Social Networks Analysis: A Game Experiment

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ABSTRACT

This study examines how early business relationships in company networks may predict later performance and centrality. We define a way of classifying centrality trajectories in social networks, providing a method that can be used more generally to predict network change over time. Employing a game simulation, we show that there are strategies that correlate with eventual centrality and profit, and other strategies that correlate with poor performance.

Categories and Subject Descriptors

J.4. [Social and Behavioral Sciences]: Economics.

General Terms

Measurement, Performance, Experimentation.

1. INTRODUCTION

A key question in social networks and alliances studies is how networks in which companies are embedded affect the companies' behavior, conduct, and profitability (e.g., [9], [11], [12]). Typically, studies analyze companies as autonomous entities, endeavoring for competitive advantage by either studying the external industry sources or the internal organizational capabilities and resources [11]. We explore how entities may achieve a competitive edge, but by concentrating on their relationships with other entities, the network where they reside. This study investigates the evolution of networks through a laboratory experiment using a simulation. We use the simulation to: (1) establish a realistic environment for laboratory research on social networks by creating simulated networks; and (2) gain insights regarding company structure, conduct and performance.

We show that centrality is indeed important, and that early choices people or companies make can be used to predict network connectivity and profit later. We also show that there are strategies that correlate with eventual centrality and profit, and other strategies that correlate with isolation and poor performance.

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2. BACKGROUND

Social networks are occasionally described in Information Systems literature, mainly in the context of electronic networks, digital communication or biotechnology. For example, [7] explore the structure embedded in e-mail relationships; [16] present a roadmap for research using 'Second Life' and other virtual social networks; [21] present a method for event-based dynamic network visualization and analysis; [24] address an identity matching problem based on social contextual information; [19] consider spyware and security breaches that affect Internet users, and analyze how social networks are created to solve the specific problems; [15] and [14] examine how individual social capital influences knowledge contribution in electronic networks; [2] investigate startups' alliances; [22] study the formation of an industry network; [17] and [18] look at networks in biotechnology communities; None of these studies, however, uses network concepts to create networks, where one may measure centrality and its consequence – performance.

One of the most studied concepts in social networks analysis is the links between groups or individuals ([10], [5]). Studies argue that those links create a competitive advantage for those who span them [4]. Some authors (e.g., [1], [12], [13]) argue that emerging networks rely primarily on strong ties that provide them resources and only later they expand to include weak ties. Others (e.g., [10], [20]) argue that emerging networks enhance their search for new information by a large number of weak ties. We use this concept to examine whether entities seize opportunities to bridge between two communities in order to gain social capital. That is, whether this positioning yields profits. For that, we need to investigate the structure and the alliances of the network.

Among the several measures analyzing the structure and alliances of social networks are: (a) degree (suggested by [8]; and (b) network redundancy (e.g., [7]). Degree is frequently associated with the notion of centrality ([6], [23]) and is defined as the number of ties that a given vertex has [3]. Network redundancy is an index that measures the existence of structural holes. In this study, we propose a new longitudinal measure we call the centrality trajectory based on the degree and the network redundancy measures. We explore this measure in the methodology section.

3. METHODOLOGY

We employ the International Operations Simulation Mark/2000. The simulation is highly realistic, meant to simulate the total environment. Participants were divided to teams ("companies") and immersed themselves in an artificially created hi-tech industry, where companies conducted research, produced and marketed chips and PCs.

Playing the game, each company could concentrate on any one or any combination of the functions of manufacturing, marketing of one's own products or selling to overseas distributors, serving as a distributor or a subcontractor, exporting, importing, financing and licensing. The ultimate measure of company performance was the net profits each company achieved throughout the game.

The decision-making process in this simulation is based on an analysis of the company, interaction with other companies and the constraints stated in the player's manual (e.g., procedures for production, types of marketing channels available). The game has become highly realistic as a result of the efforts invested in it to simulate the environment. It forces participants into a stream of top management decisions, typical of any large firm. Incoming participants play six game-periods ("stages") in each semester. The length of each simulated stage is usually referred to as one year. Each semester we played the game with new participants.

We conducted this study with senior MBA candidates during eight semesters from Summer 2005 to Summer 2008. A total of 602 students participated in this experiment. The participants allocated responsibilities for specific functions, and worked to achieve the common goals of their company, as they themselves defined.

4. HYPOTHESES

This study proposes using a new longitudinal network measure we call *the centrality trajectory*. We use this notion to evaluate company collaboration during the early stages of the simulation. We use this measure to explain, for example, how certain companies succeed more through their ties with other companies and are able to gain profits while other companies suffer from conflict and losses.

We define four main trajectory types (a) low energy, a strictly below average collaboration; (b) increasing energy, a continuous increase in collaboration over time; (c) high energy, a strictly above average collaboration; and (d) declining energy, a continuous decrease in collaboration over time.

In order to determine the trajectory type of a company, we need to define its level of collaboration with other companies. For that, we use the degree measure, i.e., the number of ties an entity hold in a network.

The centrality trajectory compares the degree measure of each vertex to the average degree of the network only in the first two stages and determines the trajectory type of the each vertex accordingly. Then, those first two stages are used to predict the final stage. Our hypothesis is that companies classified as Low Energy or Declining Energy under-perform other companies while High energy companies outperform other companies.

5. RESULTS

To examine our hypothesis, we analyzed the simulation as a network: the simulated companies are characterized as vertices and interactions between companies are represented by the edges. Each link between two companies represents a trade transaction and is backed up by a contract.

In Figures 1.1 and 1.2 we show an example of the evolving network of relationships in the spring semester of 2006. Figure 1.1 illustrates the industry after the first stage, whereas Figure 1.2. shows the industry by the end of the game, after six simulated stages.

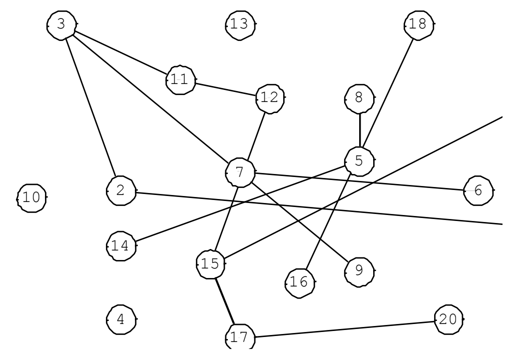

Figure 1.1. Network structure in the spring semester of 2006: the beginning of the game.

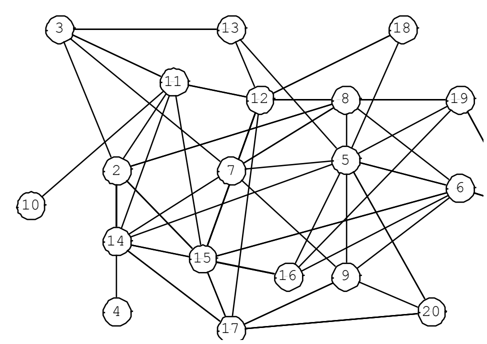

Figure 1.2. Network structure in the spring semester of 2006: the end of the game.

Next, we classified each company in each semester into one of the trajectory types according to the degree values in the first two stages of the game. Next, using the data from all semesters, we created a regression; using the trajectory types as dummy variables, we predict the relative net profit of each company. In Table 1 we detail the value of each trajectory type along with the regression's F and P values.

Table 1. Variables, F- and p-values for the regression according to the degree and network redundancy measures

Variable	Relative Net Profit
Low Energy	-38.1
Increasing Energy	3.8
High Energy	100.4
Declining Energy	-53.3
F-Value	17.62
p-Value	<0.0001

As can be observed, both regressions are significant and exhibit relatively close results. A low energy company performs more than 35% worse than the average company; an increasing energy company performs just above the average company; High energy companies perform more than 100% above average; and finally, declining energy companies present a below average performance of more than 50%. As the regression is significant, it appears that only high energy companies, maintaining their ties with other companies, tend to significantly outperform other companies; other companies struggle to make the average net profit.

Overall, our findings indicate how variation in the network structure when the network emerges produces significant differences in company performance, contributing directly to an explanation of how and why centrality emerges for some and not for others.

6. DISCUSSION AND CONCLUSIONS

Those results indicate that just by looking at the strategy used in the first two rounds, we could predict success in the last round. High energy strategies – that is, sustained centrality – predict success, and low energy strategies – that is, a tendency to isolation – predicts failure. In this study, companies that positioned themselves at the central, pivotal point of the network early in the game and maintained alliances produced better performance. While this in retrospect may seem predictable, only about 20% of the companies actually implemented all this strategy. The remaining companies either partially implemented these guidelines or ignored them all together; that is, there are many other strategies that the participants used: some have intentionally held back, trying to differentiate their company from the competition. Others lacked the ability to sustain partnerships and suspended their alliances in the hopes of better integrating their activities.

Yet, it seems that a single-minded focus on the network is a promising business strategy. As the network grows, more ties are based on a calculation of economic costs and benefits. This makes the network more intentionally managed network where companies exploit structural holes. Companies wishing to enhance their performance should: (a) establish partnerships and alliances; (b) construct them into an efficient network that grants access to diverse information and capabilities with minimum redundancy; and (c) prudently partner with potential rivals that offer more business opportunities and less risk of intra-alliance rivalry. Future research can examine whether those strategies are also valid in the real-world.

We state a caveat: although simulations today present sufficient complexity to provide a realistic network setting, no simulation can reproduce all aspects of real-life networks. For example, in real-life markets, new companies are constantly being formed, in contrast to the experimental environment, in which all companies formed simultaneously. Therefore, the relation of these finding to business practice must be examined with caution. As more data from real business networks become available, it will be easier to determine the extent to which game situations resemble reality. In addition, this study was conducted with students, which is a limitation by itself, as students do not necessarily present the characteristics of real company executives.

In a future, larger study we may be able to test a series of hypotheses about which other combinations work best and worst. For example, it may be that the conjunction of a high energy with an increasing energy company might do even better than the combination of a high energy with a high energy company. In other words, it may be that certain strategies are symbiotic, and others are counter-productive.

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