成群結隊的董事們：董事多重連結研究

研究生：劉顯仲　　　　　　　　　　　　　　　　　　指導教授：楊　千

國立交通大學經營管理研究所博士班

摘　　要

董事會與董事行為是公司治理研究的重要議題，本研究探討董事行為的一個普遍但是未曾被仔細探討的現象–董事成群結隊。董事成群結隊是指兩位董事同時擔任相同兩家或更多公司的董事或者是多位董事同時擔任相同兩家或更多公司的董事。傳統的董事會連結文獻稱此種現象稱為多重連結。多重連結普遍存在，例如在國內 (2004 年 12 月資料)，徐旭東與席家宜兩位先生同時擔任亞泥、遠紡、宏遠、東聯、遠東商銀等五家公司董事，是雙重連結到五家公司。許勝雄、柯長崎與郭賢明三位先生同時擔任金寶、統寶、建榮等三家公司董事，是三重連結到三家公司。嚴凱泰、陳莉蓮、蘇慶陽、吳舜文、徐善可、戚維功、陳國榮、黃日燦、黃文成等九位先生女士同時擔任裕隆與中華兩家公司董事，是九重連結到兩家公司。

本研究嘗試解答三個問題。第一個問題，董事多重連結是巧合抑或是有意識的行為？第二，多重連結如果是策略性的行為，參與如此行為的董事以及董事會有何特徵？又為了什麼原因？第三，董事成群結隊對公司績效的影響是正面或者是負面的？

本研究提出一個成群結隊的社會網路模型以探討第一個問題，經由電腦模擬比較隨機網路與成群結隊模型產生的網路，發現成群結隊模型產生的網路遠比隨機網路更近似真實世界的董事會網路。因此推斷董事多重連結並不是隨機行為。第二以及第三個問題則經由統計分析台灣 2005 年董事會資料來解答。迴歸分析結果顯示，控制大量國內公司資產的董事、擁有一家公司多數股份的董事以及內部董事比較會參與多重連結。最後，董事會中有成群結隊董事的公司，績效較差。

關鍵詞：公司治理、董事會、董事會連結、董事會多重連結、關聯網路、網路模型。

Multiple Interlocks of Corporate Directors

Student：John S. Liu Advisor：Dr. Chyan Yang

Institute of Business and Management
National Chiao Tung University

ABSTRACT

Behaviors of corporate board and their directors are one important area of corporate governance research. This study examines in detail the herding phenomenon, a commonly observed but not fully studied behavior of corporate directors. Herding is the multiple interlocks of corporate directors, or, the situation when a group of board directors who sit side-by-side on not just one but several company boards. Such tight mutual relationships exist in virtually all corporate governance systems. Three research questions are addressed. First, is such tight mutual relationship a coincidental and random behavior or a strategic behavior? Second, if such tight mutual relationship is formed of strategic purpose, what kind of directors and boards are involved? And for what propose? Third, what is the impact of herding on corporate performance?

To address the first question, an affiliation network model that captures the herding behavior is proposed. The proposed model is a simulation model based on the arbitrary degree distribution concept developed by Newman, Strogatz and Watts (2001). The intensity of herding is controlled by two parameters, one is the size of the actor pool; the other is the number of times for an event to continuously select actors from the same pool. By choosing a proper mix of these two parameters, this research is able to reproduce networks that carry properties very similar to the board of directors network in Taiwan. Several parameters highlighting the herding behavior such as bipartite clustering coefficient (Robins and Alexander, 2004), redundancy coefficient (Latapy et al., 2006), social inertia (Ramasco and Morris, 2006) and herding balance are all in better approximation to the real-world board network than to the random generated networks. The fact that the reproduced networks deviate from the random networks but closely similar to real-world network provides strong evidence that herding is a crucial social process that is at work in real-world board of directors networks.

Second and third research questions are addressed through statistical regression analysis. A sample of Taiwan's board of directors network in the end of year 2005 is analyzed with binary logistics regression model. The research unit includes a pair of boards and a pair of directors which have potential to form multiple interlocks. This is different from the common approach that uses either the board or the director as the research unit. Under such a design, the effects of the attributes of board and directors are investigated at the same time. Statistical analysis results indicates that directors who control a large amount of effective assets in the corporate world, own a high percentage of equity in a company, or hold an inside management position are more likely to be involved in multiple firm interlocks. Taken together, controlling shareholders and their associates are the main individuals who are involved in multiple interlocks. Finally, corporate boards which involved in multiple interlocks show inferior financial performance.

This study contributes to the corporate governance literature in four aspects. First, it is the first study that explores in detail the multiple interlocks phenomenon in the corporate world. Second, it confirms that a certain portion of director multiple interlocks are created intentionally rather than coincidentally. Third, it hypothesizes and provides evidence that the multiple interlocks of boards and directors in corporate Taiwan is formed by controlling shareholders and their associates when these individuals monitor their investments together. Fourth, company financial performance is found to be negatively related with multiple interlocks.

Keywords: Corporate governance, interlocking directorates, multiple interlocks, board of directors, affiliation networks, bipartite graph, network model

誌　　謝

隨著年歲的增長，對「學海無涯」的意義更加能深刻體會，在無盡的瀚海中尋覓，經常失去方向，有人卻能以一兩句精簡卻飽含智慧的提示，就解開了心中的迷惑，楊千老師所扮演的指導教授角色，就如同他給人的印象，精鍊而且關鍵，句句觸中要害。其它如待人處事方法的指導與各種機會的引薦也是與楊老師學習的意外收穫。

丁承老師、胡均立老師以及曾芳代老師提供它們各自專業上的意見，具體、務實且具建設性，對後續研究方向有深刻的啟發。

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我的家人，體諒鑲嵌在我個人體內終生學習基因所造成的讀書「嗜好」，無數個週末的親子休閒時間，放棄攜我同行，並給與我最大的支持與鼓勵，就這樣，完成了學業。

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BCC : bipartite clustering coefficient

n_{N} : total number of N-links in an affiliation network.

n_{B} : total number of butterfly-links in an affiliation network

I_i : social inertia for node i

s_i : node strength for node i

k_i : degree for node i

rc_i : redundancy for node i

hb_k : herding balance for multiple interlock cluster k

HI_j : holder index for director j

CI_j : control index for director j

1. Introduction

1.1 The importance of corporate governance

Corporate governance has been an important research topic and has become even more so since the collapse of Enron and WorldCom. While there is a large amount of empirical literature focusing on the corporate governance in the wealthy countries, little is on the rest of the world. In fact, corporate governance in the emerging economies needs more attention than the well established economies because their state of governance is more susceptible to breed companies like Enron and WorldCom. One corporate governance failure reminiscent of the Enron scandal occurred in Taiwan recently in January 2007. Rebar group, one of the largest conglomerates in Taiwan, fell into deep financial trouble. Members of the controlling family were discovered to embezzle a total of 2.21 billion US dollars from the shareholders of the group's related companies. This corporate governance failure is the largest ever in Taiwan. The Rebar scandal was not the only case in the emerging economies. It highlights the urgency of sharing corporate governance experiences in various emerging economies so that corporate governance failure does not repeat itself. This research provides Taiwan's experience on an interesting subject of the corporate governance research, the multiple interlocks among corporate boards and directors, or director herding.

1.2 Multiple interlocks and interlocking directorates

A group of corporate elites who sit side-by-side in not only one but also on several company boards is given the term "multiple interlocks" in the literature (Stokman and Wasseur, 1985; Battiston et al, 2003; Robins and Alexander, 2004).[1] While "board overlap" is a similar way of describing the phenomenon (Loderer and Peyer, 2002), multiple interlocks refers to board overlap of two or more directors. Multiple interlocks are special cases of the more general interlocking directorates, which include single interlocks and multiple interlocks. One director serving on more than one corporate board creates single interlocks between these firms. Two or more directors on more than one corporate board at the same time create multiple interlocks. Sitting side-by-side either by chance or by design, multiple interlockers can form influential subgroups on corporate boards. These subgroups tend to lobby and affect the decision of the boards they sit on (Battiston et al, 2003), and in doing so, corporate directors involved in multiple interlocks may become the central power of the board they

[1] There is one exception in using the terminology "multiple interlocks". Barnes and Ritter (2001) refer to "directors who sat on three or more boards" as "directors involved in multiple interlocks." Such directors are not necessarily involved in reciprocal interlocking. In this study we follow the definitions used in the majority of the literature.

serve. In addition, these multiple interlockers strengthen the relationship between the companies they serve and largely increase the function of interlocking directorates such as policy coordination and information sharing.

Interlocking directorates has been a major area of corporate governance studies for several decades (Mizruchi, 1996). However, not many in the literature look into the phenomena of multiple interlocks. Multiple interlocks are mentioned in several literature studies on interlocking directorates, but are not the main focus of these studies (Stokman and Wasseur, 1985; Canna et al., 1999; Heemskerk et al., 2003; Robins and Alexander, 2004). This study focuses on multiple interlocks and examines the phenomenon in detail under the corporate governance context in Taiwan.

One example of multiple interlocks is the heavy interlocking among the companies in the Rebar group. Boards of the five listed companies of the Rebar group are heavily overlapped. Two major companies in the group, China Rebar and Chia-Hsin Food & Synthetic Fiber, have eight directors in common. These two companies also have two or three directors in common with Union Insurance and Chinese Bank. Figure 1.1 shows multiple interlocks among the five companies in the Rebar Group.

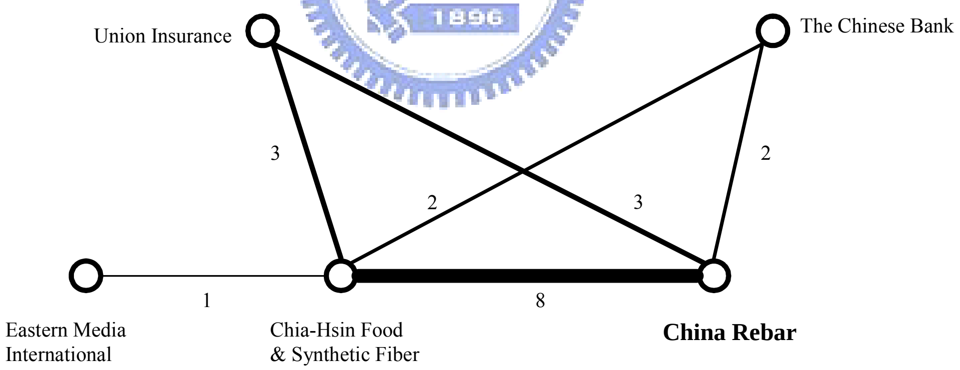


Figure 1.1 Multiple interlocks among companies in the Rebar group

Note: This figure shows multiple interlocks among five listed companies of the Rebar group. Line widths drawn as well as the numbers marked are according to the total number of common directors between the two companies. The two major companies Chian Rebar and Chia-Hsin Food & Synthetic Fiber have total eight common directors.

Classical interlocking directorate studies do not distinguish single interlocks from multiple interlocks, as they are treated as one general phenomenon. The main purpose of this study is to take one step further to examine specifically the phenomenon multiple interlocks. Somewhat similar research studies in the literature are those covering CEO reciprocal interlocks (Fich and White, 2005; Yeo et al., 2003). This study on multiple interlocks fills the gap in-between the classical interlocking directorate studies and that of CEO reciprocal interlocks. By filtering out the single interlocks, a behaviorally stronger phenomenon can be addressed. A group of directors sitting on several boards together is certainly less likely to happen than only one director sitting on several boards. By including directors other than CEOs in the scene, the scope of study is richer. This is especially proper in Taiwan where there are sometimes no clear line between the role of the CEO and the chairman of the board, and whereby CEO reciprocal interlocks are not common.

1.3 The network view on multiple interlocks

Multiple interlocks or director herding can be studied from a network point of view, or more exactly, from an affiliation network point of view. Affiliation network is one common form of network that consists of two distinct groups of nodes. Nodes in each of the two groups do not connect to their counterpart in the same group directly. Relationship among the nodes in the same group, however, can be established indirectly through their direct association with the nodes in the other group. In social network terminology, the two distinct groups are called events and actors. The real-world examples of events include corporate boards, movies, academic articles and soccer teams, etc. The corresponding actors include directors of boards, movie actors, authors and soccer players, etc.

An affiliation network is commonly mapped into two one-mode projection networks, the event network and the actor network. Event network has the events as nodes. Links between any two events are established if they directly associated with the same actor in the original affiliation network. Link weight is the number of distinct actors they are associated with. Actor network has the actors as nodes, and the links and weights are established the similar way. It should be noted that certain information embedded in the affiliation network is lost when it is mapped into one-mode network.

Real-world affiliation networks carry an interesting characteristic that is attracting more attention recently. That is, there exist heavily linked clusters of events and actors. Two or more events may be associated with several actors, and two or more actors may be associated with several events at the same time. For example, in co-authorship networks, two scientific articles may be co-authored by not one but several authors. On the other hand, the same two authors may appear in several published articles together. This phenomenon is named *herding*, the same two or more actors participating in the same two or more events in an affiliation network. Paraphrasing in the terms of board of directors, herding is the multiple interlocks of directors, or, the situation that a group of board directors who sit side-by-side on not just one but several company boards.

A herding cluster can be *balanced* if the numbers of the events and actors in the cluster are the same, *wide* if the number of the actors is greater than the number of the events, or *deep* if otherwise. Two authors appear in two published articles together is balanced herding. Five authors appear in two published articles together is wide herding. Two authors appear in five published articles together is deep herding. Real-world board of directors networks seem to have more wide herding clusters than deep herding cluster. Figure 1.2 shows the difference between wide and deep herding. Wide herding contributes heavier link weights to the one-mode event network than to the actor network. The effect of deep herding on link weight in one-mode networks is reversed.

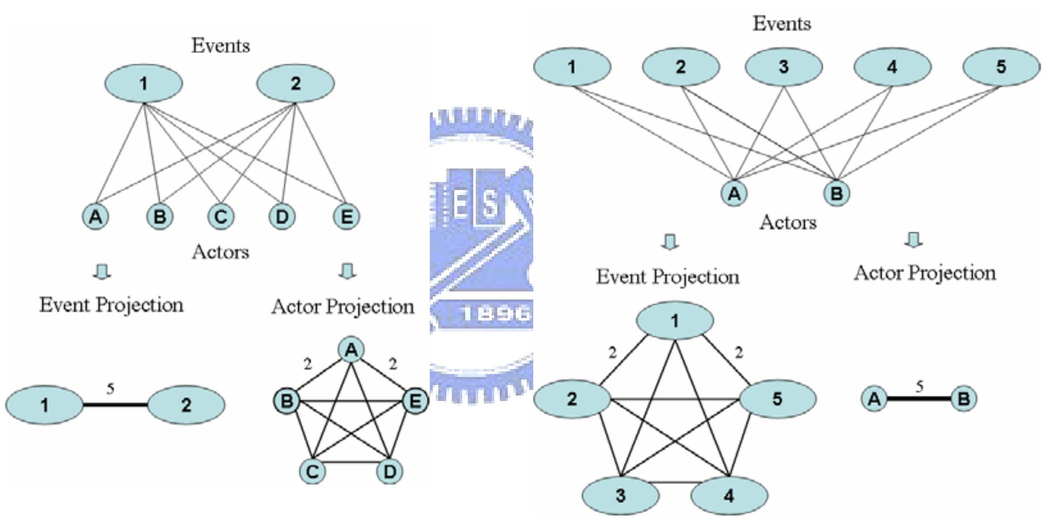


Figure 1.2 Schematic representations of wide herding (left) and deep herding (right).

Note: For wide herding, the number of the actors in the cluster is greater than the number of the events. For deep herding, the number of the events is greater than the number of the actors. Note that wide and deep herding have different effects on the link weights in the projected one-mode networks.

Why do directors go in groups to form multiple interlocks? Are the rationales to form multiple interlocks different from that of forming single interlocks? Literature provides few hints on this question. For general director interlocking, Mizruchi (1996) summarizes five causes. They are collusion, cooptation and monitoring, legitimacy, career advancement and social cohesion. Career advancement and social cohesion can be seen as individual oriented motivation, the others are organization oriented. While each of these rationales certainly has contribution to multiple interlocks, it is hypothesized that monitoring is the major cause for multiple interlocking. That is, multiple interlocks are mainly formed as a result of control and monitoring of company investments by controlling shareholders.

1.4 Research objectives

The phenomenon of directors in herds has becomes an important subject of study in the corporate governance discipline. Herding could have interesting political influence in a boardroom and important economical impact to a corporate. A group of directors that forms a lobby in a boardroom could have power more than what their accumulated votes can offer. This distorted power structure may further causes uncharacteristic corporate economical outcome be it is good or bad. From the complex network point of view, properties of network topology induced by herding are not well understood at this moment in time. It is important to explore the network topology and to formalize the understanding on networks characterized with herding.

Previous studies model the affiliation networks without looking specifically at herding. Both the theoretical and simulation results were based on random assumption and achieved only limited success in simulating the real-world networks. This posts a big question on that if herding is merely a result of random association among corporate directors. The first research objective is thus to answer the question: is herding a coincidental phenomenon, or a strategic social process?

If herding is not a coincidental phenomenon but a strategic social process, then it is of both academic and practical interests to further discover that directors of what characteristics are participated in herding. From the finding, it may be inferred on their intention to do the herding and the consequences of such herding. The second research objective is then to find out that who are the people involved in herding, and for what purpose? The third research objective is to answer the question: is herding good for company performance?

1.5 Research flow

This study addresses the three research questions with two methods: simulation and statistical testing. Data of Taiwan's corporate board and director is first collected and transformed into an affiliation network. This affiliation network is used as the base for network simulation and statistical analysis. Hypotheses are developed based on predictions from literature. Research flow is presented in Figure 1.3.

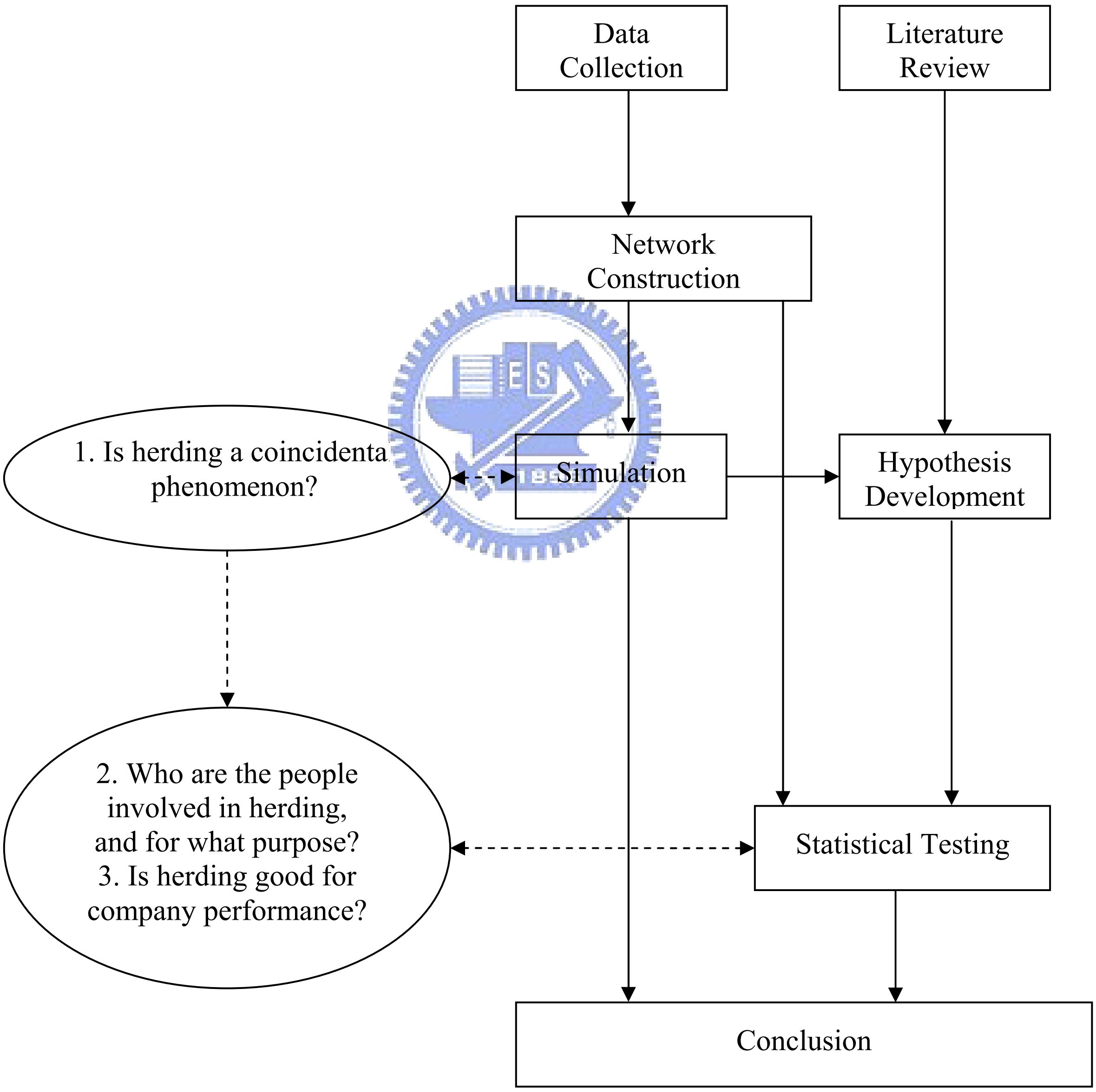
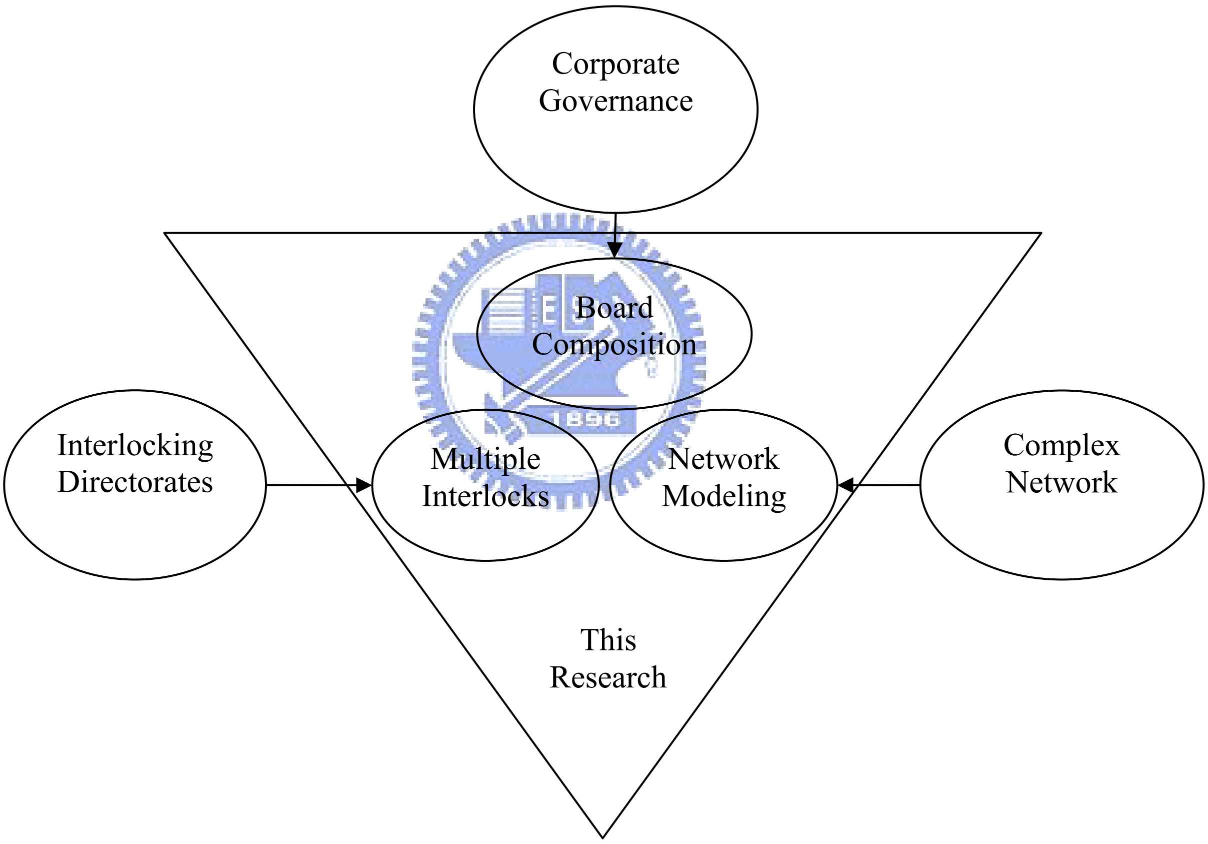


Figure 1.3 Research flow

1.6 Position of this research in the literature

Although the three main questions addressed in this research are corporate governance questions, they are rooted in three separate academic disciplines. Network modeling in complex network research inspire the methods to the first research question. Multiple interlocks and its composition are a special topic in the general interlocking directorates literature. Board composition and its effect to financial performance of a company is one of the key focuses in corporate governance research. This research is interdisciplinary in the sense that it is positioned at the interfaces of corporate governance, interlocking directorates and complex network disciplines.



1.7 Organization of the document

The remainder of this document is organized as follows. Chapter 2 reviews related literature. Chapter 3 elaborates on various herding measures. Chapter 4 presents basic board and director related statistics in corporate Taiwan. Chapter 5 discusses the simulation scheme and the simulation results. Chapter 6 provides the hypotheses development details and the statistical analysis results. Chapter 7 summarizes findings and concludes.

2. Literature Review

2.1 General corporate governance

As suggested by Shleifer and Vishny (1997) “The fundamental question of corporate governance is how to assure financier that they get a return on their financial investment.” Since Jensen and Meckling (1976) applied the agency theory to explain the operations of modern corporations, theoretical and empirical research in corporate governance have attracted the attention of scholars in various fields. The financial scandal of Enron and WorldCom made the awareness of good corporate governance practice more imminent.

Denis and McConnell (2003) suggested two generations of corporate governance research. First generation corporate governance researches emphasize mainly the corporate governance practices in the U.S. At the center of the relevant issues includes board of directors, ownership and control and the external control market. Board of directors studies the board composition and executive compensation. Ownership and control works on the issues such as ownership concentration around the world, ownership change via privatization and the private benefits of control. The external control market quests the effect of takeover market on the efficiency of corporate governance.

Second generation corporate governance researches shifted the focus to the systems and laws in protecting the investors, as well as the comparison of corporate governance systems in various countries. La Porta et al. (1998) began this stream of study. The main argument in their study was that the extent of the law and the efficiency of executing these laws in protecting the investors determine the level of corporate governance of a country. Data from 49 countries were collected and analyzed. The countries with low level of investor protection were found to have higher level of stock concentration and that was a reasonable response to the deficiency of law protection. The research issues in second generation studies include legal protection and economic growth, control vs. ownership, etc. One signature of the second generation studies is the comparison of the status and evolving patterns of corporate governance in different countries.

La Porta (1999) in a study on large companies in 27 wealthy economies suggested that families control most large companies in 27 wealthy economies and that these families obtain power using chain of control and participation in management. Claessens et al. (2000) and Yeh et al. (2001) further confirmed that family control prevails in Taiwan. Controlling families typically exercise chain of control and participation in management by sending associates to these subsidiaries. Multiple interlocks can be largely formed in these situations.

One major suggestion made by Denis and McConnell (2003) for future corporate governance research was the study of corporate governance systems of countries other than the U.S., Great Brittan, German and Japan. This study responds to the suggestion and focus on the board composition issue of corporate Taiwan. One contribution of this study is that it relates multiple interlocks of board directors to the empirical results of La Porta (1999).

2.2 Interlocking directorates and multiple interlocks

Interlocking directorates has been an important field of study for several decades. Two major theories in the literature propose the function of interlocking directorates. They are the resource dependence theory and the class hegemony theory. The resource dependence theory posits that the reason for organizations to exchange their resources through interlocks is to overcome the environmental uncertainty. Class hegemony theory instead has that the reason for interlocks is to control the economies and benefit the directors who involved in the interlocks.

Mizruchi (1996) summarizes five causes for interlocking directorates. They are collusion, cooptation and monitoring, legitimacy, career advancement and social cohesion. Career advancement and social cohesion can be seen as individual oriented motivation, the others are organization oriented. Collusion indicates the intention for interlocking among competing companies is to reduce competition. To avoid collusion, Section 8 of the U.S. Clayton Act of 1914 forbids the sharing of common directors among competing companies. Cooptation is the adaptation to environmental uncertainty. For example, firms may invite its financing banks to sit in their board. Monitoring occurs when institution investors join the board in order to keep track or even to take control of the activities of the companies their put their money in. Company may invite celebrities or public figures to sit on their board. The endorsement from these public trusted figures can attract investors and gain more public support. Therefore, legitimacy is one of the causes of interlocking directorates. Interlocking directorates can be resulted from the pursuance of director's personal benefits. Attending multiple boards is very like to extent a director's personal network, which can be beneficial to his career advancement. Being a director on multiple boards is also a status symbol. This indicates social cohesion is another cause of interlock directorates.

As far as the consequences of interlocking directors, traditional view has that it is positive to corporate governance. Information sharing and experience transferring through interlocking directors can reduce the risk in managing in uncertain environment. Empirical results, however, are inconsistent. Most of the literature found that interlocks are negatively related to a firm's financial performance (Mizruchi 1998). Others, on the contrary, found positive relation.

Mizruchi (1998) summarized the research results on the consequences of interlocking directorates and indicated that although empirical results are inconsistent, one can not claim that interlocks do not link to the strategic choices of companies. Some quotations of this much quoted work are as follow: "… the issues of whether interlocks actually affect the firms involved remains the subjects of much debate, as research has produced mixed and contradictory results." "I argue that, …., interlocks remain a powerful indicator of network ties between firms. When properly applied, I suggest, they continue to yield significant insights into the behavior of firms. ……. But it is incorrect to claim that interlocks 'just do not predict much that is interesting in the strategic choices of firms'. The evidence that they do predict such choices is overwhelming."

Carpenter (2001) studied 600 U.S. companies and found that, in a stable environment, directors who sit on strategically related 'other' board can improve their director function in the original board. In a unstable environment, it is the directors who sit on strategically non-related 'other' board improved their director function. Haunschild (1998) examined not the direct effects of interlocking directorates but that of the intermediate factors.

There are several studies examine interlocking directorates in Asian counties. Peng (2001) studied 200 listed companies in Thailand. The main founding was that MNEs have denser interlocks than non-MNEs. Ong (2003) examined 295 listed companies in Singapore. Market value, board size, total assets and profit before tax are positively related to interlocks. This is support the bank control theory and resource dependence theory. Another study on Singapore companies reached similar conclusion. Phan (2003) worked on 191 Singapore listed companies and found that interlocks is positively related to company performance.

Battiston (2004) studied the network among stockholders of the Italian stock market (MIB) and US stock market (NYSE and NDSDAQ). The main founding was that 0.94% of the stockholders effective control 50% of the NYSE companies. This is in comparison to 1.65% of NASDAQ and 12% of MIB. The concentration of stock shares of U.S. listed companies is much higher than Italian companies. The stock index and holder index concept proposed in Battiston (2004) are adopted in this study.

A few interlocking directorates literature mentioned multiple interlocks of directors. Stokman and Wasseur (1985) compared multiple interlocks among ten European countries. The comparison was made based on multiple link percentages. Canna et al. (1999) studies interlocking directorates of 500 financial firms and 200 non-financial firms in Ireland and compare his results with that of Stokman and Wasseur (1985). The results were that the level of multiple interlocks of Irish board networks is of much lower level than that of the other ten

European countries. It should be noted that these studies described the multiple interlock phenomenon and provided descriptive statistics but did not delve into empirical analysis. This study is the first that conduct empirical analysis on multiple interlocks of corporate directors.

Heemskerk et al. (2003) compares the interlocks among large Dutch firms in 1976 and 1996. An interesting founding was that the level of interlocks reduced 25% after 20 years. The level of multiple interlock for financial companies reduced even more. Mean multiplicity multiple lines were used as measures for multiple interlocks. Battiston and Catanzaro (2004) found that multiple interlocks is a macroscopic phenomenon. There are 35% of the U.S. boards involved in multiple interlocks (1999 data). The equivalent number for Italy is 44% (1986 data) and 63% (2002 data).

Robins and Alexander (2004) adopted a different approach in studying multiple interlocks. Rather than examine the board network or the director network, bipartite network is examined directly. Bipartite clustering coefficient was first proposed in this article. The main founding was that the network structures tend to be influenced by the clustering of directors on boards, rather than the accumulation of many board seats by individual directors - “big linkers”. Therefore multiple interlocks is the main structure factor in the U.S. and Australia board of directors network.

A group of directors who sit on multiple boards can be regards as lobby (Battiston and Catanzaro, 2004) as their opinions can have heavier weight than their vote count. Battiston et al. (2003) study the effect of size and topology to a boards’ strategic decision applying simulation techniques. The main conclusion was that lobby could actually drive the decision of the board. This further emphasizes the importance of multiple interlocks.

A special situation when CEO cross sitting on each other’s board is called CEO reciprocal interlocks in the literature. Hallock (1997) studies the effect of CEO reciprocal interlocks on executive compensation. There are 8% of the large boards in study involved in CEO reciprocal interlocks and that compensation of CEO in these boards are higher than their counterparts in non-reciprocal boards. Fich (2004) examined Forbes 500 board and found that CEOs who sit on each other’s boards did so mostly for their personal benefits rather than that of stockholders. Yeo (2003) studied CEO reciprocal interlocks of French firms. The larger the company is, the more likely their CEO sits on each other’s board. The same study found that a firms ROA is positively related to CEO reciprocal interlocks.

2.3 Affiliation network models

One important issue in network study is to find an equivalent random network as the base for comparison or normalization. Equivalent to what extent, or how much alike would the proposed model emulate real social networks, is the center theme of many affiliation network studies. Newman (2000), Albert and Barabási (2002), and Dorogovtsev and Mendes (2002) provided thorough and detailed reviews on the subject. Intuitively, two networks with the same number of nodes and average degree would be the simplest form of equivalence. Newman et al. (2001, 2002) argued that degree distribution could also play a crucial role. Degree distribution certainly embeds the average degree of information. Therefore, it is best for an affiliation network model to consider both the number of nodes and degree distribution of information. Newman et al. (2001, 2002), and Guillaume and Latapy (2004) are two examples of a random graph model that requires the prescription of degree distribution.

Erdös-Rényi random graphs (1959) and the WS small-world model (Watts and Strogatz 1998) are the two widely referenced models in the literature. One issue with these two models is that their degree distribution does not match that of real-life networks. For example, the Erdös-Rényi model has Poisson degree distribution and the WS small-world model features a degree distribution of a Poisson kind (Barrat and Weigt 2000). Most social networks have been verified to have non-Poisson degree distribution. One needs to be careful in interpreting the result predicted by these two classical models. In addition, they both operate on one-mode networks. Newman et al. (2001) suggested that "the construction of the one-mode network however involves discarding some of the information contained in the original bipartite network, and for this reason it is more desirable to model collaboration networks using the full bipartite structure." We will focus our discussion on a genuine bipartite model in this section.

One widely used bipartite random network model is the arbitrary degree distribution model (Newman et al. 2001, 2002). The model applies to both one-mode and two-mode networks. Conyon and Muldoon (2006) well summarized the two-mode elements of the model and applied the model to board and director networks. Assuming one has a group of boards and directors, the total unique number of boards M and directors N are known. In addition, the degree distribution for both boards and directors are given. In other words, one knows the spread of board size (e.g. 100 boards have 8 director seats, 50 boards have 10 director seats, etc.) and the spread of director engagements (e.g. 20 directors sit on 3 boards, 50 directors sit on 2 boards, etc.) To simulate a random affiliation network, one begins by randomly assigning each board with seats and directors with engagements according to their respective degree distribution. It is important to make sure that the resulting number of board seats and director engagements are exactly the same; if not, redo the process until the above condition is met. For the next step, one links board seat to directors one-by-one randomly with the restriction that no director should be linked to the same board more than once. A random affiliation network is then generated. One can run the simulation procedure multiple times. Averaging out the properties of all these randomly generated networks, one obtains reference properties of equivalent random affiliation networks.

Newman et al. (2001, 2002) were able to predict mathematically some averaging properties, including path length and transitivity, of the two one-mode projections of random affiliation networks generated this way. The theoretical prediction allows us to escape from the computer simulation process. This arbitrary degree distribution model is more realistic than the Erdös-Rényi random graphs and the WS small-world model not only because it is grounded on the two-mode structure, but also because it imitates the degree distribution. It should be noted that this model is a 'random' model. The real-world social network, as we expected, should have some structure embedded. The arbitrary degree distribution model is useful more as a reference to gauge structure properties than as a tool to predict that of real-world social networks.

Another widely used model is the exponential random graph model or the p-star model. Rooted in Holland and Leinhardt (1981) and Strauss (1986) works, the model takes a rudimentary view to the network structure. The basic idea is that networks are regarded as being constructed by a set of components or building blocks. These building blocks can be edges, 2-stars (open triples), triangles, and other higher-level forms. The numbers of these components in the network are treated as explanatory variables in the model. One fits the model to a known network by properly assigning a set of structural parameters. Each parameter indicates the importance of its corresponding building components in the network. In a general model, explanatory variables can include not only simple counts of components, but also network statistics such as transitivity or path length. The simplest form of the p-star model, referred to as the Bernoulli graph distribution in the literature (Frank 1981, Frank and Nowicki 1993), consists of only edges. Wasserman and Pattison (1996) is an excellent source on the subject. Based on this model, Robins et al. (2005) proposed a simulation scheme to generate an ensemble of networks according to the given structural parameters. The simulation scheme turns out to be a very useful tool to verify the effect of each network components. If one would like to examine the effects of certain network components, then one simply gives high value to parameters of these components and then checks the properties of the resulting network ensemble. In addition, one can use the simulation scheme to generate a Bernoulli graph distribution, where the ensemble of the networks consisted of only single edges. The Bernoulli graph distribution is naturally the equivalent random network that can be used to gauge small-worldliness. The application of the exponential random graph model is not limited to unipartite networks. Robins and Alexander (2004) applied the same simulation scheme to a bipartite network, generating equivalent random bipartite networks as the comparison base.

In sum, the arbitrary degree distribution model (Newman et al. 2001, 2002) provides a suitable base for this study to do further improvement.

3. Herding Measures

How extensive is the multiple interlocks phenomenon? The literature has reported multiple interlocks in several different measures. Stokman and Wasseur (1985) calculated multiple interlocks using the percentage number of multiple links among all links in the board network. For ten European countries, the number ranges from 7% (Britain) to 33% (Belgium) in 1976. Caldarelli and Catanzaro (2004) reported the percentage number of boards that share more than one director with others for Italy and the U.S., which is 44% and 63% for Italy in 1996 and 2002, respectively, and 35% for the U.S. in 1999. Heemskerk et al. (2003) provided the information of the average multiplicity of multiple links,[2] where the average multiplicity of the Netherlands ranges from 2.46 in 1976 to 2.11 in 1996. Among the three measures mentioned above, one counts the number of multiple links in the board network, one counts the number of multiple interlocking boards, and the other measures the average multiplicity of the board network. Recently, several new measures were proposed. They are the bipartite clustering coefficient, social inertia, redundancy and herding balance.

3.1 Bipartite clustering coefficient

The measures mentioned above are many facets of a more generic measure based on a bipartite network – the bipartite clustering coefficient.[3] The bipartite clustering coefficient was introduced by Robins and Alexander (2004) to measure "the extent to which directors re-meet one another on two or more boards". Suppose Directors *a* and *b* sit on Boards *1* and *2*, respectively. Director *b*, at the same time, sits on Board *1* and interlocks Boards *1* and *2*. The mutual relationships among Directors *1* and *2* and Boards *a* and *b* form a three-path (L3, or N-link) in social network terminology. If Director *a* is invited to join Board *2*, then the structure formed by Directors *1* and *2* and Boards *a* and *b* becomes a multiple-link (C4, or

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[2] If two corporate boards share more than one director, then the link between them is multiple. The "multiplicity" of such a link is defined as the number of directors that the two boards share. Average multiplicity is the average of such multiple links that are greater than one.

[3] Bipartite networks, or affiliation networks, are one common form of social networks. They display a natural bipartite structure that consists of two distinct groups or classes of nodes. In bipartite networks, relations among actors in the same group are established indirectly through a common association to the other group. Two familiar bipartite network examples are the movie and the actor networks where the movies and the actors are the two distinct groups; and the board and director networks where the boards and directors are the two distinct groups. "Bipartite clustering coefficient" is the bipartite network counterpart of the clustering coefficient (transitivity) in the normal 1-mode network.

butterfly link).[4] Corporate governance literature (Fich and White, 2005; Yeo et al., 2003) refer to C4 as reciprocal interlocks. Figure 3.1 shows the difference between an N-link and a butterfly-link. The bipartite clustering coefficient (*BCC*) is defined as the tendency of a N-link to become a butterfly link in a bipartite network, mathematically shown by:

$$BCC = 4 \text{ x (unique number of C4s) / (number of L3s), or}$$

$$BCC = 4 \cdot n_{\mathrm{N}} / n_{\mathrm{B}}, \quad (3\text{-}1)$$

where n_{N} is the total number of N-links and n_{B} is the total number of butterfly-links in an affiliation network. N-link is a foursome of nodes with at least three links among them, while butterfly-link is a foursome of nodes with four links. A foursome is a basic unit in affiliation networks that has potential to form multiple interlocks. It is composed of two event and two actor nodes. The subscripts in the notation mimic the link topology. Other alternatives of bipartite clustering coefficient are discussed in Latapy et al. (2006). In this study, *BCC* defined in Eq. (1) is adopted.

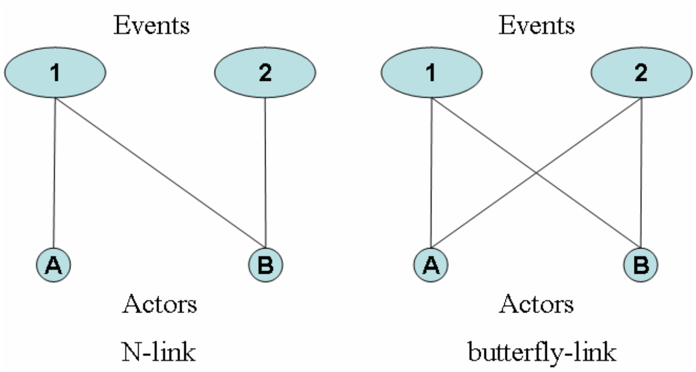

Figure 3.1 Schematic representations of N-link and butterfly-link.

Note: Bipartite clustering coefficient is defined as the probability of an N-link to become a butterfly-link in an affiliation network.

Since C4 is the basic element that forms multiple interlocks, the number of C4s provides a natural measure to multiple interlocks. BCC ranges from 0 to 1. It can be a local as well as global measure. The global BCC is ratio between the total number of C4s and L3s in the network. A large global BCC indicates that there are large numbers of multiple interlocks in the network. BCC is calculated from the generic structure of the corporate board network and is therefore a generic representation for the level of multiple interlocks.

[4] According to Robins and Alexander (2004), the letters in L3 and C4 refer to “line” and “circle”, respectively.

3.2 Social inertia

Social inertia was first introduced by Ramasco and Morris (2006). It is defined as the average link weight of a node in a one-mode network. Mathematically,

$$I_i = s_i / k_i , \tag{3-2}$$

where s_i is the node strength, k_i is the degree for each node i in the one-mode projected network. Node strength s_i is defined as the sum of the link weight extended from a node, that is,

$$s_i = \sum_{allneighborsof\, i} w_{ij} , \tag{3-3}$$

where w_{ij} is the weight for link between node i and j.

Social inertial measures the tendency of a group of boards or directors to keep on working together with previous partners. In the corporate world, if the same two directors tend to attend the same board together, they each have high social inertia. Or, if the same two boards tend to have the same directors sit in their board, they each also have high social inertia.

3.3 Redundancy

From the perspective of link efficiency, herding causes redundancy. When two event nodes can be associated with just one actor, additional actors that do the same are redundant. Redundancy coefficient is defined by Latapy et al. (2006) as

$$rc_i = \frac{\text{numberof redunant links}}{\text{numberof links this node} i \text{ generates}} . \tag{3-4}$$

In other words, redundancy coefficient is the fraction of pairs of neighbors of node i that link to another node.

In the corporate world, one common director between the two boards should be able to establish the communication channel between the two boards. Additional common directors are redundant. Similarly, two directors who sit on one board together are enough to establish their mutual relationship. Additional boards they work on together are redundant. Redundancy coefficient measures the level of redundancy for each director and board and in the affiliation network.

3.4 Herding balance

This research introduces a new coefficient hb_k that measures the balance of herding. It is defined as the logarithm of the ratio the number actors over the number of events in a multiple interlock cluster.

$$hb_k = \ln\left(\frac{\text{numberof actors}}{\text{numberof events}}\right). \tag{3-5}$$

Herding balance is zero for balanced herding, positive for wide herding, and negative for deep herding. The overall herding balance *hb* in an affiliation network is the sum of hb_k normalized by *nq*, the total number of unique multiple interlock clusters in an affiliation network.

$$hb = \frac{\sum_{k=1\sim nq} hb_k}{nq}. \tag{3-6}$$

The rationale for defining the herding balance measure is that there exists a combination of wide herding (the number of the directors is greater than the number of the boards in a herding cluster) and deep herding (the number of the directors is greater than the number of the boards) in a board of directors network. Some affiliation networks may have more wide herding clusters than deep herding clusters, while others may have otherwise. Herding balance indicates the level of the balance for each network. When observing an affiliation network in detail, herding balance provides additional information on the structure of the network. Two affiliation networks could have all the other herding measures matches quite well except the herding balance. Herding balance is therefore a particularly important measure in comparing simulation results.

It should be noted that bipartite clustering coefficient *BCC* and herding balance *hb* are global properties. On the other hand, both redundancy coefficient rc_i and social inertia I_i are local properties. From a different perspective, bipartite clustering coefficient, herding balance and redundancy are properties on affiliation networks; and social inertia is a property on one-mode projection networks.

4. Board of directors network in Taiwan

4.1 Sample

Board and director data in Taiwan as presented in the Taiwan Economic Journal (TEJ) database on December 2005 are collected.[5] The companies taken into consideration are those listed either on the main market (TSE) or the over-the-counter market (GTSM).[6] The database lists the names of directors and supervisors along with the names of the corporate boards on which they serve. The supervisors in Taiwan's corporate governance system are designed to monitor the board of directors. As with directors, supervisors are selected by shareholders in the shareholders' meeting. In practice, the roles of supervisors and directors are not as clearly separated as they were officially designed. Many of the supervisors are closely related to the owners or management of a company. Solomon et al. (2003) described in detail the function of supervisors on Taiwanese boards and offered a similar viewpoint. In order to seize the behavior of these corporate elites more faithfully, both the directors and the supervisors are included in the study and are herein refer to as directors.

4.2 Constructing the networks

The raw data are translated into an affiliation (bipartite) network whereby the boards and directors are the two distinct groups in the network and the links represent the directors' occupancy to the board seats. The affiliation network is then mapped into two one-mode networks – the board network and the director network. The nodes of these two networks consist of the boards and directors, respectively. The links in the board network represent the interlocks between the two boards. The links in the director network represent the interlocks between the two directors. Weights are assigned to each link and they represent multiplicity – the number of common directors shared by the two boards or the number of boards that the directors sit on together, respectively.

Figure 4.1 and 4.2 displays the constructed board network and director network, respectively. Only part of the network is shown as the full network is too large to be presented completely. Link weight is indicated both by numbers and thicker lines in the network graph. A large quantity of multiple interlocks is easily observed from the networks.

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[5] TEJ database provides business and financial data for many Asia countries. It is widely adopted by academic researchers in Taiwan.

[6] The TSE (Taiwan Stock Exchange) is the main stock market in Taiwan. The GTSM (GreTai Securities Market) is the secondary stock market that is similar to the over-the-counter market in the U.S.

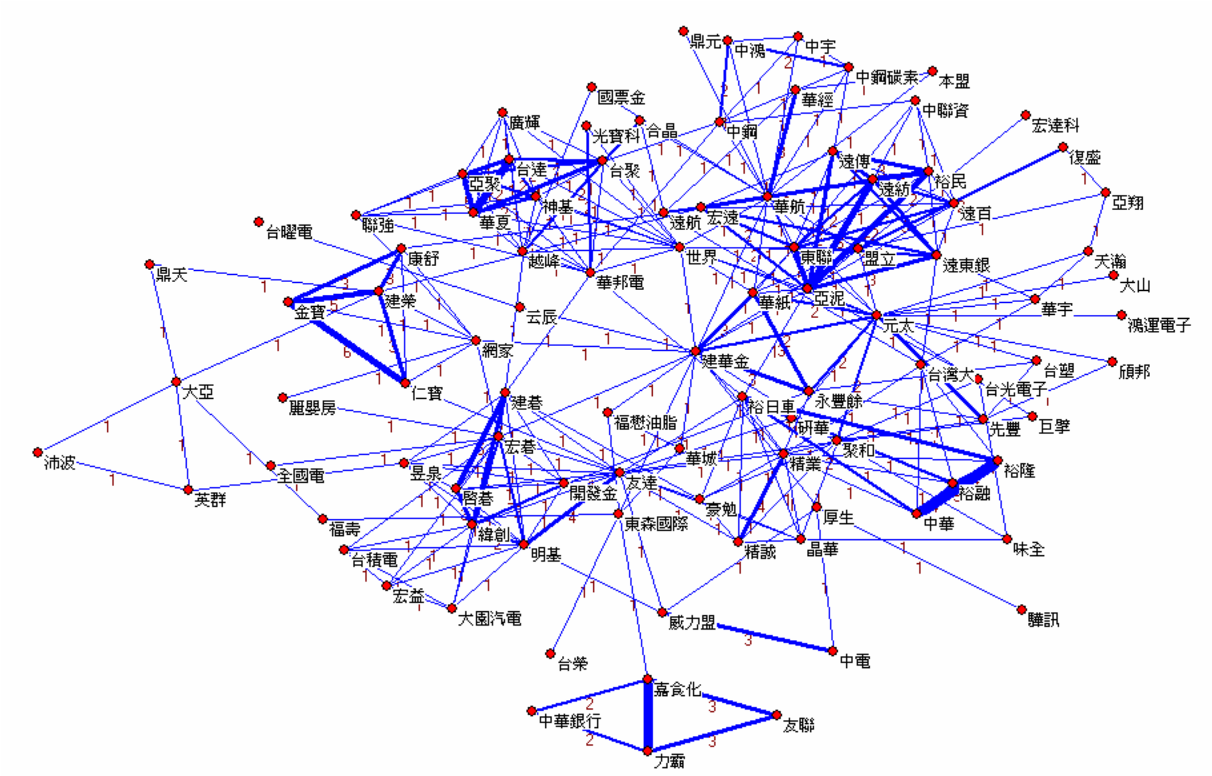

Figure 4.1 Board network (partial) of listed companies in Taiwan

Note: The network is constructed from a snapshot of board of directors data in December, 2005. Only part of the network is shown here. Numbers indicate link weight, the number of common directors shared by the two boards.

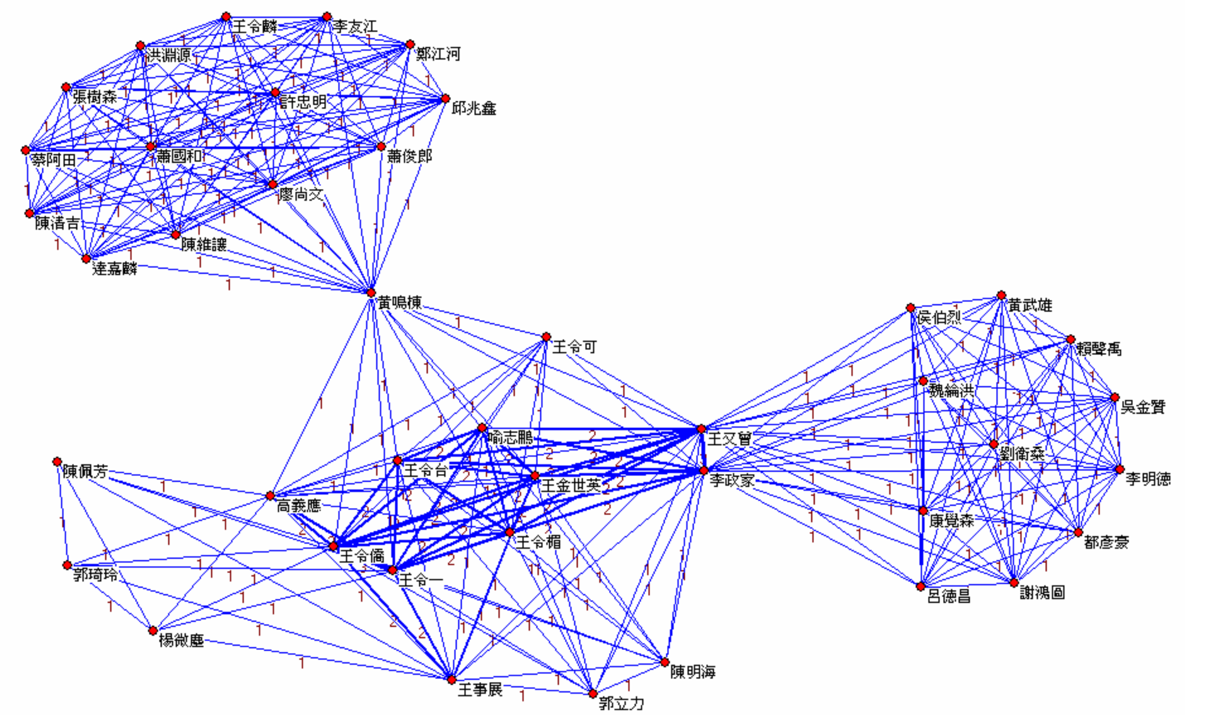

Figure 4.2 Director network (partial) of listed companies in Taiwan

Note: The network is constructed from a snapshot of board of directors data in December, 2005. Only part of the network is shown here. Numbers indicate link weight, the number of boards the directors sit on together.

4.3 General statistics of the affiliation network

Table 4.1 displays the general statistics of the affiliation network constructed. There are 9,511 distinct individuals filling a total of 11,450 seats offered by the 1,194 company boards. Among the 1,194 companies, 690 (57.8%) of them are listed in the main market and 504 (42.2%) of them are listed in the over-the-counter market.

Table 4.1 General statistics of the affiliation network

	Affiliation Network	Board Network	Director Network
No. of Boards	1194	1194	
No. of Directors	9511		9511
Total No. of Seats	11450		
Average Board Size	9.59		
Network Density	0.001008		
No. Edges	11450	2427	53099
Transitivity	0.081536	0.341	0.689
Clustering Coefficient		0.239	0.931
Path Length		5.036	5.978
No. of Interlockers		974	1288
No. of Interlockers (%)		81.57%	13.54%
No. of Multiple Interlockers		405	630
No. of Multiple Interlockers (%)		33.91%	6.62%
No. of Multiple Interlocking Edges		411	967
No. of Multiple Interlocking Edges (%)		16.93%	1.82%
No. of Herding Seats	1508		
No. of Herding Seats (%)	13.17%		
Average Multiplicity		2.740	2.135
Social Inertia		1.2427	1.0102
Redundancy		0.0350	0.0544
Herding Balance	0.0402		

Note: These statistics are calculated based on a sample of 1,194 listed companies in December 2005.

4.4 Statistics regarding multiple interlocks

This section presents the statistics regarding multiple interlocks from the corporate governance point of view.

The bipartite clustering coefficient is 8.15%. Examining from the board side, 974 (81.6%) boards are interlocked with others, while 405 (33.9%) boards share two or more common directors. There are 411 (16.9%) multiple lines in the total of 2,427 lines that link the boards.

The average multiplicity is 2.74. The statistics for the directors show that there are 1,288 (13.5%) directors interlocking with others and 630 (6.62%) of them serve on more than two boards. The director network has 967 (1.82%) multiple links among a total of 53,099 links. The average multiplicity is 2.14. Examples of multiple interlocks are listed in the Appendix.

Table 4.2 compares these data with those of other countries that are reported in the literature. To be able to compare the data measured in various facets of multiple interlocks, all comparable data calculated from the sample are provided. Three comments are worth mentioning regarding these statistics. First, Taiwan's level of multiple interlocks ranks in general in the middle when compared with ten European countries, but is on the low side when compared with that of the U.S., Italy, and Australia, whether the comparison is under the bipartite clustering coefficient measure or others. Second, it certainly demonstrates that the literature has yet to provide a unique way of reporting the level of multiple interlocks. It is suggested that bipartite clustering is a good choice as it is calculated from the generic structure of the bipartite network. Third, although around one-third (33.9%) of the boards in Taiwan share more than one director with others, the directors who involved in these multiple interlocks are relatively few (6.62%). These directors are the elites among elites. One of the major purposes of this study is to understand the characteristics of these directors.

Table 4.2 Comparison on the levels of multiple interlocks

Measures	Taiwan	Ten European countries [a]	U.S.A. [b, c]	Italy [b]	Netherlands [d]	Australia [c]
Generic aspect (2-mode)						
Bipartite clustering coefficient (%)	8.15		23.2 [c]			46.4
Board aspects (1-mode)						
Multiple interlocking boards (%)	33.9		35 [b]	44-63		
Multiple board links (%)	16.9	7-33			6.7-13.3	
Average multiplicity	2.74	2.14-3.06			2.11-2.46	
Director aspect (1-mode)						
Multiple interlocking directors (%)	6.62					
Multiple director links (%)	1.82					
Average multiplicity	2.14					

Notes: Numbers for Taiwan are calculated based on a sample of 1,194 listed companies in December 2005.

[a] 1976, numbers are deduced from Table 2.3 in Stokman and Wasseur (1985).

[b] U.S.A. 1999, Italy 1996 & 2002, Caldarelli and Catanzaro (2004).

[c] 1996, Robins and Alexander (2004).

[d] 1976-1996, Heemskerk et al. (2003).

CEO reciprocal interlocks have been the focus of various corporate governance studies. It is the situation whereby the CEO of one company serves on a second company's board and the second company's CEO sits on the first company's board. Fich and White (2005) reported that 12.15% of 576 U.S. firms had at least one reciprocal CEO interlock. Yeo et al. (2003) stated a much higher number (57%) among 197 French companies. The CEO position is not common in Taiwan, as individuals appointed by the company board to take responsibility of company operations usually bear the title of 'President'. In this study, individuals who bear the title of either CEO or President are taken as the CEO of the company. Based on this definition, the sample shows that there are only 40 (3.35%) among 1,194 sample companies that had at least one reciprocal CEO interlock relationship. In comparison with U.S. and French data, this number is relatively low. For completeness, these statistics in a different angle of view are provided. There are a total of 1,257 unique reciprocal interlocks (C4s) in the sample. Among them, 39 (3.10%) are Chairman reciprocal interlocks, while 21 (1.67%) are CEO reciprocal interlocks. Taking Chairman/CEO mixed interlocks into consideration, there are a total of 129 (10.3%) reciprocal interlocks that involve both Chairmen and CEOs. Even this number is low compared to CEO reciprocal interlocks with that of the U.S. and France.

Table 4.3 Sizes of director groups shared by multiple boards

Size of Director Groups \ No. of Boards	2	3	4	5
2	133	87	16	4
3	101	31	2	
4	37	6		
5	19			
6	8			
7	3			
8	3			
9	1			

Note: The table reads that there are 1009 cases of two boards sharing two common directors, 4 cases of five boards sharing two common directors, 6 cases of three boards sharing four common directors, and 1 case of nine common directors serving together on two boards, etc.

To further comprehend multiple interlocks, the patterns of local clustering are also analyzed. These include finding the spread of the director group size, and the largest number of boards that a director group serves on together. Table 4.3 displays the findings. There are 1,009 two-director groups and 101 three-director groups that serve together on exactly two boards. The largest group that serves on exactly two boards consists of nine directors. It is discovered that in this extreme case, one of the companies is the parent company of the other. Regarding the clustering of boards, 87 two-director groups serve on exactly three boards. The largest number of boards that a director group sits on together is five. There are four such groups that consist of two directors. The most tightly interlocking situations are those where three companies share the same four directors in their board. It is identified that interlocking companies in all these six cases bear parent-subsidiary relationships.

An interesting phenomenon is learned from Table 4.3 that partnering between boards occurs more often than partnering between directors. For example, there are total 34 pairs of boards share more than 4 common directors but only 4 pairs of directors serve on more than 4 boards together. To be able to achieve such a clustering at the board level, it would require strategic initiation at the company level.

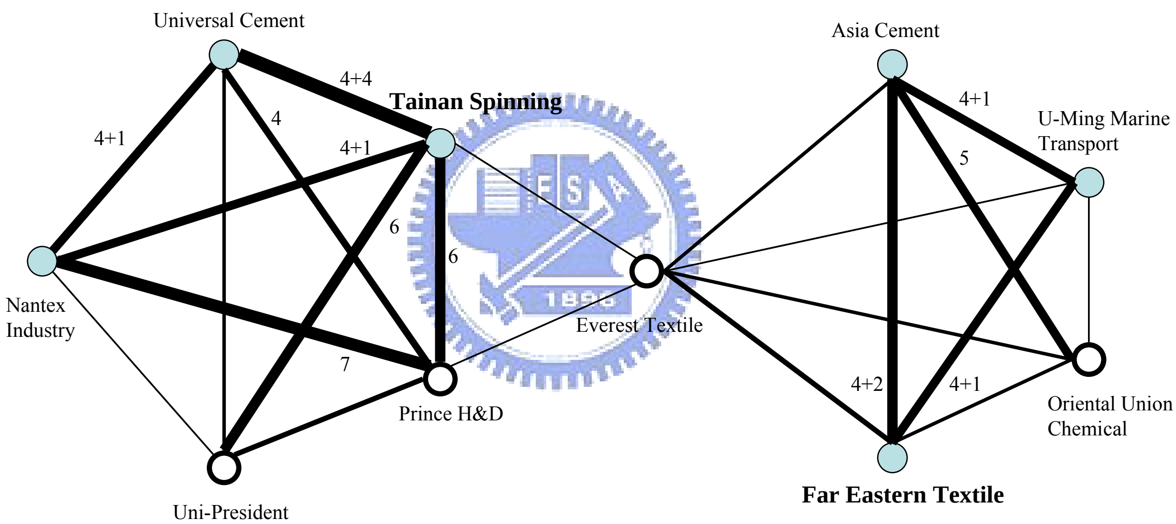

Figure 4.3 Multiple interlocks of the two family-controlled business groups

Note: Line widths drawn as well as the numbers marked are according to the total number of common directors between the two companies. Filled-circles designate the companies that share the same four common directors. They are Tainan Spinning, Universal Cement, and Nantex Industry as well as Far Eastern Textile, Asia Cement, and U-Ming Marine Transport, respectively. Each pair of companies has additional common directors other than the four common directors. The two family-controlled business groups shown here are commonly called the Tainan Spinning Group and the Far Eastern Textile Group. Subsidiaries of these two groups are far more than what are shown here. Only the companies relevant to the discussion are displayed. It happens that the two groups can be linked through Everest Textile.

Figure 4.3 displays the network relationships of two of the most tightly interlocking situations, where two well-known family-controlled business groups in Taiwan, Tainan Spinning Group and Far Eastern Textile Group, play the main role. Both groups are conglomerates owning companies in various business sectors. The companies within each group are heavily linked through common directors. In Figure 4.3 the marked number on the side of a link indicates the number of common directors shared by the two companies on both ends of the link. Subsidiaries of these two groups are far more than what are shown. Only those companies relevant to the discussion are displayed. Everex Textile is displayed, because it happens that the two groups are connected through this company. Among the companies in each group, Tainan Spinning, Universal Cement, and Nantex Industry as well as Far Eastern Textile, Asia Cement, and U-Ming Marine Transport share the same four directors, respectively. The fact that each pair of companies has additional common directors other than these four common directors is also indicated in the figure. The tight interlocking of directors among companies within the business groups strongly suggests that the control and monitoring of family-controlled businesses to the subsidiaries are significant sources of multiple interlocks.

5. Simulating the herding phenomenon

5.1 Simulation procedure

Simulation models proposed in the literature to reproduce the structure of affiliation networks can be categorized into two general types – the arbitrary degree distribution model and the growth model. The arbitrary degree distribution model was first mentioned in Newman *et al.* (2001). It joins randomly the given degrees extended from the given events and the actors. This model is random in the sense that connections among available degrees are matched up without any humane intervention. Ramasco and Morris (2006) proposed a growth network model that continuously increases the events and the actors in an affiliation network.

The model is based on the arbitrary degree distribution model. Unlike Newman *et al.*, which joins up the given degrees randomly, this research added herding mechanism to the model. If herding behavior plays a major role in real-world affiliation network, the properties of the networks produced should be more similar to real-world networks than those without.

The basic concept of the herding model is quite simple. It simulates real-world scenario where a group of authors might continue their collaboration after initial attempt, or, a group of corporate directors may be appointed together again to the board other than the one they currently sit. The proposed model thus consists of an actor pool and a mechanism to repetitively assign actors to other events from the same pool. In addition to the given bipartite degree distribution, it requires two parameters. One parameter *ps* controls the size of the actor pool; the other parameter *pc* controls the number of times for an event to continuously select actors from the same pool. Both ranges from 0 to 1.

To make the description more comprehensible, this research uses the terms *boards* and *directors* to describe the rules of the model. The simulation starts with a given degree for each board and director. The degree for each board is the number of seats on the board. The degree for each director is the number of board that the director is assigned to serve. Each board seat is open and waiting to be matched with a director service. The process to match between boards and directors is as follows:

1. Randomly pick a board as target. Determine the size of the director pool and the number of times to repetitively appoint directors from this pool according to the following rules:

   $$director\,poolsize = ps \cdot boardsize \cdot random_{0-1}$$

   $$repititioncount = pc \cdot boardsize \cdot random_{0-1}$$

2. Randomly pick directors that have availability greater than two and put these directors

into the pool until it is full. Assign the directors in the pool to the target board. Randomly fill the remaining seats on the target board with directors whose availability is one.

3. Randomly pick another board as the current target.
4. Assign the directors in the pool to the board until the pool is exhausted. For the remaining seats on the board, fill them with randomly picked directors.
5. Repeat procedure 3 through 4 for the given *repetition count* times or until all directors in the pool are unavailable.
6. Repeat procedure 1 through 5 until all boards are processed.

Procedure 5 is the key to this herding model. It repeatedly assigns the same group of directors to different boards.

5.2 Simulation results

In order to verify the effectiveness of the simulation model, board and director data in Taiwan as presented in the Taiwan Economic Journal (TEJ) database on December 2005 is taken as the reference real-world network. The companies taken into consideration are those listed on the main market (TSE) and the over-the-counter market (GTSM). The database lists the names of directors and supervisors along with the names of the corporate boards on which they serve. The board supervisors are treated the same as the directors. This affiliation network consists of 1,194 companies and 9,511 directors.

The board and director degree distributions of this affiliation network are shown in Figure 5.1. These distributions serve as the basic constraint for the simulation. It is interesting to notice that board degree peaks at 8, 10 and 12, which indicate that Taiwanese corporations favor even numbers of directors.

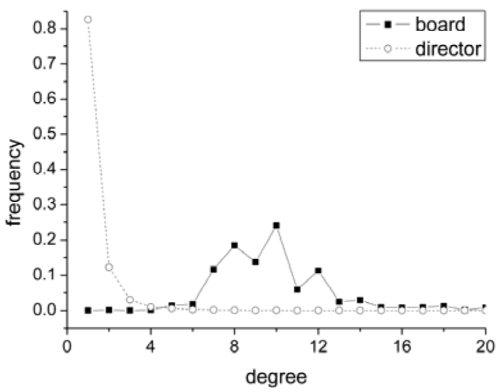

Figure 5.1 The bipartite degree distributions of the real-world board of directors network.

The simulation is explored in two stages. The first stage of the simulation is to examine the effect of the pool size. *pc* is fixed at 0.5 and ran the simulation with *ps* increasing from 0 to 1 at the increment of 0.1. Each pair of *ps* and *pc* is simulated 30 times. Simulation results are averaged over the number of simulations. All properties are computed on the giant component of the network. Figure 5.2, shows the resulting bipartite clustering coefficient and redundancy. Figure 5.3, Figure 5.4 and Figure 5.5 display the resulting social inertia, clustering coefficient and path length, respectively.

Each of the herding properties, bipartite clustering, redundancy and social inertia increases decisively with the pool size. These significant results suggest that herding mechanism is at work. The larger the pool develops into, the higher the bipartite clustering. So do the link redundancy and the tendency of directors stays with the same group.

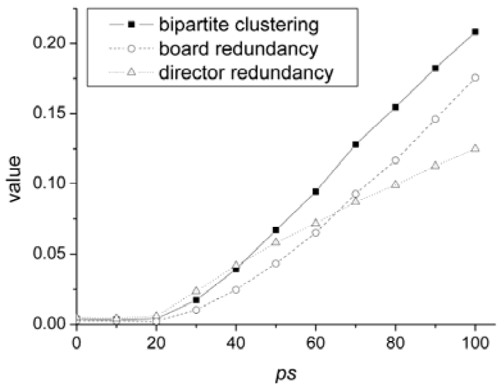

Figure 5.2 Trend of bipartite clustering coefficient and redundancy as the function of ps.

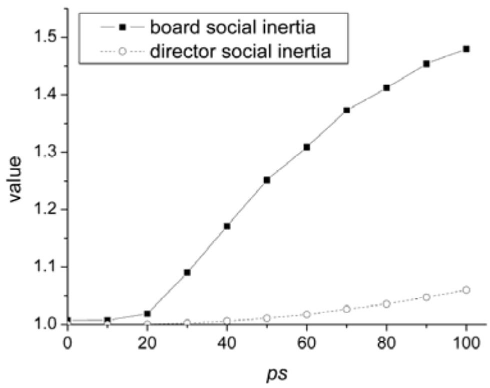

Figure 5.3 Trend of social inertia as the function of ps.

Clustering coefficient increases with herding in both the one-mode board network and one-more director network. But the effect on the director network is not significant. Path length in both the board and director networks increase with herding but eventually flatten out.

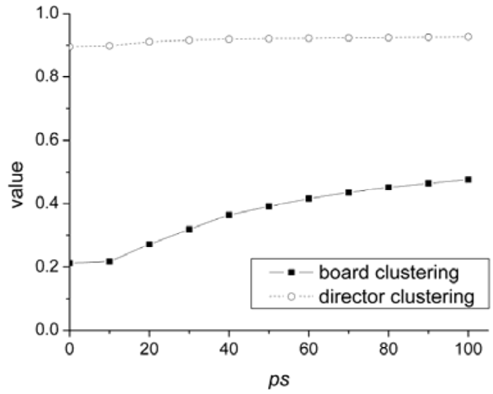

Figure 5.4 Trend of clustering in one-mode network as the function of ps.

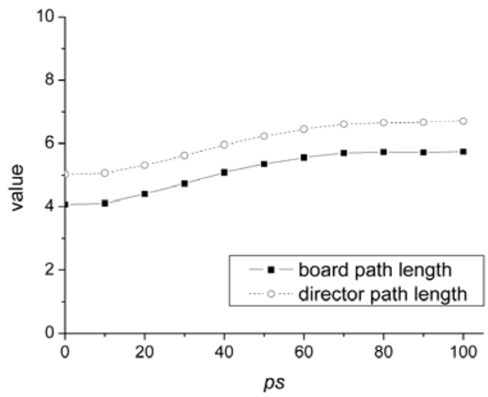

Figure 5.5 Trend of path length in one-mode network as the function of ps.

The second stage of the simulation is to see if the real-world board of directors network can be imitated. This research find that a set of *ps* and *pc* value, 0.55 and 0.5, produce an affiliation network that carries properties very close to that in the real-world network. The simulation results at these two values are shown in Figure 5.6, Table 5.1 and Table 5.2.

Figure 5.6 shows board degree distribution of the simulated network in parallel with the random network and the real-world board of directors network. The random network results are obtained by randomly matching board seats with director services. In comparison with the random network, simulated herding network emulates the real-world network more closely. This result strongly suggests that the real-world board of directors network is not random and that social process such as herding is inherent in it. Herding in effect is a clustering process. It increases the proportion of boards with degree 1 and 2 at the expense of reducing higher degree boards.

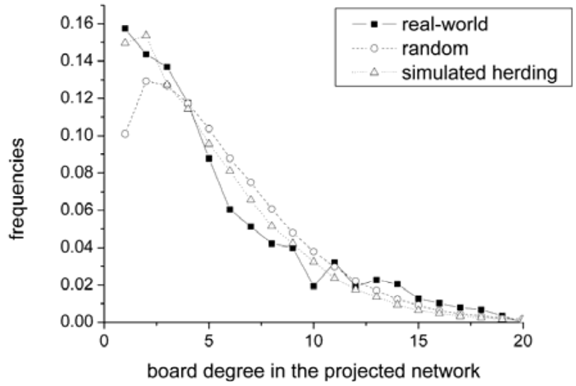

Figure 5.6 The board degree distribution of the projected real-world, random, and simulated herding network.

Table 5.1 compares the various network parameters among the real-world, random and simulated herding networks. In comparison with the random network, simulated herding network has higher values of bipartite clustering coefficient, redundancy coefficient, social inertia, clustering coefficient and path length with only one exception. Saturation in clustering makes the clustering coefficient stays the same in the one-mode director network. These properties have values close to their counterpart in the real-world network. The results again support the hypothesis that herding is a major social process in real-world board of directors network.

The spread of herding clusters is shown in Table 5.2. It views the effect of herding from a different angle. The random scheme generates only very few balanced multiple interlock clusters. Both the real-world and simulated herding network have many multiple interlock clusters. Their overall herding balances are positive, that is, leaning towards wide herding.

Table 5.1 Comparison of the various network parameters among the real-world, random and simulated herding networks

	Bipartite network				one-mode board network				one-mode director network			
	BCC	board <*rc*>	director <*rc*>	*hb*	<*I*>	*pl*	*cc*	cc^w	<*I*>	*pl*	*cc*	cc^w
Real-world	0.0806	0.0445	0.0686	0.040	1.2723	5.04	0.32	0.31	1.0130	5.98	0.91	0.91
Random	0.0005	0.0003	0.0006	0.000	1.0017	4.67	0.28	0.28	1.0000	5.52	0.92	0.92
Herding	0.0819	0.0545	0.0652	0.068	1.2844	5.46	0.40	0.39	1.0141	6.35	0.92	0.92

Note: *BCC*: bipartite clustering coefficient, *rc*: redundant coefficient, *hb*: herding balance, *I*: social inertia, *pl*: path length, *cc*: clustering coefficient, cc^w: weighted clustering coefficient, and <> denotes average value.

Table 5.2 Comparison of the spread of multiple interlock clusters

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	2	***3***	***4***	***5***	***6***	***7***	***8***	***9***
2	133	87	16	4				
3	101	31	2					
4	37	6						
5	19							
6	8							
7	3							
8	3							
9	1							

real-world, *hb* = 0.040

	2	***3***	***4***	***5***	***6***	***7***	***8***	***9***
2	6							
3								
4								
5								
6								
7								
8								
9								

random, *hb* = 0

	2	***3***	***4***	***5***	***6***	***7***	***8***	***9***
2	133	43	6					
3	85	22	1					
4	49	2						
5	22							
6	7							
7	3							
8	1							
9								

simulated herding, *hb* = 0.068

5.3 Summaries

In summary, the proposed simulation model is able to reproduce real-world affiliation networks with the given events and actors degree distributions. The key element of the model is ‘herding’, a group of actors to participate in several events together. The intensity of herding is affected by two parameters, one control the size of the actor pool; the other controls the number of times for an event to continuously select actors from the same pool. By choosing a proper mix of these two parameters, a network that is very similar to the board of directors network in Taiwan is reproduced.

The reproduced network deviates from the random network on all multiple interlock related properties. The results provide a strong support to the hypothesis that herding is a crucial social process that is at work in real-world affiliation networks.

5.4 Discussions

The proposed simulation model generates mostly networks with positive herding balance (more wide herding than deep herding). The effect of *repetition count* is not as obvious as *director pool size.* This is in fact consistent with the real-world board of directors network. There is one shortcoming of the current model. It always generates larger giant-component than that of the real-world network. There should be other non-random mechanism at work in the real-world networks.

This simple repetitive-assignment-from-the-same-pool model demonstrates that the real world board of directors network can be closely simulated in the particular setting described above. This is, however, more a conceptual than a rigorous behavior driven model. The two parameters are found posteriorly and can not be estimated beforehand. One suggestion for future study to improve the model is to introduce the objective functions of boards and directors and turn the simulation to a process for boards and directors to optimize their goal. This type of model will be more rigorous and be able to generalize to herding behavior in other types of affiliation networks.

6. Statistical analysis

6.1 Hypotheses

La Porta (1999) in a study on large companies in 27 wealthy economies indicated that relative few of these companies are widely held. They are typically controlled by families or the state, and that “the controlling shareholders typically have power over firms significantly in excess of their cash flow rights, primarily through the use of pyramids and participation in management.” In addition, controlling shareholders runs these companies. The top management is usually part of the controlling family. Claessens et al. (2000) and Yeh et al. (2001) confirmed that family control indeed prevails in Taiwan. Yeh et al. (2001) further pointed out that on average, the largest family shareholder controls 26% of company shares and holds 53% of the board seats in Taiwan.

Based on these findings and the preliminary observation on interlocking data, it is conjectured that multiple interlocks in Taiwan are mostly formed when controlling shareholders of large companies use “pyramids and participation in management” to exercise control or to monitor investments. Individuals who participate in the management of companies in the chain of control may consist of family members, friends, and senior managers with whom the controlling shareholders trust. When these corporate elites sit on the board of various subsidiaries and affiliates, basic connections between these companies are established. In the case whereby financial participation is so large to a point that a herd of directors is dispatched, multiple interlocks occur. Accordingly, the boards and the directors who involved in such herding should demonstrate specific characteristics. Hypotheses on the characteristics of these boards and directors are developed.

Characteristics of the directors

It is conjectured that multiple interlockers are the controlling shareholders or controlling shareholders’ representatives. They naturally represent large equity ownership in the board they serve. This leads to the first hypothesis.

> ***Hypothesis 1****: Directors who own large equity in the company where they serve are more likely to be involved in multiple interlocks.*

The percentage of stock shares a director owns or represents in a board is used to test the first hypothesis. As a multiple interlocker has different stakes in each of the company board he or she serve, it is necessary to make a distinction on the ownership between different boards.

The first hypothesis suggests that large equity owners are more likely to be multiple interlockers, but virtually every company has at least one or two such directors. The directors being able to participate in more than one company board are very like the directors who are exceptional in their total assets. These directors control large portion of aggregated corporate assets and are more influential than the others because their decision has bigger impact to the business world. It is further hypothesized that those who are more influential and have high controlling power in the corporate world are more likely to be multiple interlockers.

Hypothesis 2*: Directors who possess high controlling power in the corporate world are more likely to be involved in multiple interlocks.*

For the second hypothesis, a "control index" is derived as the proxy to controlling power. It is like a indicator to personal power and wealth. The control index indicates the total assets in the corporate world that a director is able to control effectively. It is an asset-weighted version of a director's holder index (HI). Battiston (2004) defined the holder index as the sum of the fraction of the control power a director holds on each board he or she serves. It gives the total fraction of corporate boards a director is able to effectively control in the corporate world. All the companies in the sample, which are listed in Taiwan's main stock market and over-the-counter market, compose the corporate world. The holder index converts a holder's stock share percentage in a company into his/her effective control power in the corporate world. Its definition is as follows.

$$HI_j = \sum_{i \in companies.j.owns.stocks} \left(\frac{w_{ij}^2}{\sum_k w_{ik}^2} \right), \tag{6-1}$$

where w_{ij} = share percentage of holder j in company i

The formulation pretty much reflects the power distribution of directors in a corporate board. It gives high weight to big shareholders. For example, a company director who owns dominant stock shares gets close to one for his/her fraction of controlling power in the company. Those directors who are big investors in several companies would accumulate a relatively high holder index. Directors with a high holder index are in effect the real power holders in the corporate world.

To catch the control power more realistically, the proposed control index weights a director's holder index in each company with the company's total assets. A small company's director in a weighted version would own less controlling power in the corporate world than a director who controls the same fraction of a bigger company. The control index is defined as follows.

$$CI_j = \sum_{i \in companies.\, j.owns.stocks} A_i \left(\frac{w_{ij}^2}{\sum_k w_{ik}^2} \right), \qquad (6\text{-}2)$$

where $w_{ij} =$ share percentage of holder j in company i

$A_i =$ total assets of company i

In the regression model, the natural log of the control index is used as the independent variable.

Characteristics of the boards

Loderer and Peyer (2002) found that large companies have more pronounced board overlap than small companies in Switzerland. They argue that large firms have more directors than that of small firms and naturally the possibility of board overlap are greater. In addition to this argument, this research adds that large companies may have more financial resources to invest in strategic businesses than small companies. Overseeing these investments make multiple interlocks unavoidable. It is therefore hypothesized that boards of large companies are more likely to be involved in multiple interlocks.

Hypothesis 3*: Boards of large companies are more likely to be involved in multiple interlocks.*

To test this hypothesis, the natural log of a company's total assets is used to indicate the size of a company.

Monitor and control

Yeh et al. (2001) found that the majority of Taiwanese listed companies are family-dominant and that they hold the majority of board seats. Claessens et al. (2000) reported that around 60% of family-controlled East Asian companies have the CEO, board chairman, or vice-chairman come from the controlling family. For Taiwan, this percentage goes as high as 80%. These findings indicate that members of controlling shareholders not only take up a large percentage of the board seats, but also hold many inside management positions. Stokman and Wasseur (1985) suggested that when one of the interlocking directors holds an inside position in a company, the interlocks is "used to effect the possibilities of control created by financial participations." In other words, key individuals are sent to sit on the board of subsidiaries to exercise controls. In doing so, the controlling shareholder is able to monitor the activities and to control the strategic direction of a subsidiary. If the financial stakes in the chain of control are big, then the controlling shareholders would have more than one of their associates sit on the subsidiary's board. This type of strategic behavior is an important source of multiple interlocks.

In the case where more than one individual are sent to watch the subsidiaries, they could not all play the role of CEOs or chairmen. Some instead play the role of senior managers. It is conjectured that these insiders are more likely to be involved in multiple interlocks. Insiders are generally taken as directors who take part in all major decisions within a company on a day-to-day basis (Stokman and Wasseur, 1985). They are typically employed full time by the company. The CEOs and the directors who hold a management position within the company are insiders. This research also view the chairmen of the board as insiders,[7] because many of the chairmen on Taiwanese corporate boards are deeply involved in the company operations if not day-to-day business. In the sample, 30.2% of the companies have one individual in both the role of the chairman of the board and the CEO or president. This leads to Hypothesis 4.

Hypothesis 4*: Inside directors are more likely to be involved in multiple interlocks.*

A categorical indicator is adopted to test this hypothesis. The indicator is four when the director is both the chairman and the CEO in the company; three when the director is the chairman of the board; two when the director is the CEO; one when the director holds a management position; and zero otherwise. Independent directors are automatically categorized as outsiders with a value zero. In Taiwan only less than half the board provides independent director seats as of December 2005.[8]

Financial performance

In correlating the interlocks and company financial performance, there are three lines of reasoning commonly seen in the literature. The first and the second lines of reasoning are associated with the 'why' question. If a company has a reputable financial performance, then it's CEO and directors are more likely to be invited to sit on other boards to share their good experience. The level of interlocks as such increases with company financial performance. Yeo

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[7] Other views of insiders include executives, board members, and large shareholders as insiders (Sheu and Yang, 2005). In this study we take the chairmen, the CEOs, and managers who also sit on the board as insiders

[8] The Taiwanese legislature passed a law to regulate the requirements of independent directors on December 2005. This new regulation was effective in January 2007. Loose rules for independent directors were established in February 2002. Starting from that time, companies newly approved to list on TSE and GTSM are required to host two independent directors and one independent supervisor. Companies already listed in the TSE and GTSM are only 'encouraged' to invite independent directors to sit on their boards. As of January 2006, there are about 27% of TSE companies and 50% of GTSM companies host independent directors and supervisors on their board.

et al. (2003) reasoned along this line to explain the positive relationship between the number of CEOs' reciprocal interlocks and their company's performance. The second reasoning is somewhat in contradiction to the first. It proposes that a bad performer would seek assistance from reputable outside directors to enhance their performances. The level of interlocks is negatively correlated with company performance in this case.

The third line of reasoning is associated with the consequences. If the interlocks are of strategic purpose to an organization, then they should be positively correlated with the company's financial results. On the other hand, if the interlocks serve the individual rather than the organization, then the level of interlocks may be negatively correlated with the company's financial results. Research studies along this line of reasoning do not achieve consistent results, but lean more towards a negative effect of profitability (Mizruchi, 1996).

This research encounters this issue in a different context. First, multiple interlocks rather than general interlocks or CEO reciprocal interlocks are what this research are examining. Second, corporate governance practices in Taiwan show a rather different setting. Recent studies on corporate governance in Taiwan provide some evidence hinting on the negative correlation between controlling shareholders and the general financial situation of a company. Lee and Yeh (2004) suggested that the more directors there are who are controlled by the largest shareholder, the greater the likelihood the company will succumb to financial distress. Kao et al. (2004) found that the function of using stocks as collateral by boards of directors is more serious in conglomerate companies than in non-conglomerate companies in Taiwan. When controlling shareholders of a conglomerate company choose to benefit themselves, the financial performance of the company is very likely to be negatively affected. It is conjectured earlier that controlling shareholders are closely related to multiple interlocks. Multiple interlocks therefore could be negatively correlated with a company's financial performance. This leads to Hypothesis 5.

Hypothesis 5*: Multiple interlocks are negatively related to a company's financial performance.*

This hypothesis is tested with returns on assets before tax (ROA) as the dependent variable and multiple link indicator (C4) as the independent variable.

6.2 Data and regression method

Two regression models are applied to test the hypotheses. Hypotheses one through four are tested with binary logistics regression model and hypothesis five is tested with linear regression model. Both work on a research unit of mixed foursome consisting of a pair of boards, a pair of directors as well as four possible links among them, and examine under what condition the mixed foursome would evolve from a three-path (L3) to a multiple-link (C4) - that is, the research unit is not a board nor a director, but a mixed foursome. Denoting the pair of boards as Board *1* and Board *2* and the pair of directors as Director *a* and Director *b*, the links in-between are *a1*, *a2*, *b1*, and *b2* (please refer to Figure 6.1). Each link represents a board seat. Certain attributes, such as ownership or position of a director, are associated with these links. Assuming a mixed foursome has links *a1*, *a2* and *b1* completed. This research looks for the likeliness of closing the missing link *b2* in L3. Under such a design, this research is able to investigate the effects of the attributes of board and directors at the same time. More importantly, this design is able to differentiate between multiple interlockers' status on each of the board they serve. For example, a director may sit on two boards. On one board, he or she servers as the chairman and own large share of stocks, while on the other a plain director and own very few shares. The director's roles on the two boards are different and are analyzed as two separate items in this research design.

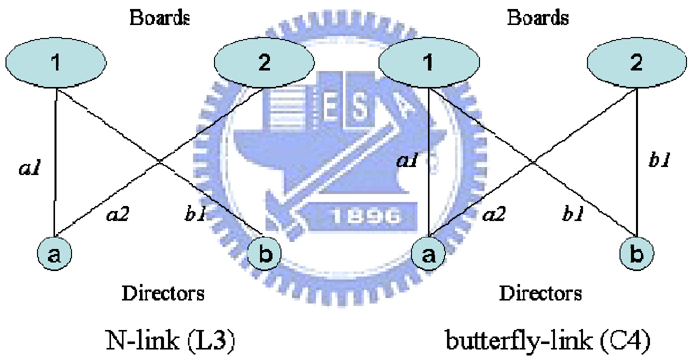

Figure 6.1 Basic units in a bipartite network

Notes: Ellipses represent board nodes. Circles represent director nodes. In a L3 there are three links - *a1*, *a2*, and *b1*. In a C4, one additional link *b2* closes the reciprocal relationships. In a L3, directors *a* serves on two boards and director *b* serves on only one board. In a C4, both directors *a* and *b* serve on board *1* and *2*.

For hypotheses one through four, the dependent variable is a binary indicator. For each mixed foursome, if it is a L3, then the indicator takes a value of zero. If it forms a C4, then the indicator takes the value of one. The binary indicator is estimated using the binary logistic regression model. For hypothesis five, the dependent variable is returns on assets.

The sample set is the same as that used to measure the level of multiple interlocks, which was mentioned in the previous section. Table 6.1 presents the basic descriptive statistics on companies, boards, and directors. Board and director data are transformed into a bipartite network. This research looks for the L3s and the C4s in this bipartite network. There are total of 61,666 L3s, and among them 5,028 are C4s. The company financial information is taken from a separate database. Summaries of all variables are listed in Table 6.2. For most of the director properties, three variables need to be addressed for each research unit. For example, regarding directors' share of stock, there is the share of Director *a* in Board *1*, the share of Director *a* in Board *2*, and the share of Director *b* in Board *1*. Table 6.3 reports the statistics for all the variables.

The binary logistic model controls for three pairs of company-related variables, one pair of director-related variables and one set of link-related variables in estimating the odd ratio. They include the market where the stocks are traded, total stock shares of directors, the number of external directorships of all directors; the number of boards a director serves, as well as a representative indicator. Explanations of these control variables are listed in Table 6.2.

Table 6.1 Descriptive statistics on companies, board and director

	Sample Size	Mean	Median	Frequency [a]	Standard Deviation
Companies					
Ln (total assets in NT Dollars)	1194	15.215	14.97		1.54
Returns on assets	1194	5.297	5.19		9.02
Boards					
Board size	1194	9.590	9		2.90
Chairman and CEO are the same person (0, 1) [b]	1194			30.2%	
Traded in the big market (0, 1)	1194			57.8%	
Single interlocks (0, 1)	1194			81.6%	
Multiple interlocks (0, 1)	1194			33.9%	
Directors					
No. of boards a director serves	9511	1.204	1		0.64
Ln (control index)	9511	9.587	11.10		5.18
At least one role is a representative of an institution (0, 1)	9511			23.0%	
Single interlocks (0, 1)	9511			13.5%	
Multiple interlocks (0, 1)	9511			6.6%	

Notes: The sample consists of 9,511 distinct directors serving in 1,194 company boards. These are the companies traded on the main stock market and the over-the-counter market in Taiwan in December 2005.

[a] The frequency of 1 for binary indicators.

[b] (0, 1) denotes binary indicator.

Table 6.2 Variable definitions

Variables	Definitions
Dependent variable	
Multiple link (C4)	0 – the mixed foursome forms a three-path (L3).
	1 – the mixed foursome forms a multiple-link (C4).
Performance (ROA*1*, ROA*2*)	Company's returns on assets of the previous four quarters.
Independent and control variables	
Stock shares (SHARE*a1*, SHARE*a2*, SHARE*b1*)	The director's shares of stock in percentage.
Control index (CI*a*, CI*b*)	Natural log of the total assets the director is able to control effectively.
Company size (TASS*1*, TASS*2*)	Natural log of the total assets of the company
Position (POS*a1*, POS*a2*, POS*b1*)	4 – the director is both the chairman and the CEO.
	3 – the director is the chairman of the board.
	2 – the director is the CEO.
	1 – the director holds a management position other than CEO.
	0 - otherwise
Market indicator (MKT*1*, MKT*2*)	1 – the company is listed in the big market (TSE).
	0 – the company is listed in the over-the-counter market (GTSM).
Directors commitment (DSHARE*1*, DSHARE*2*)	Total number of stocks owned by all directors on the board in percentage.
External directorships (NOD*1*, NOD*2*)	Total number of outside directorships held by all the directors on the board.
Director connectivity (NB*a*, NB*b*)	Number of boards the director holds a seat.
Institutional representation (REP*a1*, REP*a2*, REP*b1*)	1 – the director is a representative of an institution.
	0 – otherwise

Notes: Ending character on the board variables (*1*, *2*) identifies the board in the mixed foursome. Ending character on the director variables (*a*, *b*) identifies the director. Ending characters on the link variables (*a1*, *a2*, *b1*) identify links. For example, SHARE*a1* indicates the stock share of the director *a* on the board *1*.

Table 6.3 Descriptive statistics of the dependent and independent variables

	Mean	Median	Frequency (%) [a]	Standard Deviation
C4 (0, 1)			8.15	
ROA*1*	6.042	5.490		7.714
ROA*2*	6.071	5.610		7.807
SHARE*a1*	2.417	0.760		3.861
SHARE*b1*	2.325	0.770		3.645
SHARE*a2*	2.567	0.840		4.044
CI*a*	13.573	14.676		4.397
CI*b*	11.106	12.614		5.282
TASS*1*	16.125	15.860		1.813
TASS*2*	15.961	15.770		1.735
POS*a1* (0/1/2/3/4) [b]			79.0/ 3.4/ 3.6/11.6/ 2.3	
POS*b1* (0/1/2/3/4)			76.1/ 9.1/ 6.1/ 6.7/ 2.0	
POS*a2* (0/1/2/3/4)			78.0/ 3.4/ 3.7/12.5/ 2.4	
MKT*1* (0, 1)			74.1	
MKT*2* (0, 1)			73.0	
DSHARE*1*	25.582	22.91		14.734
DSHARE*2*	25.479	22.67		14.637
NOD*1*	13.705	12		8.768
NOD*2*	12.936	11		8.430
NB*a*	4.104	4		2.073
NB*b*	1.953	1		1.539
REP*a1* (0, 1) [c]			26.1	
REP*b1* (0, 1)			26.5	
REP*a2* (0, 1)			25.2	

Notes: The total number of mixed foursomes is 61,666.
[a] The frequency of 1 for binary indicators.
[b] (0/1/2/3/4) denotes categorical indicator ranging from 0 to 4.
[c] (0, 1) denotes binary indicator.

6.3 Empirical results

Table 6.4 presents the statistical analysis results of the binary logistic regression model. The table is organized in a way such that the total seven possible attributes of a variable in a research unit are displayed in five columns. The first two columns display the results for board and director related variables. The third through fifth columns display the results for link related variables. The sign of the regression coefficients (β) indicates the direction in which the multiple interlocks are correlated with the independent variables. The odds ratio of multiple interlocks changes by *exp*(β) amount for a one-unit change in the independent variables.

The result provides strong support for both Hypotheses 1 and 2. The equity ownership by a director or the institution he or she represents shows a positive and significant correlation to the likeliness of multiple interlocks. The same to control indices for both Director *a* and Director *b*. The regression coefficients for CI*a* and CI*b* are generally greater than that of SHARE*a1*, SHARE*b1* and SHARE*a2*. This confirms the conjecture that not only the directors who own large equity in a board is likely to be involved in multiple interlocks, big players among them show a grater herding tendency. Those directors who control effectively large amounts of assets in the Taiwan corporate world are more likely to be involved in multiple interlocks. Nevertheless, large companies do not. Hypothesis 3 is not supported. Company assets show a negative correlation to both Board *1* and Board *2* and the result on Board *2* is not significant. Summarizing the results, the elites among elites in the corporate world and big equity holders in each company are people who show a tendency to be involved in multiple interlocks. Company sizes are not relevant.

Hypothesis 4 is strongly supported by the regression results. All the categorical indices show a positive and significant correlation to multiple interlocks, with only one exception. Director *b* as a manager on Board *1* does not correlate statistically to multiple interlocks. Other than that, insiders such as the chairmen, the CEOs, and the company managers are deeply involved in multiple interlocks. In the case of CEO duality, one person being both the CEO and chairman, the correlation is also positive and significant. In other words, CEO duality is positively correlated with multiple interlocks. This result is in-line with Yeo et al. (2003), who suggested that CEOs who also have a chairman position are more likely to hold reciprocal interlocks.

These results bring about a major picture to the multiple interlocking scenarios. Heavy players, most likely families, who control large amounts of assets in the corporate world, for the purpose of controlling and monitoring their investments, send family members and professionals whom they trust to be insiders on the boards of these companies and in the course of so doing create multiple interlocks. The companies involved may be large or small. Such a scenario is indeed very much in agreement with the observation on the multiple interlocks of Rebar group, Tainan Spinning group and Far Eastern Textile group as described in the earlier section.

Control variables do show some results that are worth a discussion. Apparently, the companies trading in the main stock market are more into multiple interlocks than those in the over-the-counter market as market indicators show significant likeliness. Total equity share owned by all the directors in a board do not show a consistent correlation with multiple interlocks. The number of outside directorships for both Board *1* and Board *2* is significant yet correlates with multiple interlocks in different directions. It indicates that to complete the link between the unlinked Board *2* and Director *1*, the number of Board *2*'s total outside directorships does help. This is in agreement with the findings on CEO reciprocal interlocks by Fich and White (2005) and shows that the probability of a reciprocal CEO interlock increases with the number of outside board obligations of a given board. The results on the total number of boards a director serves are interesting. The total number of corporate boards that Director *a* serves on is negatively correlated with multiple interlocks. That implies that single interlockers show a wider accumulation of board seats than multiple interlockers.

Table 6.5 presents the statistical analysis results of the linear regression model. ROA*1* and ROA*2* are estimated separately. Hypothesis 5 finds good statistical support. Both ROA*1* and ROA*2* show a negative and significant relation with multiple interlocks. A most likely explanation for this result is that controlling shareholders did engage in expropriation and other misconducts and in the end shrank their company earnings.

6.4 Summaries

This research has examined in detail the phenomenon of multiple interlocks among boards and directors. The descriptive statistics show that multiple interlocks in Taiwan are moderately extensive although they are on a smaller scale than in the U.S. and Australia when measuring with the bipartite clustering coefficient. The statistical analysis includes a pair of boards and a pair of directors as a research unit. This design allows the examination of the boards and the directors at the same time. The regression results show that the directors who control a large amount of effective assets in the corporate world, own a high percentage of equity in a company, or hold an inside management position are more likely to be involved in multiple interlocks. This leads to typical multiple interlocking scenarios in corporate Taiwan. Controlling shareholders and their associates are the major participants in multiple interlocks. They move in herds to watch their ventures and investments. Companies involved in multiple interlocks nevertheless show inferior financial performance in terms of returns on assets.

6.5 Discussions

One main finding of this research is that the directors who control a large amount of effective assets in the corporate world, own a high percentage of equity in a company, or hold an inside management position are more likely to be involved in multiple interlocks. The second type of directors, those who own a high percentage of equity in a company, is in many cases representatives of an institution. They do not personally own stock shares but represent an institution which owns large stock shares. This kind of practice is quite common in Taiwan. Table 6.1 indicates that there are 23.0% of the directors who play at least one role as a representative of an institution. Although the regression analysis does not find consistent relevance on the effect of institutional representation to multiple interlocks, it remains an interesting issue for further investigation.

Table 6.4 Regression results with C4 as the dependent variable

	Regression coefficients (β)				
	Board *1* or Director *a*	Board *2* or Director *b*	Link *a1*	Link *b1*	Link a2
Independent variables					
SHARE*a1* / SHARE*b1* / SHARE*a2*			0.051 (0.000)*	0.017 (0.001)*	0.027 (0.000)*
CI*a* / CI*b*	0.052 (0.000)*	0.175 (0.000)*			
TASS*1* / TASS*2*	-0.146 (0.000)*	-0.029 (0.023)			
POS*a1* / POS*b1* / POS*a2* (1)			0.619 (0.000)*	-0.021 (0.762)	0.697 (0.000)*
POS*a1* / POS*b1* / POS*a2* (2)			0.711 (0.000)*	0.363 (0.000)*	0.712 (0.000)*
POS*a1* / POS*b1* / POS*a2* (3)			0.516 (0.000)*	0.564 (0.000)*	0.403 (0.000)*
POS*a1* / POS*b1* / POS*a2* (4)			0.625 (0.000)*	0.640 (0.000)*	0.472 (0.000)*
Control variables					
MKT*1* / MKT*2*	0.313 (0.000)*	0.380 (0.000)*			
DSHARE*1* / DSHARE*2*	-0.009 (0.000)*	-0.003 (0.026)			
NOD*1* / NOD*2*	-0.009 (0.001)*	0.065 (0.000)*			
NB*a* / NB*b*	-0.357 (0.000)*	0.377 (0.000)*			
REP*a1* / REP*b1* / REP*a2*			-0.025 (0.541)	0.046 (0.254)	0.113 (0.004)*
Intercept	-3.973 (0.000)*				
N			61,666		
Pseudo R^2 (Cox & Snell)			0.136		
Pseudo R^2 (Nagelkerke)			0.316		

Notes: The sign of the regression coefficients (β) indicates the direction in which the multiple interlocks is correlated with the independent variables. The odds ratio of multiple interlocks changes by *exp*(β) amount for a one-unit change of the independent variables. *p*-values are in parentheses. * indicates statistical significance at the 1% level. The table is organized in a way such that the total seven possible attributes of a variable in a research unit are displayed in five columns. The first two columns display the results for board and director related variables. The third through fifth columns display the results for link related variables.

Table 6.5 Regression results with ROA as the dependent variable

	Regression coefficients for ROA*1*				Regression coefficients for ROA*2*			
	Board *1* or Director *a*		Board *2* or Director *b*		Board *1* or Director *a*		Board *2* or Director *b*	
Independent variables								
C4	-0.029	(0.000)*			-0.032	(0.000)*		
Control variables								
TASS*1* / TASS*2*	0.068	(0.000)*	0.089	(0.000)*	0.083	(0.000)*	0.094	(0.000)*
MKT*1* / MKT*2*	-0.038	(0.000)*	-0.037	(0.000)*	-0.039	(0.000)*	-0.046	(0.000)*
DSHARE*1* / DSHARE*2*	0.195	(0.000)*	0.021	(0.000)*	0.022	(0.000)*	0.191	(0.000)*
NOD*1* / NOD*2*	-0.031	(0.000)*	-0.015	(0.004)*	-0.025	(0.000)*	-0.008	(0.144)
CI*a* / CI*b*	-0.078	(0.000)*	-0.053	(0.000)*	-0.091	(0.000)*	-0.012	(0.006)*
NB*a* / NB*b*	0.102	(0.000)*	0.040	(0.000)*	0.101	(0.000)*	0.016	(0.001)*
Intercept	-5.481	(0.000)*			-7.068	(0.000)*		
N	61,666				61,666			
R^2	0.058				0.056			

Notes: *p*-values are in parentheses. * indicates statistical significance at the 1% level. The table is organized in a way such that the total seven possible attributes of a variable in a research unit are displayed in five columns. The first two columns display the results for board and director related variables. The third through fifth columns display the results for link related variables.

7. Conclusions

7.1 Conclusions

The proposed simulation model is able to reproduce a network with herding properties similar to the real-world affiliation network given events and actors degree distributions. The reproduced network deviates from the random network on all multiple interlock related properties. The results provide a strong support to the hypothesis that herding is a crucial social process that is at work in real-world affiliation networks.

Statistical analysis results indicates that directors who control a large amount of effective assets in the corporate world, own a high percentage of equity in a company, or hold an inside management position are more likely to be involved in multiple firm interlocks. Taken together, controlling shareholders and their associates are the main individuals who are involved in multiple interlocks. Finally, corporate boards which involved in multiple interlocks show inferior financial performance.

This study contributes to the corporate governance literature in four aspects. First, it is the first study that explores in detail the multiple interlocks phenomenon in the corporate world. Second, it confirms that a certain portion of director multiple interlocks are created intentionally rather than coincidentally. Third, it hypothesizes and provides evidence that the multiple interlocks of boards and directors in corporate Taiwan is formed by controlling shareholders and their associates when these individuals monitor their investments together. Fourth, company financial performance is found to be negatively related with multiple interlocks.

The findings of this study have one policy implication. The overall negative relation of herding with company financial performance highlights the potential pitfall of multiple interlocks and the necessity of establishing corporate governance policies to monitor directors that go in herds especially those which practice heavy multiple interlocks. Heavy wide herding are more prone to embezzling of shareholders wealth than other types of herding as it is the situation where monitoring becomes total control. The only law we are aware of that restricts director interlocks is the Section 8 of the U.S. Clayton Act of 1914 which forbids the sharing of common directors among competing companies. It may be the time for corporate governance agencies worldwide to initiate mechanisms to monitor companies with heavy wide herding of directors.

7.2 Suggestions future research

This research found statistically that companies with boards and directors involved in multiple interlocks have inferior financial performance than companies do otherwise. A proper reasoning is that controlling shareholders of a conglomerate company choose to benefit themselves such that the financial performance of the company is negatively affected. There are, however, exceptions. For example, the boards of Yulon and China Motor have eight nine common directors and yet both enjoy better than average financial performance for the last several years. This implies that the effect of multiple interlocks can possibly be either very good or very bad depending on controlling shareholders' goodwill. A future research may use a more complex regression model to investigate whether this U-shaped effect actually exist.

Examining longitudinal variation of multiple interlocks is another area for future study. Board directors are reelected once every several years. In between their terms, there are also situations that directors leave their post and new directors are assigned. The associated board of directors network therefore evolves with time. This research has done a cross-sectional study and found that the multiple interlocks of boards and directors in corporate Taiwan is formed by controlling shareholders and their associates when these individuals monitor their investments together. Such behavior may also shift with time. In a preliminary study, bipartite clustering coefficient is found to be decreasing with time for the last decades. A longitudinal study would be able to follow the behavior shift by examining the variation of multiple interlocks.

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APPENDIX

台灣上市上櫃公司董事多重連結實例

1. 雙人拍檔參加三家以上董事會實例

H3x2 聯電 智原 欣興: 曹興誠 宣明智

H3x2 神達 聯強 資通: 果芸 苗豐強

H3x2 大同 華映 大世科: 林郭文艷 林蔚山

H4x2 光寶科 閎暉 敦南 建興電: 林行憲 宋恭源

H4x2 金寶 仁寶 飛信 華寶: 陳瑞聰 柯長崎

H4x2 江申 裕隆 中華 華晶科: 徐善可 嚴凱泰

H4x2 環泥 太子 南紡 南帝: 侯博義 吳昭男

H5x2 亞泥 遠紡 宏遠 東聯 遠東商銀: 席家宜 徐旭東

H5x2 台塑 南亞 台化 南科 台塑化: 王永慶 王永在

H5x2 統一 大統益 太子 統一超商 統一實: 林蒼生 高清愿

H5x2 台泥 嘉泥 福聚 中橡 遠傳: 張安平 辜成允

2. 三人拍檔參加四家董事會實例

H4x3 亞泥 遠紡 遠傳 裕民: 李冠軍 徐旭平 徐旭東

H4x3 環泥 南紡 南帝 太子: 吳昭男 侯博明 侯博義

3. 四人拍檔參加三家董事會實例

H3x4 亞泥 遠紡 裕民: 李冠軍 徐旭平 李坤炎 徐旭東

H3x4 環泥 南紡 南帝: 吳昭男 吳亮宏 侯博明 侯博義

H3x4 台聚 華夏 台達: 周新懷 吳亦圭 陳耀生 鄭大志

H3x4 台達 華夏 亞聚: 吳亦圭 苗豐強 周新懷 劉鎮圖

H3x4 力麗 力鵬 力麒: 郭俊男 郭銓慶 郭木生 郭紹儀

H3x4 裕隆 中華 裕融: 蘇慶陽 陳國榮 黃日燦 嚴凱泰

4. 董事成群結對的參加兩家董事會實例

H2x7 華夏 台達: 吳亦圭 周新懷 柯衣紹 苗豐強 陳耀生 劉鎮圖 鄭大志

H2x7 佳和 怡華: 陳燦榮 翁川配 張汝華 翁全輝 翁茂欽 翁茂鍾 莊榮州

H2x7 太子 南帝: 鄭麗玲 吳中堅 吳文雄 吳昭男 侯博明 侯博義 陳仁欽

H2x8 環泥 南紡: 吳中和 莊英男 吳亮宏 吳昭男 侯博明 侯博義 侯博裕 顏岫峰

H2x8 士紙 萬海: 陳清治 陳朝亨 陳朝傳 陳慧穎 林欣蓓 陳力 陳柏廷 陳致祥

H2x8 嘉食化 力霸: 李政家 王令楣 喻志鵬 王又曾 王令一 王令台 王令僑 王金世英

H2x9 裕隆 中華: 陳莉蓮 黃文成 蘇慶陽 吳舜文 徐善可 戚維功 陳國榮 黃日燦 嚴凱泰