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To Join or Not to Join: The Effects of Healthcare Networks

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***Abstract*—**This study uses a simulation to establish a realistic environment for laboratory research on Accountable Care Organizations. We study network attributes in order to gain insights regarding healthcare providers' conduct and performance. Our findings indicate how network structure creates significant differences in organizational performance. We demonstrate how healthcare providers positioning themselves at the central, pivotal point of the network while maintaining their alliances with their partners produce better outcomes.

***Keywords*—**Social Networks, Decision-Making, Accountable Care Organizations, Performance

I. Introduction

ONE of the key questions in social networks research is where an organization should position itself within its network or industry (e.g., see [16]). This question becomes particularly important in the Untied States healthcare industry, where healthcare providers (physicians, hospitals, medical centers) strive for competitive advantage by means of either external sources or internal capabilities [19]. Our contention in this paper is that the conduct and performance of organizations in the healthcare industry can be more fully understood by examining their network of relationships instead of just focusing on the autonomous entity. Such a network encompasses the organization's set of relationships with other organizations in the industry. One way to deepen the understanding of entity positioning from this perspective is to investigate this area using a simulation-based laboratory experiment.

In conducting simulated laboratory research, the researcher designs controlled experiments in such a way so as to be able to answer specific organizational questions [5]. Ein-Dor and Segev [10] assert that the complexity and the high cost of creating simulated environments encourage researchers to employ field surveys or case studies rather than laboratory experiments. However, laboratory experiments are particularly attractive because this approach affords the opportunity to obtain precise measurements and to define and validate findings from the field. These objectives can be achieved by using simulations as the means by which to establish realistic environments for laboratory research on organizational positioning in the healthcare industry. Furthermore, this study fosters a heightened awareness of network attributes in order to gain insights into organizational conduct and performance in the United States healthcare industry.

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The investigation of this area will begin with a review of recent changes in the healthcare industry and how those changes can be related to network theory. Then, we state the study's hypotheses and discuss the value of using the network approach in simulation design, followed by an analysis of performance, according to network characteristics. Finally, we discuss the applicability of our findings and propose some future research directions.

II. Literature Review

In the past three decades health costs have been on the rise worldwide. Expenditures in the United States, for example, surpassed $2.3 trillion in 2008, more than three times the $714 billion spent in 1990, and over eight times the $253 billion spent in 1980 (Centers for Medicare and Medicaid Services [7]). Accountable care organizations (ACOs) have been proposed as a novel way to slow the fast-rising health care costs, to improve the quality of health provided, and to create a new healthcare industry structure ([12], [18], [24]). A wide variety of provider organizations could be ACOs: existing integrated delivery systems or other coordinated care arrangements including hospitals and physicians [25]. Three core principles are defined for all ACOs: 1) Provider-led organizations with a strong base of primary care that are collectively accountable for quality and total per capita costs across the full continuum of care for a population of patients; 2) Payments linked to quality improvements that also reduce overall costs; and, 3) Reliable and progressively more sophisticated performance measurement, to support improvement and provide confidence that savings are achieved through improvements in care [21].

The notion of ACO begs the question of how the ACO network affects the individual providers' behavior, conduct, and profitability [19]. This research explores how healthcare providers may achieve a competitive edge by concentrating on their relationships with other organizations within the ACO network that they reside. Our hypothesis is that performance in the healthcare industry can be more fully understood by examining the individual entity's relationships and ties within the network in which it is embedded (the ACO). Such a network encompasses the entity's set of relationships with other healthcare providers in the ACO structure.

Increasing interest in social networks research in the past decade has resulted in an exponential growth of studies across several disciplines in this area, including healthcare ([2], [8]). Network theory is an interdisciplinary field that searches for a common formalism for networks found in real-life. The goal of network theory research is to gain a greater understanding of the structure and flow patterns within networks.

Networks exist in all aspects of life (see Newman [22] and references therein). Each network consists of *vertices* (e.g., people, web pages, power plant and substrates) and *edges* (e.g., relationships, hyperlinks, power lines and metabolic processes); the latter providing the means by which the vertices are connected. We employ those network notions using the platform offered by simulations.

III. Hypotheses

In this study, we focus on the practical aspect of networks and examine how entity collaboration in the healthcare industry impacts performance. Numerous studies examined the structure of networks and the characteristics of their vertices from different perspectives (e.g., [2], [6]); however, the way through which the network characteristics affect performance is still largely unknown. Studies investigating the economic consequences of social or strategic networks show that entities enter alliances to improve their competitive position (e.g., [3], [14], [16]). It seems clear that if healthcare is to become more cost effective, better strategies for disseminating information and diffusing innovations through communities using social influence processes need to be devised [29]. In addition, healthcare social networks have been used before to yield meaningful measures of social integration, and to investigate the social dynamics underlying community function and population health ([8], [28]). In this study we examine how healthcare organizations profit from collaboration. Therefore, we hypothesize:

Hypothesis H1: Organizations collaborating with other organizations outperform entities that do not.

Studies show that the lack of strong links between groups or individuals generates holes in the structure of the network ([4], [15]). These structural holes create a competitive advantage for those who span them [3]. Structural holes are also related to network resilience. Network resilience is defined as a network's ability to function, or continue its flow from one vertex to another, after some vertices and their connections are removed [22]. The existence of strong links within the network strengthens its resilience. Structural holes do the exact opposite, as network resiliency becomes dependent on a few vertices that span those holes.

Researchers confirm a positive correlation between profits and entities spanning over structural holes (e.g., [4], [23]). Therefore, we hypothesize:

Hypothesis H2: Organizations having the biggest impact on network resilience outperform the average organization.

IV. Methodology

A. The Simulation Employed

A simulation is, by definition, a highly complex man-made environment. The objective of using simulations in the management arena (including healthcare management) is to offer participants the opportunity to experiment by doing in as authentic a management situation as possible and to engage them in a simulated experience of the real world (e.g., [13], [20]). The area of simulations in the management arena is extensively covered in literature. Over the years, researchers have reported the extent of usage of simulations in both academe and industry (e.g., [1], [9], [11], [17], [26], [27]).

We used a simulation developed in the United States, commonly known as the International Operations Simulation - INTOPIA B2B (http://www.intopiainc.com). The simulation is designed to yield substantial payoffs in practical training. It involves the participants in the executive process, motivates their need for decision-making aids and forces them to adopt a managerial viewpoint. The simulation is highly realistic, meant to simulate the total environment. Participants immerse themselves in an artificially created world where each organization (healthcare provider) can operate several branches. Incoming participants take part in several simulated time-periods (each simulating one year). The task of the entities is to make decisions which will guide operations (simulated by a relatively easy computer interface) in the current period and which will affect operations in subsequent periods. Decisions were made once a week and were e-mailed to the simulation administrator to be fed to the computer program. After the program ran the data, it generated outputs that included financial reports (e.g., a balance sheet, an income statement), and market researches. These outputs were then e-mailed to the entities and are used for their decision making in sequential periods. Dozens of decisions, covering the entire range of a typical healthcare enterprise, were required of an organization in each simulated period. The decision-making process was based on an analysis of the organization's history as presented to the participants at the beginning of the simulation, interaction with other entities and the constraints stated in the simulation. The performance of an organization in each period was affected by its past decisions and performance, the current decisions, simulated customer behavior, and the competition – the other organizations in the industry.

B. Participants and Procedures

This study was conducted in a university accredited by the Association to Advance Collegiate Schools of Business (AACSB). The participants were senior MBA candidates. We conducted five (independent) runs of the simulation, each with different participants. Table I details the number of simulated healthcare entities created in each run.

At the beginning of each run, the students were asked to form competing teams. The formation of the teams and allocation of executive roles within teams proceeded without any external intervention or manipulation. Our experience shows that executive roles are usually allocated according to the participants' expertise in certain functional areas (e.g., accountants and bankers are usually assigned the role of chief financial officers). In each run, we recorded the decisions made by all the teams. We also kept track of the teams' performance. For this research, we aggregated all the results and statistically analyzed them, as presented later.

V. Findings

A. Network Analysis

This study proposes analyzing the simulation as a network, with all of the associated implications being acknowledged. In Table I we detail the number of entities (organizations) the students operated in each run. As can be observed, the number of entities in the industry varied from 16 to 20 entities, with an average of 17 entities.

TABLE I
THE NUMBER OF ENTITIES IN EACH RUN

Run	Run I	Run II	Run III	Run IV	Run V
No. of Entities	20	17	16	16	16

We consider the simulation as another kind of a social network, where each entity serves as a vertex and its relations or interactions with other entities are considered as edges. For example, Figure 1 illustrates the network structure at the end of Run I. The industry was made of 20 organizations. The figure demonstrates the complexity of the network structure in the simulation. Note that in that particular example, 19 organizations had a least one collaborator (organization 11, for example, had 5 collaborators). One entity, organization 18, did not collaborate with any other entity.

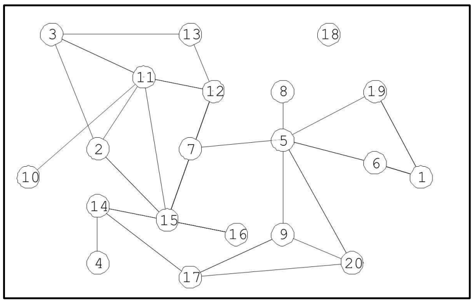

Fig. 1 Network structure at the end of Run I. The industry consists of 20 organizations and exhibits a complex network structure.

TABLE II
THE NUMBER OF EDGES PER ENTITY IN EACH RUN

Run	Run I	Run II	Run III	Run IV	Run V
No. of Entities	20	17	16	16	16
No. of Edges per Entity	2.70	2.59	2.56	2.63	2.06
Standard Deviation	1.63	1.42	1.31	1.36	1.24

Table II presents the average number of edges of each entity in each run and the standard deviation. On average, in all five runs, each entity had 2.51 edges on average with a standard deviation of 1.39. The correlation between the number of entities and the number of edges is 0.48, indicating that the larger the number of entities participating in the simulation, the larger the number of interactions between them.

B. Investigating the Hypotheses – Performance Analysis

This section examines the research hypotheses and tests performance versus network characteristics. In all runs, performance was measured by its accumulated retained earnings (i.e., the accumulated profits).

TABLE III
PERFORMANCE IN ABSOLUTE VALUES AND IN PERCENTAGE RELATIVE TO THE AVERAGE ENTITY IN RUN IV

Entity No.	Performance in Absolute Values (in K$)	Performance (in %) Relative to the Average Entity
1	1,267	-59
2	(456)	-115
3	1,358	-57
4	6,248	100
5	(2,354)	-175
6	10,564	238
7	562	-82
8	(3,214)	-203
9	1,267	-59
10	16,234	419
11	(235)	-108
12	23	-99
13	(5,248)	-268
14	3,624	16
15	7,562	142
16	12,834	310
Average	3,127	0

For example, Table III exhibits the performance of organizations in Run IV in absolute values and in percentage, relative to the average organization in that run. The average organization in Run IV achieved accumulated retained earnings of about 3.1 million dollars. Organization no. 6, for example, achieved accumulated retained earnings of more than 10 million dollars, which is 238% more than the average organization in that run. Note that organizations that achieved negative profits may present performance worse than -100%. To avoid biases, we do not measure entity performance in absolute values, but in percentage, relative to the average entity of the associated run. For example, the performance of entity no. 6, described above, would be 238 (which represents 238% more than the average entity), while the performance of entity no. 9 would be -59. We emphasize that the results in this section are aggregated for all five runs.

In all runs, 85% or more of all organizations collaborated with at least one other organization. Table IV shows the average performance of the collaborating entities and the 'independent' entities (those entities that decided not to collaborate) in each run, relative to the average entity.

TABLE IV
ENTITY PERFORMANCE – HYPOTHESIS H1

Run	Run I	Run II	Run III	Run IV	Run V
% of collaborating entities	95	88	94	94	87
Performance of collaborating entities	2.24	1.20	2.11	3.93	2.93
Performance of single entities	-42.68	-8.98	-31.68	-59.00	-20.54

The results reveal that entities that did not participate in alliances with other entities usually had below-average results. We cannot determine that all results are significant due to the relatively small number of entities. We also note that some of the collaborating entities performed much worse than the 'independent' entities in the same run, but overall, on average, collaboration prevailed.

C. Investigating the Hypotheses – Network Resilience

The concept of network resilience reveals the following characteristics of a network: (1) entity dependency on other entities; (2) the notion of centered or pivot entities; and (3) ineffectual or weak entities. The removal or collapse of centered or pivot entities may lead to a network breakdown, whereas the collapse of ineffectual or weak entities does not significantly affect the flow of information or goods within the network.

Network resilience is a measure of the number of centered entities within the simulated network. For example, in Run I, the (artificial) removal of only two entities (organizations 5 and 15) results in a large dysfunction of the network, as shown in Figure 2: the large component of 19 entities breaks up to 5 smaller ones. On the other hand, a removal of an entity placed on the edge of the large component, connected to only few other entities (for example, entity no. 10, which is connected to only one entity), would have little effect on the "flow" within the network, as this entity serves as an insignificant satellite of the large component.

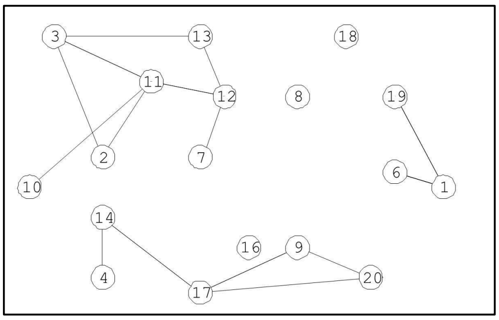

Fig. 2 The network structure of Fig. 1 after the (artificial) removal of two entities (entities 5 and 15)

Using a computer program, we analyzed the performance of the entities whose (artificial) removal would result in the greatest fragmentation of the network.

The findings reveal that when only one entity was removed, it outperformed the average entity by 82.8%. When two entities were targeted, those entities outperformed the average entity by 52.2%. Those results were statistically significant. The findings show that organizations positioned at the heart of the connection between network components were those that benefited most and outperformed the average organization. They simply exploited their centrality and significance to their own benefit and thus enhanced their performance.

VI. Discussion and Conclusions

This research used network theory concepts to better understand how healthcare organizations should position themselves within the healthcare network. For that, simulated entities were formed. Although the general environment was mutual to all participants, the entities became differentiated: each assumed considerably a different strategy, different operating decisions, and a different approach to collaboration with other entities. Leaving the decision on network strategy to the groups resulted in a variety of behaviors toward other entities in the industry. It appears that these entities reflect most real-life approaches.

Beyond the creation of simulated organizations and industries, this study tested two hypotheses relating network characteristics and organizational performance. Both were confirmed. These results agree with those of previous similar field studies (e.g., [14]).

Furthermore, our findings complement and extend traditional strategy and social frameworks and perspectives. They shed light on our main question of where a healthcare organization should position itself with regard to other organizations in the industry. The answer is complex and has two main aspects: (a) work with other business partners in a large component; or (b) position the organization in the junction between two components. Combining these aspects, we come to the following answer: "position the organization at the pivotal point of the network."

Nevertheless, although simulations today present sufficient complexity to provide realistic network features and characteristics, no simulation can seize all aspects of real-life networks. As more data from real organizations become available, it will be easier to determine the extent to which simulation situations resemble reality. Therefore, the applicability of the simulation findings to the real-world must be examined with caution. Also, there is a need to determine how simulations can be applied in studying various aspects of networks. For example, we showed that generally, performance is improved when organizations operate in large clusters. This begs the question of why this phenomenon is not so frequently found in real life. A deeper investigation may provide important insights to better comprehend these collaboration relationships and address the notion that some entities succeed in coalescing into highly-profitable collaborative components while others suffer from conflict and losses.

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