Corporate finance: from the viewpoint of complex system

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Abstract

With the development of complex system, various disciplines have been discussed together. Although many experts have mentioned the potential that complex system could be applied to finance, few of them do further and detailed researches especially in corporate finance.

During the past few years, financial crisis has widely influenced the global environment. It makes scholars start to reconsider the suitability of traditional financial theories. In this article, we attempt to discuss corporate finance from a new point of view, complex system. We primarily illustrate the basic concepts of the association between corporate finance and complex system. Furthermore, we will provide empirical results of some specific cases.

Because of the adaptability of complex system, we can use the knowledge learning from one subject to solve the problem meeting in other fields. Here, we will elaborate some corporate finance issues and compare them with the similar situations in other areas such as biology, physics and material science. For example, we may figure out the impact of CEOs'entremchment level and personality on CEO turnover rate by examining the structure of plants. Studying the pollination process, we can realize the advantages of horizontal alliances and non-horizontal alliances. In addition, the food chain of the nature may give us some ideas about supply chain.

The goal of this article is to introduce a new method for corporate finance studies. When observing with attention, we will find the situations in corporate finance are exactly similar to those in other complex systems. The knowledge from other systems may provide a more efficient solution and theoretical base for corporate finance.

1. Introduction

Recently, the global financial and economic crisis affects almost every economy. From then on, scholars begin to reconsider the existing finance theories and try to establish new theories. Under these circumstances, complex system might be an efficient and effective method. Because of the adaptability of complex system, people could apply the knowledge of one complex system to other complex systems with similar situation (Goldenfeld and Kadanoff 1999; Amaral and Ottino 2003). Through using the present concepts of one complex system, people could obtain primary thoughts about the problem and find the potential solution from other systems in a short period of time.

Many experts have mentioned that the possibility to combine complex system and finance (Cilliers 1998; Robert et al. 2008). However, few researchers discuss finance from the viewpoint of complex system, especially in corporate finance. In this article, hence, we emphasize the relation between corporate finance and complex system. We also provide more specific examples to show the similarity between corporate finance and other complex systems. This is the first paper to illustrate the connection between corporate finance issues and complex system concepts with the empirical results. The goal of this paper is to exhibit that there is plenty of knowledge which corporate finance could learn from other complex systems. We believe that complex system might provide corporate finance a new direction.

The rest of the paper is organized as follows. Section 2 reviews literatures which mentioned both finance and complex system. It further explains the methodology of applying complex system. In section 3, we use the knowledge of complex system to elaborate some corporate finance issues. Section 4 summarizes the above discussion and makes a conclusion.

2. Literature Reviews and Methodology

Before 19th century, scientists emphasize the relationship among few variables. From 19th century, physical scientists attempt to establish the theory which can cope with plenty of variables at the same time (Weaver 1948). Unlike traditional reductionism, the study of complex system exactly focuses on understanding a system's integral behavior (Anderson 1972). In 1999, Goldenfeld and Kadanoff point out that a complex system does follow some simple rule although it seems complicated. Based on the complex system, people could utilize the existing knowledge of one complex system to another complex system because of complex systems' adaptability (Goldenfeld and Kadanoff 1999; Amaral and Ottino 2003).

Nowadays, some literatures have used the concept of complex system in finance. However, few of them explicitly mention the importance of complex system. Until 2008, Robert et al. clearly point out the concept of complex system in a paper published in Nature. In that paper, they discover that the network of Fedwire interbank payment is quite similar to the network of plants' pollination. Both of them are highly disassortative. More specifically, small banks incline to connect with large banks and large banks incline to connect with small bank. It is also this disassortative trait that keeps the financial system stable just as the situation in plants' pollination.

Besides, the main application of complex system is in financial engineering rather than in corporate finance. Thus, this article attempts to discuss more about corporate finance and complex system. Table 2-1 summarizes these literatures which are related to complex system.

Table 2-1 Literatures related to finance and other complex systems

Application in finance	**Originated from (other complex systems)**	**Literatures**
Brownian motion	underwater movement of pollens (biology)	Brown (1828)
Black-Scholes: partial differential equation	heat transfer (physics)	Johnson et al.(1987)
Liption's option valuation formulas	self-similarity (physics)	Avellaneda (2001)
prediction system of stock price, exchange rate, option price, and etc.	neural networks (computer science)	Kimoto et al. (1990) Yoon and Swales (1991) Refenes et al. 1993 Garcia et al. 2000
topology of stock markets, interbank payments, and etc.	topology (branch of mathematics)	Vandewalle et al. (2001) Soramaki et al. (2007)
network of Fedwire interbank	network of plant's pollination	Robert et al. 2008

payment flows	(biology)	

In 1998, Cilliers provides the basic definition of the complex system. According to his book, a complex system should own the following features.

(1) There are a great number of elements within a complex system.

(2) There are abundant interactions among elements. Each element will not only affect other elements but also be affected by other elements.

(3) A complex system often interacts with the environment.

(4) The above interaction is non-linear.

(5) There is continuous energy makes the system keep working.

(6) A complex system is dynamic. The history will influence the present.

(7) It is a self-organization system. The integral behavior is unknown for single element.

In section 3, we will follow Cilliers' definition. We first show that the targeted issues belong to complex systems. We then apply the known thoughts and findings in other complex system to corporate finance.

3. Illustrations: Corporate Finance and Complex Systems

In this section, we will use some examples to present the relationship between corporate finance and complex system. This section shows that there is abundant knowledge in other complex system which corporate finance could learn.

Before discussing the specific issues, we first define a system which consists of all corporations. This system satisfies the requirement (1) of complex system because there are a lot of companies. In addition, each firm will influence others and be influenced by others. For example, one company's strategy will make an influence on other companies. Each company will also be influenced by other companies' decision. Besides, this system will interact with the environment factors such as policies, global economic situation and the society. Thus, it satisfies the characteristic (2) and (3). The above relationship is also non-linear as mentioned in criterion (4). As for requirement (5), the funds of companies make this system continue working. In a normal situation, new corporations will be founded and some current corporations may bankrupt. Thus, this system is dynamic and self-organized as feature (5) and (6). Therefore, this system composed of all corporations is a complex system.

Additionally, a corporate could be regarded as a complex system as well. It consists of different people and departments. People in one company will influence each other and have the connection with the environment, company's culture. This relationship is not linear. The capital keeps the company continuously operating. A firm is also dynamic because there will be organization reconstruction and employee flows. Thus, it satisfies the basic requirement of a complex system.

From above, we know that a corporation is a complex system. A system composed of all corporations is also a complex system. For the same reason, a plant is a complex system and a system consists of all plants is also a complex system. It is obvious that a food chain could be a complex system. In the following, we then apply the knowledge of other complex systems to corporate finance issues.

3.1 CEOs' Turnover Rate and Bamboo's Structure

In corporate finance, the agency cost has been widely discussed for a long time. The interest conflict between management and board is a very normal problem that a company faces (Jensen et al. 1976; Lang et al. 1995). One important aspect to analyze this problem is CEOs' turnover rate. Researchers often analyze CEOs' turnover rate from CEOs' entrenchment level, personality, and their managerial power (Dezso 2007; Faleye 2006). They try to figure out the relationship between

these factors and CEOs' turnover rate. Afterward, scholars start to consider this issue from CEOs' network and social tie (Westphal et al. 2006; Brown et al. 2009). Actually, if we further examine the agency problem, we will know that all related factors such as CEOs' entrenchment and their power can be summarized to CEOs' network. Plants also have the similar network. Hence, we hope to discuss CEOs' turnover rate from the aspect of plants' structure.

Different plants have their own structures. Plants' structures play an important role when plants interact with the environment. For plants, one crucial issue is to deal with the wind stress and protect themselves. Plants' different structures will have the different effectiveness when plants deal with the wind stress.

This condition is alike to CEOs' network which is crucial when CEOs interact with the whole corporation. For CEOs, one major issue is to deal with the shareholders' stress and to protect their own benefits. CEOs' different network will have the different effectiveness when CEOs deal with the shareholders' stress.

If we apply the known outcomes from botany, we can know that if CEO's network is stronger, then their turnover rate will be lower because of the following reasons. As mentioned before, different plants will have the different effectiveness when facing the wind stress. Bamboo is one of the plants that can ideally cope with the wind stress because of its special structure (LAI et al. 2005). Bamboo's lignin and hemicellulose stick its xylogen cells extremely together, which give the bamboo compressive strength and perfectly elasticity. Because of this structure, modern architects often learn bamboo's structure to design the anti-earthquake buildings. From bamboo's structure, we can assume that CEOs can deal with the shareholders' stress well and reduce the CEOs' turnover rate if they can establish a strong network. This finding is also consistent with empirical results in corporate finance studies that CEOs' network is negatively associated with CEOs pay-performance sensitivity and positively associated with CEO compensation (Brown et al. 2009; Hwang et al. 2009).

3.2 Corporate Alliances and Plants' Pollination

Pollination is the method for plants to reproduce. There are two types of pollination, self-pollination and cross-pollination. Self-pollination means flowers acquire pollen from the same flower or acquire pollen from other flowers of the same plant. Unlike self-pollination, cross-pollination means flowers obtain pollen from other plants (Sleper and Poehlman 2006).

In order to survive the competition, companies may decide to join the alliances (Harrigan 1988). There are also two types of alliance, horizontal alliance and non-horizontal alliance. When comparing the pollination and the alliance, we will find that horizontal alliance is similar to self-pollination and non-horizontal alliance is similar to cross-pollination. More specifically,

horizontal alliance, created by partners from the same industry, is like self-pollination which obtains pollen of the same clone. Non-horizontal alliance, created by partners from different industries, is like cross-pollination which obtains pollen from other plants. Hence, we would like to use the knowledge of plants' pollination to corporate alliances.

Horizontal alliance and non-horizontal alliance have their own advantages. Horizontal alliance is superior when we consider the transaction cost, increase of firm value and information asymmetry (Harrigan 1988; Chan et al. 1997; Gomes-Casseres et al. 2006). Non-horizontal alliance is better when we consider the risk sharing and competitive relationship (Contractor et al. 1986; Hamel et al. 1989). Currently, intangible assets become more and more for a corporation. In 2006, Gomes-Casseres et al. discuss the horizontal alliance and non-horizontal alliance from the aspect of knowledge flows within alliances. They prove that the knowledge flow within horizontal alliances is stronger than that within non-horizontal alliances. In reality, however, there are more non-horizontal alliances. This leaves an unanswered question, whether horizontal alliance or non-horizontal alliance is better.

If we regard this issue from the plants' pollination, we will know that horizontal alliance is better in short term but non-horizontal alliance is better in long term because of the subsequent finding. Scientists who study the plants' pollination prove that plants will use self-pollination to quick spread because the success rate of self-pollination is much higher (Kahn et al. 1991; Weberling and Pankhurst 1992). Additionally, they indicate that cross-pollination creates the gene variation which is beneficial for plants to survive in the dynamic environment (Weberling and Pankhurst 1992; Sleper et al. 2006). This finding is consistent to the results that the performance of knowledge flows within non-horizontal alliance is better than that within horizontal-alliance (HSU 2009). HSU (2009) interprets that acquired knowledge from non-horizontal alliance significantly contribute to a company's future development; nonetheless, horizontal alliance sample does not have the statistic significance.

In 2006, Sleper et al. point out that the amount of cross-pollination plants is higher than that of self-pollination plants in the world. This is consistent with the facts that there are more non-horizontal alliances in the world. Shortly, if a company wants to reach the higher market share, it can join a horizontal alliance and more easily obtain the knowledge from its allied partners. Nevertheless, if this company likes to sustainably operate, it is supposed to join a non-horizontal alliance and receive more different knowledge to increase its competitiveness.

3.3 Other Potential Future Researches

From the above discussions, we know there may be more lessons the corporate finance can learn from other complex systems. For example, studying the food chain of the nature may inspire

some thoughts of supply chain. The connection among different layers of these two chains is non-linear. Since scientists have studied food chain for a long time and have established basic theories, we might reviews these related literatures and try to figure out some suitable methodology and theories for supply chain in corporate finance. In fact, the effects corporate finance hopes to understand often belong to non-linear relationship such as the announcement effect of issuing dividends or new shares. We can also utilize the existing knowledge about non-linear relation in other complex systems to corporate finance researches.

Besides, financial literatures often use numeral indicators to present the performance. For instance, people often use stock price to measure a firm's performance in financial studies. However, it often creates the contradiction with the real world. Complex system can also supply a rational explanation. For example, Rajan et al. (2000) interpret that there is a negative effect on firm value after diversification. Nevertheless, the truth is that corporations tend to diversify in order to compete with other companies. According to complex system, the components within this system will self-organize. In other words, interaction within a company and a company's interaction with its environment result in a company's diversification. This may not be the outcome of calculating stock price in advance.

In addition, finance studies usually hope to realize the effect of one behavior and the relationship between two parts. However, there are much more factors that will influence the results and it is hard to extract the pure affect. Thus, we may attempt to analyze financial issue from the view point of complex system and we may discover more interesting and accurate facts.

4. Conclusion

This paper presents the connection between corporate finance and complex system. Because of complex system's adaptability, we can use the known researches in other complex systems to solve the similar problem corporate finance filed facing. In this article, we illustrate two specific examples to show the potential that combine corporate finance and other complex systems. This is also the first paper that discusses corporate finance and complex system in details with empirical results.

In order to apply the knowledge from other complex systems, we first clarify the targeted systems such as a corporation and plants system are complex systems. When learning from bamboo's structure, we realize that if CEOs' network is stronger, CEOs' power is larger and CEOs' turnover rate is lower. When learning form plants' pollination, we understand that if a company desires to increase its market share in a short time, it could get involved in a horizontal alliance and receive higher knowledge flows. If a company desires to operate with sustainability, it should get involved in a non-horizontal alliance and receive the knowledge more beneficial for the future development.

To conclude, this paper provides examples that discuss corporate finance issues from the viewpoint of complex system. As a matter of fact, there is much more wisdom of complex system we can apply to corporate finance. Hope this article can stimulate more creative studies and give corporate finance a new direction.

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