2009

Network Structure and Centrallity: A Simualtion Experiment

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Abstract

This study examines how establishing early centrality in company networks may predict later performance. Using a simulation, we show that there are strategies that correlate with eventual centrality and profit, and other strategies that correlate with isolation and poor performance. The paper also defines a way of classifying centrality trajectories in social networks, providing a method that can be used more generally to predict network change over time.

Keywords: Social Networks, Centrality, Performance, Simulation.

Introduction

We know that centrality is associated with power in many different kinds of social networks, but we still do not fully understand how centrality emerges for some and not for others. In the context of business, it is clear that is advantageous for a company to be positioned centrally in a market of consumers and suppliers, yet this clarity does not in itself help us understand how some companies emerge as central.

Before electronics, centrality in marketplaces was inextricably bound up with geography, as both messages and goods needed to traverse transportation networks. Now, in an age of electronic communication, messaging at the speed of light has led us to networks models that are topological, in which distance is less important than connection. As a result, we can think of companies as information systems, which in turn are nodes in a system-of-systems we call a marketplace. The prevalent model of social network growth is preferential attachment (Barabási and Albert, 1999, Simon, 1955), which states that networks grow as newcomers attach to others in proportion to the amount of connections others already have. That is, entities attach to those who are already well connected. But does it mean that centrality emerges only for companies that are well connected? Do companies just need to increase their number of ties?

When studying real business networks, external factors, such as, for example, economic changes wrought by war, may overwhelm other factors in determining the growth of the networks. Here, we use a laboratory approach to studying business networks: we form teams of MBA students, and let them play roles as companies over a period of a year. The companies form alliances, create contracts, and go bankrupt just as companies do. The difference is that their interactions are recorded and can be analyzed in detail, providing longitudinal data from a closed system. We use this environment to ask the following broad research questions: How does centrality emerge in marketplaces? Are there strategies of behavior that tend to lead to centrality? To isolation? Is centrality a function of individual company choice, or are the relations between companies the driving forces? And how does centrality relate to profit?

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

Background

Social networks are occasionally described in Information Systems literature, mainly in the context of electronic networks, digital communication or biotechnology. For example, Cucchi and Fuhrer (2007) explore the structure embedded in e-mail relationships; Mennecke et al. (2008) present a roadmap for research using 'Second Life' and other virtual social networks; Trier (2008) present a method for event-based dynamic network visualization and analysis; Xu et al. (2007) address an identity matching problem based on social contextual information; Stafford and Urbaczewski (2004) consider spyware and security breaches that affect Internet users, and analyze how social networks are created to solve the specific problems; McLure and Faraj (2005) and Kankanhalli et al. (2005) examine how individual social capital influences knowledge contribution in electronic networks; Baum et al. (2000) investigate startups' alliances. Walker et al. (1996) study the formation of an industry network. Owen-Smith et al. (2004) and Powell et al. (1996) 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.

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., Goerzen, 2005; Gulati et al., 2000; Hite and Hesterly, 2001). Gulati et al. (2000) claim that 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. We explore how entities may achieve a competitive edge, but by concentrating on their relationships with other entities, the network where they reside.

One way to deepen understanding from this perspective is to investigate the evolution of networks over time. One popular approach of doing so is to examine real world networks. For example, Kumar et al. (2006) explored two online social networks; Leskovec et al. (2005) studied patterns in citation graphs. Greve and Salaff (2003) studied network activities of entrepreneurs through three phases of establishing a firm. Elfring and Hulsink (2007) explored patterns of network development in information technology startups. Another method of investigating the evolution of networks is through a laboratory experiment using simulation games. Simulations and games are considered a link between abstract concepts and real-world problems consistent with theories of constructive learning (Martin, 2000). We use a simulation game as the vehicle to: (1) establish a realistic environment for laboratory research on social networks; and (2) gain insights regarding company structure, conduct and performance.

One of the most studied concepts in social networks analysis is the value of a position in a structure, now named social capital (e.g., Burt et al., 2001; Coleman, 1990; White, 2004). Social capital is usually referred to as the contextual counterpart of human capital and refers to the value or the benefit that emerges from ties that an individual maintains with others. Nahapiet and Ghoshal (1998) claim that social capital facilitates the creation of new intellectual capital. The authors explore different dimensions of social capital (for example, relational and cognitive social capital) and the main mechanisms and processes necessary for the creation of intellectual capital.

Studies show that the lack of strong links between groups or individuals creates holes in the social structure of the network (Greve and Salaff, 2003; Burt et al., 2001). These structural holes create a competitive advantage for those who span them (Burt, 1992). The concept of weak and strong ties is at the core of a controversy surrounding structural holes (Elfring and Hulsink, 2007). Some authors (e.g., Batjargal, 2003; Hite and Hesterly, 2001; Jack, 2005) 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., Greve and Salaff, 2003; Steier and Greenwood, 2000) argue that emerging networks enhance their search for new information by a large number of weak ties. They state that structural holes may represent an opportunity to control information and possibly bridge the gap between people or groups from opposite sides of the holes (Burt et al., 2001). 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 Freeman, 1979); and (b) network redundancy (e.g., Burt et al. 1992). Degree is frequently associated with the notion of centrality (Carrington et al., 2005; Wasserman and Faust, 1994) and is defined as the number of ties that a given vertex has (Borgatti, 2005). 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.

Methodology and Hypotheses

The Simulation Employed

This study's platform is a simulation game. Its objective is to offer participants the opportunity to learn by doing in as authentic a management situation as possible and to engage them in a simulated experience of the real world (e.g., Garris et al., 2002; Martin, 2000). This usually enhances the characteristics of the game as a simulation of real life, and behavior observed may be generalized to reality (e.g., Lainema and Makkonen, 2003).

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.

The formation of the companies and allocation of executive roles within companies proceeded without external intervention or manipulation, and were reported to the game administrator before the game itself began.

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 started the game from the beginning with new participants.

Communication between companies can be made through email, phone calls, individual contact, or using two unique game features: (1) the game newspaper, where companies can advertise and look for partners; and (2) an electronic bulleting board created on the web with the ability to post electronic messages.

Economic changes in the game are controlled by the administrator and communicated to the students through the game's newspaper. However, in our experience, those changes have very little impact on long-term gains or losses.

Subjects

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 number of participants in each semester is detailed in Table 1. For this research, all the results are aggregated.

In all semesters, the participants allocated responsibilities for specific functions, and worked to achieve common goals that they themselves defined. Our game experience shows that executive roles were usually allocated according to the participants' expertise in certain functional areas (e.g., accountants and bankers were usually assigned the role of chief financial officers). While each of them became a specialist in his or her function, a joint effort was required to pursue the common objectives of the company.

Network Measure

This study proposes using a new longitudinal network measure we call the centrality trajectory. This measure is based on the degree and the network redundancy measures. We use the centrality trajectory 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 transformations of two measures: (a) degree; and (b) network redundancy.

Let $a^1_{i,t}$ be the degree of vertex i in stage t. That is, $a^1_{i,t} = \sum_i d_{i,j,t}$, where $d_{i,j,t}=1$ if vertex i has a direct relationship with vertex j in stage t, and $d_{i,j,t}=0$ otherwise. We also define $\bar{a}^1_t$ as the average degree in stage t. That is, $\bar{a}^1_t = \frac{\sum_i a^1_{i,t}}{n}$, where n is the number of vertices in the network.

The network redundancy index measures the extent to which the ties of a vertex are redundant, i.e., the extent that a vertex's contacts are also connected to each other. We use this index to evaluate the redundancy of each vertex; that is, the ability of the network to continue its flow from one vertex to another after the vertex (and its adjacent edges) are removed (note that the network redundancy index relates to the F measure of fragmentation; see Borgatti, 2006 and Chen et al., 2006). To measure the redundancy we modify Burt's redundancy measure (1997). The measure of redundancy for vertex i in stage t, $a^2_{i,t}$, is defined as $1-\frac{2\sum r_{j,k,t}}{n(n-1)}$, where $r_{j,k,t}=1$ if vertex j can reach vertex k via any path of any length in stage t when vertex i is removed from the network, and $r_{j,k,t}=0$ otherwise.

Note that when all remaining vertices are reachable from all the other vertices in stage t, when vertex i is removed, then $a^2_{i,t}=0$. When all the remaining vertices are independent, $a^2_{i,t}=1$.

The centrality trajectory type of vertex i according to measure k (k=1,2) is defined by the following:

$$\text{Centrality\_Trajectory\_Type}_i^k = \begin{cases} \text{Low Energy} & \text{if} \quad a_{i,t}^k < \bar{a}_t^k \quad ,t=1,2 \\ \text{Increasing Energy} & \text{if} \quad a_{i,1}^k < \bar{a}_1^k \ , a_{i,2}^k > \bar{a}_2^k \\ \text{High Energy} & \text{if} \quad a_{i,t}^k > \bar{a}_{i,t}^k \quad ,t=1,2 \\ \text{Declining Energy} & \text{if} \quad a_{i,1}^k > \bar{a}_1^k \ , a_{i,2}^k < \bar{a}_2^k \end{cases} \quad , k=1,2$$

Note that here we use the centrality trajectory to compare both the degree and the network redundancy of each vertex to the average degree or network redundancy only in the first two stages and determine the trajectory type of the each vertex accordingly. Thus, the first two stages are used to predict the final stage. Future research might examine how the accuracy of prediction might change with increasingly long trajectories.

Hypotheses

Studies investigating the economic consequences of social or strategic networks show that companies enter alliances to improve their competitive position (e.g., Burt, 1992; Gulati et al., 2000; Goerzen, 2005). Researchers also confirm a positive correlation between profits and networks with structural holes; that is, networks with less redundancy. For example, Burt et al. (2002), Reagans and Zuckerman (2001), Yasuda (1996) and Jang (1997) study the relationship between performance and market networks in US and foreign markets and industries. Burt et al. (2001) assert that the association between performance and network redundancy reveals the significance of structural holes and their ability to provide social capital.

In this study we focus on the practical aspect of networks and examine how the centrality trajectory type (of a company which also relates to structural holes) impacts its performance. This relationship between network structure, ties and centrality, discussed in Greve and Salaff (2003), Hite and Hesterly (2001) and Jack (2005), leads us to hypotheses 1 and 3. Also, recent theories of relational classification (e.g., Hill et al., 2007; Sen et al., 2008) lead us to hypotheses 2 and 4; that is, to predict that conjunction of certain company types would predict performance. Therefore, we make the following predictions:

Hypothesis 1: Companies classified as Low Energy or Declining Energy under-perform other companies.

Hypothesis 2: Low energy companies collaborating with other low energy companies tend to under-perform low energy companies collaborating with other types of companies.

Hypothesis 3: High energy companies outperform other companies.

Hypothesis 4: High energy companies collaborating with other high energy companies tend to perform better than high energy companies collaborating with other types.

In addition to the above, we also study other network characteristics and examine how they evolve over time. Network diameter is an overall characteristic of social networks that evolves as the links between network nodes change. The distance between two vertices is defined as the length of the shortest path between them, assuming there is such a path. A path between two vertices exists if and only if both vertices are linked together, either directly or through other vertices. The length of the path is the number of edges it has. The diameter of a network is defined as the maximum distance between all pairs of vertices. There are studies that have shown that diameters are slowly growing as networks evolve and their size increase (Albert et al., 1999; Bollobas and Riordan, 2004; Border, 2000; Watts et al., 1998). There are many possible reasons for diameter growth – for example, each node that joins the existing network is attached by a constant number of links. In contrast, there are also studies that show a shrinking diameter (e.g., Leskovec et al., 2005). That study explained the decrease in the following way: networks are becoming denser over time, with the average degree increasing; hence, the number of edges grows super-linearly in the number of nodes, exhibiting a gradual decrease in the diameter. While that study examined a different domain, we think that companies will tend to tighten relationships over time; that is,

Hypothesis 5: the diameter of the market network decreases over time.

Research Findings

Network Characteristics

We analyzed the simulation as a network graph G=(V,E): the simulated companies are characterized as numbered vertices where each node $v \in V$; interactions between companies are represented by the edges, that is, $< u, v > \in E$. Each link between two companies represents a trade transaction and is backed up by a contract (see the appendix for a sample contract from the summer semester of 2008). In Table 1 we detail the number of companies the students operated in each semester. As can be observed, the number of companies in the industry varied from 10 to 20 companies, with an average of about 17 companies.

Table 1. The Number of Participants and Companies in Each Semester

Semester	Fall 2005	Spring 2006	Summer 2006	Fall 2006	Spring 2007	Summer 2007	Fall 2007	Summer 2008
No. of Participants	44	90	90	74	72	68	90	74
No. of Companies	10	20	20	17	16	15	20	17

In Figure 1 we show an example of the evolving network of relationships in the spring semester of 2006. The left side of Figure 1 illustrates the industry after the first stage, whereas the right side of the figure shows the industry by the end of the game, after six simulated stages.

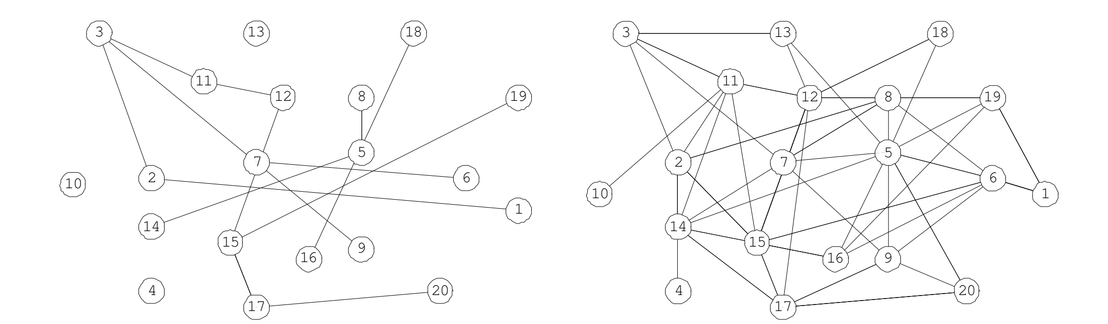

Figure 1. Network structure in the spring semester of 2006; the left represents the beginning of the game, whereas the right corresponds to the end of the game.

Next, we present the following basic graph properties: (a) average degree; (b) degree distribution; and (c) maximum and average diameter.

In Table 2 we present the average degree in each stage for each semester; that is, the sum of degrees of all the nodes, which is twice the number of edges in the graph divided by the number of nodes. We also show the average degree for each stage along with the standard deviation. As can be observed, overall, the average degree increases in the stage number.

Table 2. The Average Degree of Each Graph in Each Semester, the Average and the Standard Deviation (S.D.) of the Average Degree.

Semester Stage	Fall 2005	Spring 2006	Summer 2006	Fall 2006	Spring 2007	Summer 2007	Fall 2007	Summer 2008	Average	S.D.
Stage 1	4.4	1.2	3.4	5.4	4.0	4.3	4.0	3.9	3.8	1.1
Stage 2	8.0	4.8	8.4	7.6	5.9	6.3	6.4	6.5	6.7	1.1
Stage 3	10.8	5.6	11.0	11.6	7.5	9.0	9.6	9.1	9.3	1.9
Stage 4	12.0	6.4	12.0	11.1	8.5	9.0	9.6	9.0	9.7	1.8
Stage 5	10.6	7.8	13.4	12.0	8.4	9.0	9.6	9.0	10.0	1.8
Stage 6	12.0	9.2	16.0	11.8	8.5	9.0	9.6	9.1	10.7	2.4

In Figure 2 we illustrate the degree distribution of the network in the spring semester of 2007. To avoid biases, we averaged the degree distribution over all six stages. The graph is in a log-log scale and a linear trend-line reveals that R^2=0.65. As expected, we can find a power law. We also constructed the degree distribution graphs for all other semesters and found the same phenomenon.

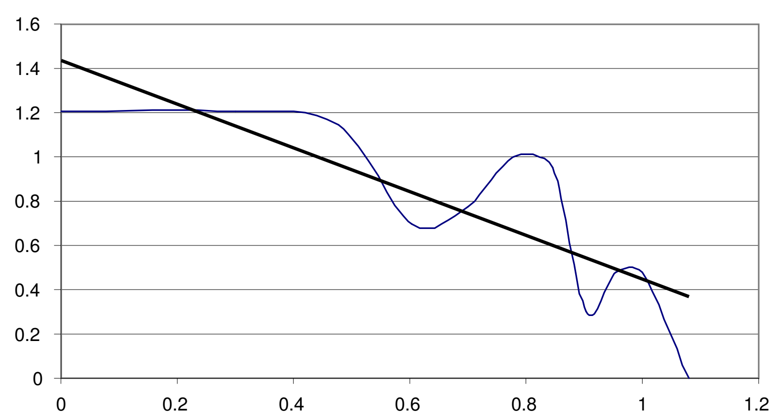

Figure 2. The Degree Distribution in the Spring Semester of 2007 and a Linear Trend-Line on a Log-Log Scale.

Next, we explore the network diameter of each graph. However, measuring just the diameter is not robust as a network may maintain a large diameter due to a single instance of a pair of vertices. Therefore, we also measured the average diameter, that is, the average distance between all pairs of vertices. In Figure 3 we present the average and the maximum diameter for each stage in the fall semester of 2005. As can be observed, both the (maximum) diameter and the average diameter first increase and then decrease in the stage number. When analyzing the other semesters, we found the same phenomenon, where the maximum diameter and the average diameter pick after two or three simulated periods.

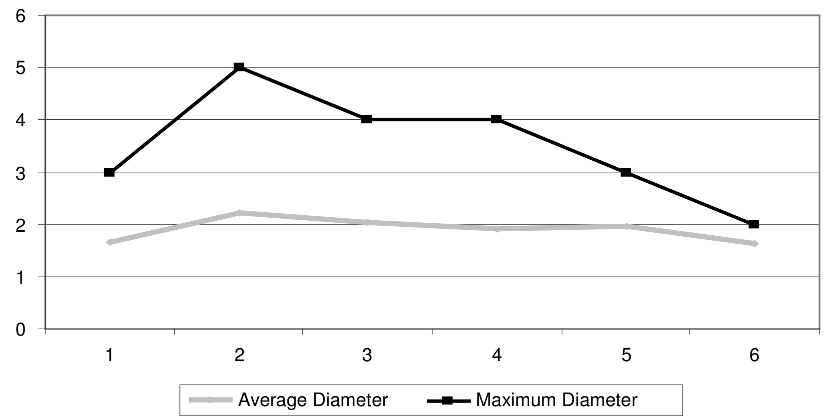

Figure 3. The Average and the Maximum Diameter for Each Stage in the Fall Semester of 2005.

Centrality Trajectory Analysis

In this section we analyze the companies according to their centrality trajectory during the game. We concentrate on the first two stages, and try to conclude their overall performance in the game according to their early trajectory.

We classified each company in each semester into one of the trajectory types according to both the degree and the network redundancy index values in the first two stages of the game. In Table 3 we present an example from the fall semester of 2005. We present the degree and the network redundancy index values of each vertex for the first and the second played period, i.e., $a^1_{i,1}$,$a^1_{i,2}$,$a^2_{i,1}$ and $a^2_{i,2}$. In addition, we show the net profit of each company relative to the average company. Finally, we specify the trajectory type of each vertex.

Table 3. Degree and network redundancy index values, relative net profit and state of each vertex (company) in the fall semester of 2005.

Vertex (Company) No.	$a_{i,1}{}^1$	$a_{i,2}{}^1$	$a_{i,1}{}^2$	$a_{i,2}{}^2$	Net profit	State
1	0	2	0.87	0.53	-4.29%	Low Energy
2	0	2	0.87	0.53	-14.87%	Low Energy
3	2	6	0.98	0.67	140.41%	High Energy
4	1	2	0.93	0.53	-38.11%	Declining Energy
5	0	2	0.87	0.53	-29.94%	Low Energy
6	0	5	0.87	0.67	29.80%	Increasing Energy
7	1	3	0.93	0.67	46.98%	High Energy
8	2	3	0.93	0.67	42.91%	High Energy
9	0	0	0.87	0.38	-78.76%	Low Energy
10	0	0	0.87	0.38	-94.14%	Low Energy
Average	0.6	2.5	0.90	0.56	0.00%	

Note the substantial impact of structural holes on the network redundancy index. For example, for analytic purposes, if we remove from the network company 3 in the last played period of the fall semester of 2006 we demonstrate the existence of structural holes as the removal significantly increases the network redundancy index from 0.38 (a relatively connected network) to 0.84 (a relatively loosely connected network); See also Figure 4 for illustration.

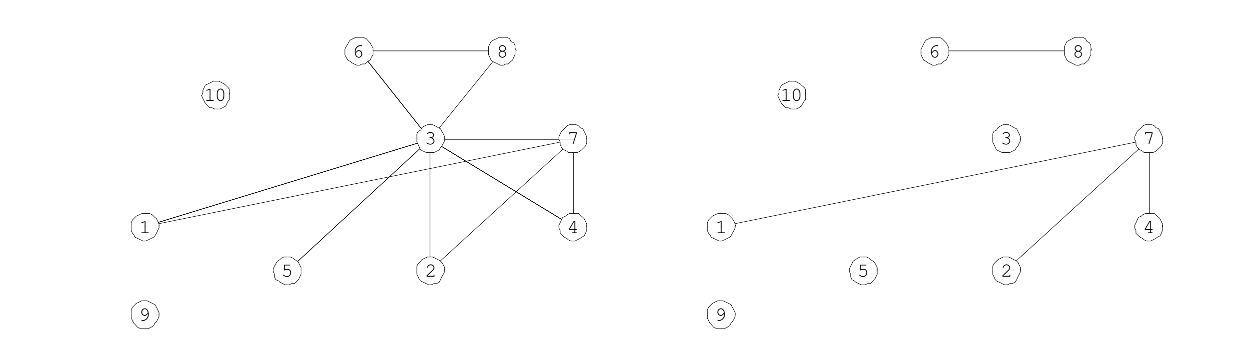

Figure 4. Network Redundancy in the fall semester of 2005; the left represents the network in the last played period, while the right corresponds to the same network with the removal of company 3.

Next, using the data from all semesters, we created two regressions; using the trajectory types as dummy variables, we predict the relative net profit of each company. In Table 4 we detail the value of each trajectory type along with the regressions' F and P values.

Table 4. Variables, F- and p-values for the regressions according to the degree and network redundancy measures.

Variable	Degree	Network Redundancy
Low Energy	-38.1	-35.9
Increasing Energy	3.8	4.3
High Energy	100.4	106.6
Declining Energy	-53.3	-54.7
F-Value	17.62	20.3
p-Value	<0.0001	<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 both regressions are 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.

In addition, we examined strategy clustering between companies. We found that high energy companies collaborating with other high energy companies tend to perform more than 80% better than high energy companies which collaborate with other types of companies. This difference is statistically significant (p-value is 0.008). Low energy companies collaborating with other low energy companies perform 72% worse than low energy companies collaborating with other types of companies. This difference is also statistically significant (p-value is 0.02).

Discussion and Conclusions

This research used a simulation to better understand social networks evolution. Although the general environment was mutual to all participants, the simulated companies became differentiated: each assumed a different strategy, different operating decisions, and a different approach to collaboration with other companies.

Beyond the creation of simulated networks, this study tested four hypotheses relating network characteristics and company performance. Our analysis provides broad support for our hypotheses. 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.

We found 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. The implication is clear: (1) redundancy spans fewer structural holes, leading to less social capital or lower profits; (2) spanning structural holes is the source of social capital and therefore presents high performance; and (3) network structure indicates both where social capital is distributed in the industry and where opportunities for collaboration (i.e., forming relationships) are located.

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.

In addition to performance, we tested a fifth hypothesis related to a network characteristic - the diameter. In contrast to other studies, we found that the distance between vertices first increases but then exhibits a gradual decrease over time. This confirms our conjecture that the overall integration of an industry tends to increase over time, as companies tend to tighten their relationships.

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.

Our hypotheses about the role combinations of companies play were also supported. The conjunction of high energy companies generates higher profits while the combination of low energy companies yields lower profits. 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. In future research, we also wish to look more closely at the way initial alliances form. We learned from the experiment that the early stages of the game are crucial, and so future studies might focus on the genesis of networks, structural holes and the emergence of social capital, and whether this genesis is the result of attributes of the company founders, or instead is random, and thus creates contingency.

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Appendix

Purchase Agreement

Agreed and signed through email on July 13, 2008

Between:

Company 17

Of the first part;

and:

Company 7

Of the second part;

In consideration of the covenants and agreements contained in this purchase agreement, the parties to this agreement agree as follow:

Declarations:

Company 17 will sell 20,000 of its chips to company 7 in period 5.

The price per chip for the transaction in 1.1 is 40$.

Company 17 will sell 100,000 chips in periods 6-10 for a price not less than 40$ per chip.

Any technological advancement will increase the price by 10$ per unit above the minimum price.

For the transaction in 1.1, which sums up to 800,000$, company 7 will pay in cash. Transactions in future periods will be paid in full each period.

> Payment will be executed in US dollars only.
>
> Company 17 will pay company 7 an amount of 1 million US dollars each period if it doesn't supply 100,000 chips in each period.
>
> Company 7 will pay company 17 an amount of 1 million US dollars each period if it decides not to buy 100,000 chips each period.
>
> Company 17 will transfer its PC inventory (20,000 PCs) for 120 US dollars per PC. Company 7 will pay for the goods in period 5.
>
> The chips will be supplied in the US only.

Shipping costs are included in all the above transactions.

The actual shipping costs will be paid by the seller of the goods only.

Settling Disagreements

Any disagreement between the parties in implementing this agreement will be settled peacefully between the parties. Any disagreement not settled within 7 days, will be settled by the game's administrators.

Signed:

____

Company 17

____

Company 7