaoxing County had exceeded 100 billion yuan in 2008, and the percentage increase in the output value from 5.53% in 2006 to 34.76% in 2007. However, the growth rate has declined sharply since 2008 as it dropped to -29.41% in 2009. In contrast, in analysing the cluster benefits, the total profit and tax increased from 4.302 billion yuan in 2005 to 6.118 billion yuan in 2007. The percentage for total profit and tax increased rapidly from 5.53% in 2006 to 34.76% in 2007 and fell drastically to -13.95% in 2009 [33, 34]. To illustrate the data described better, Figure 1 shows the changes in the scale of the output value in percentage, while Figure 2 shows the changes in the scale of the increase in profit and taxes in percentage, both figures showing the changes in graph range between 2005 and 2009.

2.3. Robustness Analysis of Risks of the Three Types of Entrepreneurship Platform. Different entrepreneurship platforms differ in structures. Therefore, observing and analysing the risks of network structure are vital as it is an important indicator that differentiates between various types of entrepreneurship platforms, and it represents the connection mode between individuals, including network connections, network configuration, and layout (with special attention to describing connection forms in terms of density, connectivity, and hierarchy) [35]. Structural differences have an important impact on entrepreneurship platform development. Wang [36] from Dongguan's IT industry believed that low-density network structures are not conducive to the development of cluster entrepreneurship platforms, while Shi [37] who did a research Wenzhou's light industry confirmed that high-density network structure is the main cause of the platform's dilemma. Though there have been scholars commenting on the risks analyses on network structures, it is not sufficient to understand the current changes in the high digital evolution of network structures and platforms performing in the demands today and the risk robustness of various platforms. In fact, very few literatures have reported and compared the risk robustness of different types of platforms. Nonetheless, there are still some useful insights that we can discover from the case studies in existing literature as we look more in-depth into the matter. This can be better understood in referring to a recent study done by a
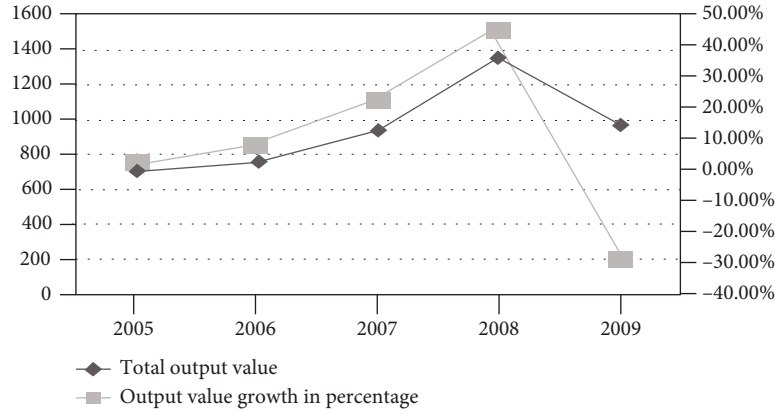
FIGURE 1: The changes in scale of the total output value of textile industry in Shaoxing County, Zhejiang by percentage, between 2005 and 2009.
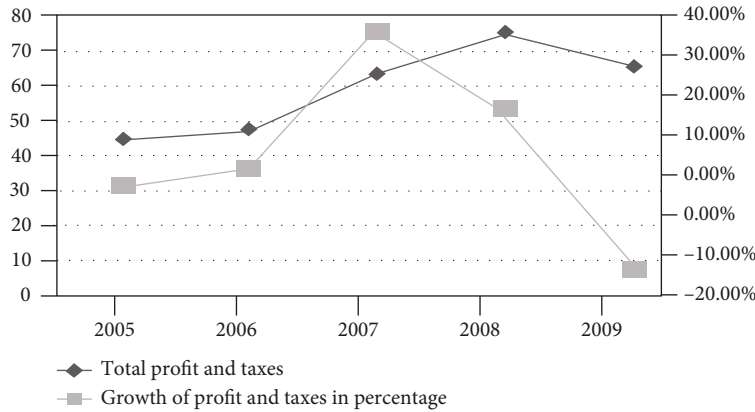

FIGURE 2: The changes in scale of the increase in profit and taxes of textile industry in Shaoxing County, Zhejiang by percentage between 2005 and 2009.

Chinese scholar, Yu [38] who had considered two Chinese household appliances industry platforms: Qingdao, a household appliance industry platform (an industrial hub-and-spoke platform that uses the platform-type enterprise Haier), as the core, and Ningbo, another household appliance industry platform, (an industrial market-based platform based on the cooperation of household electrical appliances association and several small and medium platform enterprises) as the research object. In the depiction of the two platforms, Yu found that Qingdao was less affected by exogenous risk when foreign household appliances entered the domestic market in mass in the 1990s, whereas Ningbo household appliance industry platform became more successful after experiencing an endogenous risk, that is, the emergence of digital television, a new technology [39]. Another similar research was reported by Morgan [40], where the research analysed the differences in network risk across various platforms in risk perspectives.

Encouragingly, in another study conducted much earlier by a Western scholar, Saxenian took two high-tech industrial regions in the United States—namely, Silicon Valley [40], a mixed entrepreneurship platforms consisting of platform-type enterprises such as Fairchild, Intel, and Texas Instruments and many small and medium start-up enter-

prises, and Route 128, a hub-and-spoke-platform that mainly consists of large platform-type enterprises such as Wang Laboratories and Massachusetts Institute of Technology, to evaluate the platform risks between the two based on their platform structures. In its depiction of the two entrepreneurship platforms, the author found that Route 128 was less affected by exogenous risk, which is the effect of the Japanese semiconductor industry on the US electronics industry towards the end of the 1970s, as compared to Silicon Valley [40], whereas Silicon Valley was more successful than Route 128 after experiencing an endogenous risk, where the US electronics industry shifted from semiconductors to microcomputers. After further portraying the network structure of the two entrepreneurship platforms, Acebrón et al. concluded that the two platforms differ in robustness to risk at different stages [41].

Based on the understanding from the literature mentioned above, we can conclude two different results of risks robustness as compared in its respective different situations as the following:

(1) Hub-and spoke entrepreneurship platform has higher exogenous risk when compared to market-based and mixed platforms

(2) Hub-and-spoke entrepreneurship platform has lower endogenous risk when compared to market-based and mixed platforms

Therefore, we can draw a few potential rationale and solutions to the risks described above. First of all, in the accord of taking different types of entrepreneurship platform as the subject of study, the construction of the overall network structure requires a large amount of sample data. Next, the risks and attack processes are dynamically faced in all three different entrepreneurship platforms, and thus, sufficient timespan for observation must be established in order to develop reliable evaluation. Another reason is that it is challenging to identify the victim of attacks in the platform as well as to observe the intensity of the attacks when happened in real time, making it tougher to study the overall effects of the overall attacks and risks on the platform. Consequently, the accuracy to describe the risks dynamics on platform network structure is challenged, and it is hard to be analysed quantitatively using the conventional research methods that we are familiar with. It is not only reflected in the data collection and analysis; the shortcomings of the indicator descriptions and model constructions are also echoed. Therefore, in this paper, we had used complex network theory to analyse different entrepreneurship platform types as defined, while constructing a macroscopic perspective by studying through the specific behaviours in the micro-entities, so as to effectively identify variables for detailed quantitative study of risks in entrepreneurship platform organization.

3. Research Design

Based on the complex network perspective, the network structure within the entrepreneurship platform consists of nodes (representing the enterprises within the platform) in the network and network edges (representing the relationship between the enterprises). With these nodes and edges, the platform reveals cluster, nonlinearity, and interaction characteristics between the heterogeneous entities and portrays them through resource sharing, open information, knowledge interaction, multilateral network effects, cocreation, and the complex relationship between behavioural entities and structural evolution [3, 18, 42–44]. There have been researches done by other scholars who observed the changes in activities of variables in constructing a dynamic network model, such as the degree distribution, mean path length, clustering coefficient, and network density. There are also other scholars who had analysed the cause of one or malfunctions of one or more nodes in relative effects of other nodes and edges, and how the transmission of the malfunctioning affects the whole network chains, resulting in the collapse in the entire network [45].

In this study, we observed the coupling relationship between the structure of the entrepreneurship platform network and complex network, so as to identify several network metrics that is commonly used, such as degree distribution, mean path length, and relative value of maximal connected subgraph for portraying platform network and risks. Also,

Lagrange method was used in our model, because this method can obtain dynamic equations from the dynamic equations from the view of energy, which does not need to calculate the internal force. The calculation will be convenient. With these, we established here a research model for all as reference in analysing the entrepreneurship platform network structure.

3.1. Relevant Attribute Indicators. To ensure the validity and reliability of the measuring tools, this study had used the most common indicators in the complex network theory and supplemented it appropriately according to the research objectives for this computer simulation research.

3.1.1. Degree Distribution (P). The degree of node i, k_i is the number of nodes that node i is connected to. The degree distribution of the nodes in the network can be portrayed using distribution function $P(k)$, which represents the probability that the degree of a randomly selected node is k.

$$P_k = \sum_{k'=k}^{\infty} P\left(k'\right). \tag{1}$$

The formula represents the probability distribution of nodes with degree $\geq k$. Degree distribution reflects the overall structure of the network; the higher the degree distribution of few nodes, the more uneven is the network structure, and the higher the homogeneity of the degree distribution between nodes, the more even is the network structure.

3.1.2. Mean Path Length (L). The distance d_{ij} between two nodes i and j in the network is defined as the shortest path length connecting these two nodes. The mean path length L of the network is defined as the average distance between any two nodes, that is,

$$L = \frac{1}{(1/2)N(N-1)} \sum_{i \geq j} d_{ij}, \tag{2}$$

where N is the number of nodes in the network, without considering the distance between node and self. In the network, there are multiple paths between nodes i and j, cutting some of the paths may increase the distance d_{ij} between these two nodes; simultaneously, the mean path length L of the entire network will also be increased.

3.1.3. Relative Value of Maximal Connected Subgraph (G). This parameter measures the number of nodes in the maximal connected subnetwork in the network after eliminating the malfunctioning nodes. The relative value G of the maximal connected subgraph is defined as

$$G = \frac{N'}{N}, \tag{3}$$

where N' represents the number of nodes included in the maximal connected subgraph of the network after ending

Table 3: Coupling evaluation of the ER model and market-based platform.

Model	Properties	
	Property 1	Property 2
ER model	Even degree distribution	Connected probability
Market-based platform	High commonality	Low reciprocity

Table 4: Coupling evaluation of the BA model and hub-and-spoke platform.

Model	Properties	
	Property 1	Property 2
BA model	Has "large" nodes with higher connectivity	Preferential attachment
Hub-and-spoke platform	Low commonality	High reciprocity

the malfunction. The parameter G denotes the network performance.

3.2. Research Model Establishment. This study first analysed the network characteristics of market-based, hub-and-spoke, and mixed platforms, bringing forth the analyses to perform coupling comparison with classic complex network models, namely Erdős-Rényi (ER) model [46], Barabási-Albert (BA) model [47], and local-world evolving network model. Subsequently, through the connection rules of various models, this study used computer simulation model to construct the network structure of the three platforms.

(i) MP-ER model (Table 3 shows the market-based platform and ER model): ER model is a completely random network, it was developed by Erdős and Rényi [46], and the degree distribution of the network nodes is approximated by the Poisson distribution. The model has two significant properties:

(1) The degree distribution tends to become average

(2) The edging connection between nodes occurred as probabilistic events

This study coupled the network structure of the ER model with the market-based platform network structure (MP-ER model). The probability of new entrant enterprises connecting to original enterprises in the MP-ER model is

$$\prod_i = \frac{1}{N(t)}, \tag{4}$$

where N is the total number of enterprises at time t (i.e., the total number of network nodes).

(ii) HP-BA model (Table 4 shows the hub-and-spoke platform and BA model): BA model is a scale-free network model proposed by Barabasi and Albert [47]. The network connection degree distribution

function has a power-law form; it has two significant properties:

(1) Growth characteristics (i.e., the scale of the network is constantly expanding)

(2) Preferential attachment characteristics (i.e., new nodes tend to connect to "large" nodes with higher connectivity) [47]

This study coupled the network structure of BA model with hub-and-spoke platform network structure (HP-BA model). The probability of new entrant enterprises connecting to original enterprises in the HP-BA model is

$$\prod_i = \frac{k_i}{\sum_j k_j}, \tag{5}$$

where k_i and k_j denotes the degree of nodes i and j, respectively.

(iii) SP-LN model (Table 5 shows the satellite model and local-world evolving network model): The local-world evolving network model is an improvement of the BA scale-free network model; it was proposed by Li and Chen [48]. Each node has its own local-world (local and world is connected by probability); therefore, it only occupies or uses the local connectivity information of the network. The model has two significant properties:

(1) Growth (i.e., the scale of the model is constantly expanding)

(2) Local-world preferential attachment (i.e., new nodes connect to specific nodes to form local world)

This study coupled the network structure of local-world evolving network model and mixed platforms network structure (SP-LN model). The probability of new entrant

TABLE 5: Coupling evaluation of the local-world evolving network model and mixed platforms.

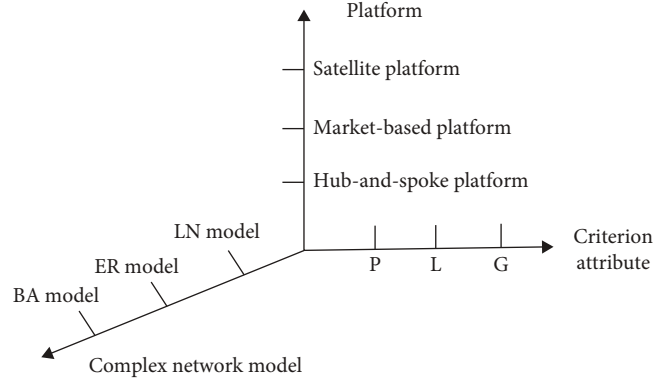| Model	Properties	
	Property 1	Property 2
Local-world evolving network model	Preferential attachment within the local world	Local and world is connected by probability
Satellite model	Hub-and-spoke platform characteristics	Market-based platform characteristics

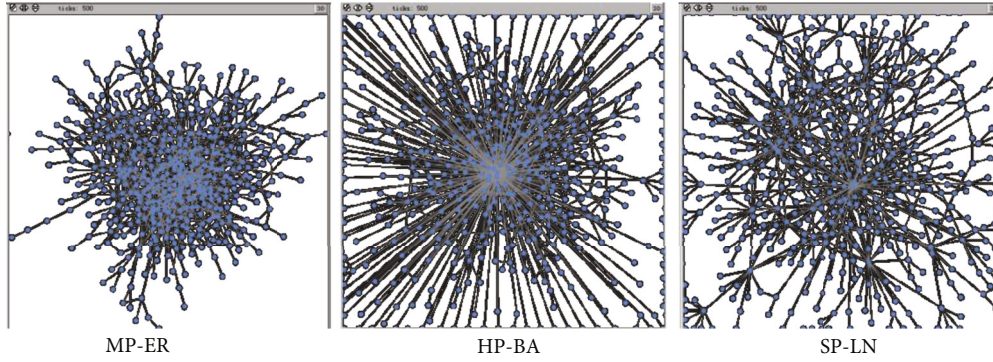FIGURE 3: Construct diagram of the theoretical model.

FIGURE 4: Platform network structure model (simulation; 500 agents in random connection).

enterprises connecting to original enterprises in the SP-LN model is

$$\prod_{\text{Local}}(k_i) = \frac{M}{m_0 + t} \frac{k_i}{\sum_{j_{\text{Local}}} k_j}, \tag{6}$$

where M denotes the selection of M number of nodes from among the existing nodes in the network ($M \geq m$) as the local-world of the new nodes, m_0 is the initial number of nodes in the network, k_i is the degree of node i, and k_j is the degree of node j.

Figure 3 presents the simulation diagram of the three model simulations. We had used simulation to first distinguish the network structure of each of the three platforms and thus established the three models: MP-ER, HP-BA, and SP-LN models (as shown in Figures 4 and 5). We assumed that the enterprises within the platform were connected through the enterprise relationship. The platform network under normal circumstances operated in a free-

flow state [49], and it remains an undirected graph, regardless of the intensity of the relationship between the enterprises; that is, the weight between the connected edges is equal. In place of the effort aimed in constructing a specific concrete model, we started by constructing a network with an initial node, and following each platform's network structure to connect nodes based on the connection probability rules, and each time a node is added, until 500 nodes were reached.

4. Result Analysis and Discussion

We had compared the evolution of network structure of the three models using computer simulation to study how risks are evaluated with attacks and obtained the distribution of risk robustness of different platforms as it developed throughout the process (Figure 6 shows the details). There are two attack strategies adopted in this study: random attack and deliberate attack. Random attack involves removing nodes in the network completely randomly; in the
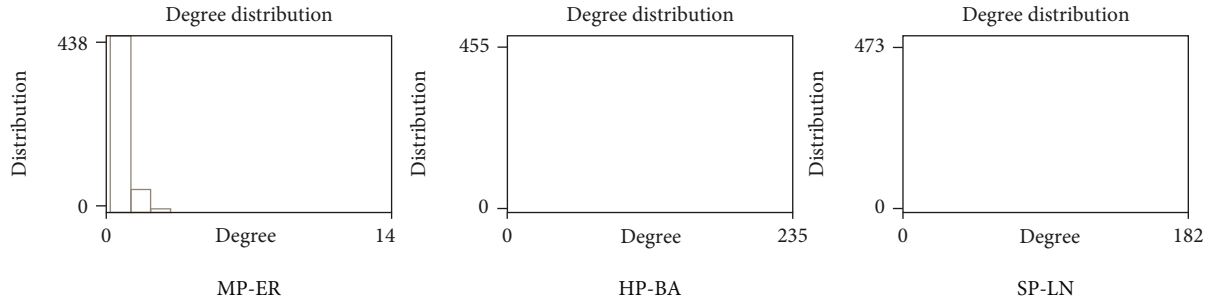
FIGURE 5: Degree distribution of platform network structure model (simulation; 500 agents in random connection).
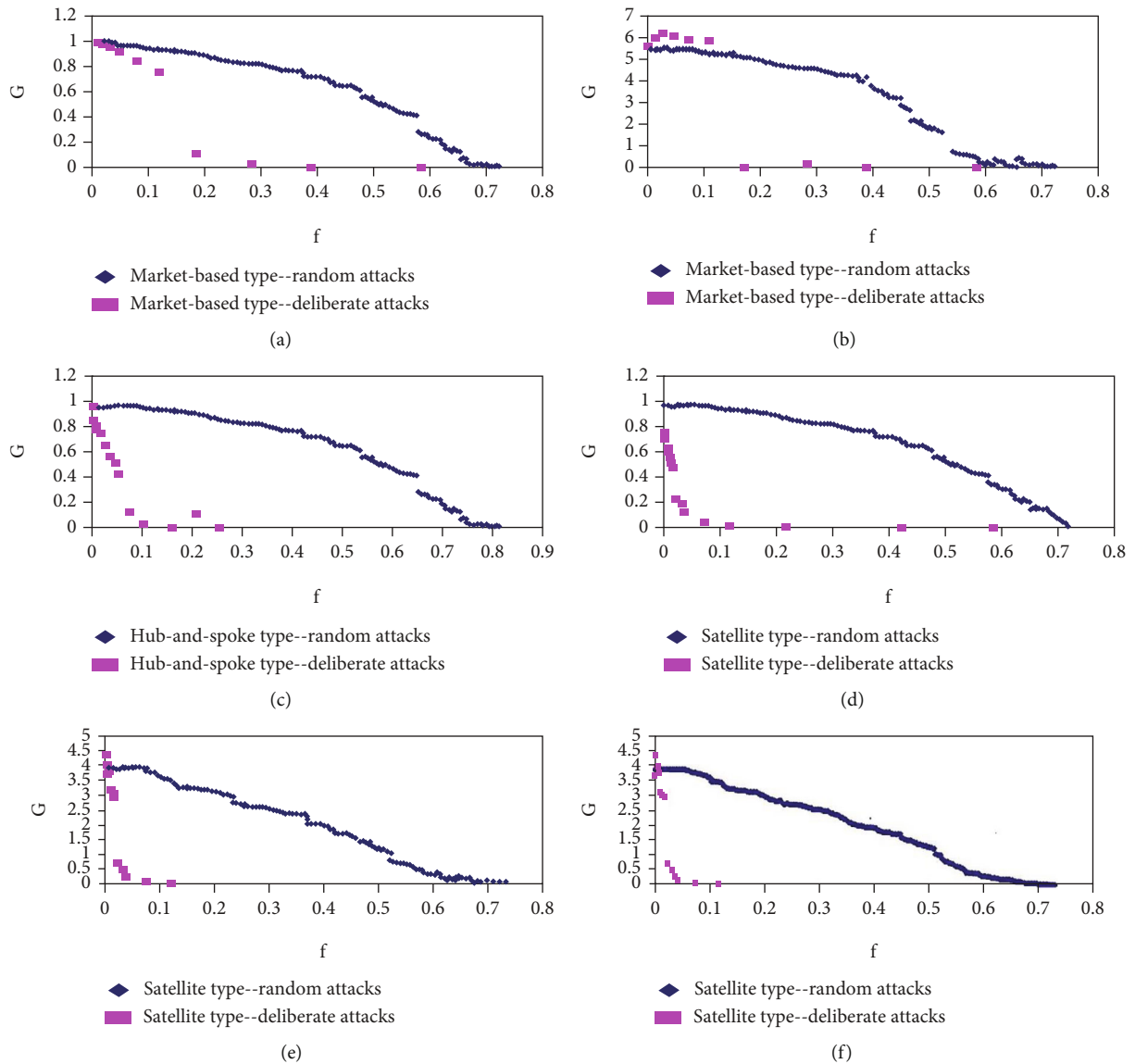

FIGURE 6: Robustness and vulnerability of the MC-ER, CC-BA, and IC-LN models. Note: curves (a) and (b) correspond to the MC-ER model, (c) and (d) to the CC-BA model, and (e) and (f) to the IC-LN model; in all curves; triangles and squares correspond to deliberate and random attacks, respectively.

current experiment, only one node was attacked at a time. Deliberate attack involves removing the nodes with the highest degrees in the network consciously and gradually; in the current experiment, each attack targeted all nodes to the same extent. Simultaneously, the attacked node and the edges that connected the node to other nodes were removed, until the connectivity of the entire network became zero. Assuming that the ratio of the number of removed nodes

to the original total number of network nodes was f, the relationship between f and the relative value of the maximal connected subgraph G and the mean path length L can be used to measure the robustness of the network. The simulation results are as follows.

4.1. Model Evolution Simulation. The relative value of maximal connected subgraph reflects the overall connectivity of the network. The speed of change of connected subgraph can reflect, on a certain level, the robustness of the model after attack. The three maximal connected subgraph diagrams of Figure 5 illustrate that under the circumstances of other conditions being identical, the development process and the results of the three models differed significantly.

(i) Random attack: the maximal connected subgraphs of MP-ER model was the first to reach zero, followed by the SP-LN model, and finally, the HP-BA model. Thus, under random attack, the robustness comparison of the three models is HP-BA model > SP-LN model > MP-ER model

(ii) Deliberate attack: the maximal connected subgraphs of HP-BA model was the first to reach zero, followed by SP-LN model, and finally, the MP-ER model. Thus, under deliberate attack, the robustness comparison of the three models is MP-ER model > SP-LN model > HP-BA model

Another observation that we can draw from the study is that the mean path length reflects the network connectivity efficiency. The change in length of the mean path length can reflect the robustness of the model after an attack at certain level. The three mean path length diagrams of Figure 5 demonstrated that under the circumstances of other conditions being identical, the evolution process and results of the three models differed significantly

(i) Random attack: the mean path length of the MP-ER model was the first to reach zero, followed by the SP-LN model, and finally, the HP-BA model. Thus, under random attack, the robustness comparison of the three models is HP-BA model > SP-LN model > MP-ER model

(ii) Deliberate attack: the mean path length of the HP-BA model dropped to zero after a relatively high f, followed by the SP-LN model, and finally, the MP-ER model. Simultaneously, the mean path length of the HP-BA model was the first to reach zero, followed by the SP-LN model, and finally, the MP-ER model. Thus, under deliberate attack, the robustness comparison of the three models is MP-ER model > SP-LN model > HP-BA model

4.2. Entrepreneurship Platform Risk and Structural Evolution Analysis

4.2.1. Entrepreneurship Platform Risk and Structural Evolution. As shown with the analysis study that is conducted and discussed above, we can now better understand

TABLE 6: Comparison of robustness of platform to risks.

Risk type	Platform type		
	Market-based	Hub-and-spoke	Satellite
Endogenous risk	Strong	Weak	Moderate
Exogenous risk	Weak	Strong	Moderate

that endogenous risk uses a specific mode of action on the microenterprise entities within the entrepreneurship platform. Therefore, deliberate attacks can be considered a manifestation of the endogenous risk. The exogenous risk uses a random mode of action on the macroenterprises within the platform. In other words, random attacks can be regarded as a manifestation of exogenous risk. The two types of risk could affect the changes in the microscopic entities of enterprises and network relationships within the platform, which led to the development of the platform network structure. In the model studied, the changes in the microscopic entities of enterprises within the platform are manifested in the form of attacks on the network nodes, that is, changes in the relative value of maximal connected subgraph. The changes in network relationship are manifested as attacks on the network edges, that is, changes in the mean at the shortest path. Thus, we can conclude that the model characterises the evolution of the entrepreneurship platform structure through two indicators: the maximum number of connected subgraphs and the average shortest path.

4.2.2. Entrepreneurship Platform Risk Robustness Comparison. The evolution process and results of entrepreneurship platform network structure are different, causing significant differences in the platform risk robustness. According to the analysis of the relative value of maximal connected subgraph and mean path length, this study considers that when platform networks are subjected to exogenous risk (random attack), market-based platform is highly vulnerable to random attack, hub-and-spoke platform has high robustness, and mixed platforms falls in-between the two. Thus, the robustness distribution of the three platforms is as such hub-and-spoke platform > mixed platforms > market-based platform. When platform networks are subjected to endogenous risk (deliberate attack), hub-and-spoke platform is highly vulnerable to deliberate attack, market-based platform has high robustness, and mixed platforms falls in-between the two. Therefore, the robustness distribution of the three platforms is market-based platform > mixed platforms > hub-and-spoke platform (Table 6 shows the details).

4.2.3. Analysis of Comparison Results. This article applies the complex network theory to the description of the entrepreneurship platform network structure and implies the reality scenarios at global states based on the ER and BA models, aimed at clearly defining the internal network composition relationship of the three types of entrepreneurship platforms and distinguish the variation of platforms. The network structure provides a new perspective for the application of complex network theory in platform research. In distinguishing between two types of risk situations, endogenous

risk and exogenous risk, the two types of attack strategies (random attack and deliberate attack) of network failures generated in complex network theory are organically combined with platform risks to distinguish the two. Using the dynamic perspective to treat the entire process of cluster risk as a function of time, it is concluded that the break in the network relationship between the network node enterprise and other enterprises is the root cause of platform risk, thus laying a foundation for quantitative description of platform risk.

Consequently, we can now draw a few significant conclusive understandings of the analysis study to better describe the risk performance of the platform network organization and structure. First, the high robustness of hub-and-spoke platform against random attacks originating from the extreme unevenness of the degree distribution of the network nodes; that is, a small number of nodes had relatively large degree, and most of the nodes had very small degree. When f is smaller, the randomly selected nodes were nodes with smaller degree, and the elimination of these nodes will not have a large effect on the connectivity of the network. However, this extreme jaggedness made the hub-and-spoke platform highly vulnerable to deliberate attacks; the attacks gradually removed the largest nodes in the network and had strongly affected the connectivity of the network.

Next, the high robustness of market-based platform against deliberate attacks originating from the high evenness of the degree distribution of the network nodes; that is, most of the nodes had similar degree. The gradual removal of the largest nodes in the network during the attacks did not have much of an effect on the connectivity of the network. However, this high evenness made market-based platforms relatively vulnerable to random attacks.

Lastly, the moderate robustness of mixed platforms against random attacks and deliberate attacks are attributable to the properties of local-world connection and moderate degree distribution of the network nodes; therefore, regardless of the type of attack, its robustness will always fall in-between that of the other two platforms.

5. Conclusions

As a complex network system, the interrelationship caused by platform risk in the evolution process of network structure is extremely complex and changeable. Therefore, quantitatively analysing the entrepreneurship platform network structure from a dynamic perspective to determine the robustness and vulnerability of the three platforms to risks is a field that is theoretically worthy of exploration. With the conduct of simulation, we have showed a result using quantitative research on the dynamic evolution of the model under different attack strategies, followed by an examination of the robustness and vulnerabilities of different platforms to risks; the following main conclusions were obtained:

(1) Deliberate and random attacks can be considered the manifestations of endogenous and exogenous attacks, respectively. These two risks affected the enterprise entities and the relationship between enterprises within the platform, leading to the evolution of platform network structure; however, the differences in evolution process and the corresponding results made the robustness distribution of platform risk vary

(2) When a platform network was subjected to exogenous risk (random attack aimed at all the enterprises within the platform), the robustness distribution of the three platforms was central satellite > satellite > market-based

(3) When a platform network was subjected to endogenous risk (deliberate attack aimed at focus enterprise within the platform), the robustness distribution of the three platforms was market-based > mixed satellite > central satellite

Our study makes several novel contributions. Firstly, our study incorporates complex network theory and platform network structure in the investigation of ER and BA platform networks' evolution. Our simulation model inspects the internal network composition relationship of the three entrepreneurship platforms and distinguishes the network structure of different types of platforms. Thus, this study has successfully provided a new perspective on the application of complex network theory in platform research. Secondly, our study endogenous and exogenous risks were distinguished, while random and deliberate attack strategies for network failure were generated in complex network theory with entrepreneurship platform network risk to distinguish the essence of attack of the two types of platform risks. Thirdly, we adopted the dimension of dynamic perspective. To gain a more complete picture, we call for investigating how the relationship between the enterprises within the platform evolve in different levels of dynamism that are characterised by different levels and combinations of robustness and vulnerability dimensions of platform risk.

Our paper provides several avenues for future research. Firstly, our model is relatively different from the actual entrepreneurship platform structure. Future studies could conduct more in-depth discussion from the following three aspects. The first aspect is the expansion and improvement of the theoretical model. Not only do different types of risks have different effects on the platform, even the same risk could affect the platform differently. Secondly, this study is specifically focusing on different types of risks, however, in terms of investigating possible ways to improve the model reflecting the effects of different risks attack intensities on the three entrepreneurship platforms shall be reported in future papers for this study. The second aspect is the problem of research subject matters. Platform risks affect not only enterprises but also the relationship between enterprises; in complex network theory, this can be reflected by the change in nodes; it can also be reflected by the connection of the edges. Moreover, the load and capacity of different nodes are different, and the robustness to risk is also different. The difference in connection strength, connection mode, and connection direction also manifested differently

to risk. The effect of this type of change between the two on the model is also a problem that requires further research. At last, this study only conducted a simulation experiment based on the theoretical models. We suggest that future studies should select empirical cases corresponding to the three types of entrepreneurship platforms as the research subject, analyse the network structure, perform evolution experiment on this basis, and track actual cases on long-term basis for dynamic study of comparative analysis.

Data Availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

It is declared by the author that this article is free of conflict of interest.

Acknowledgments

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