Sustainable Enrollment Management: A Dynamic Network Analysis

Forrest Murray Stuart

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SUSTAINABLE ENROLLMENT MANAGEMENT: A DYNAMIC NETWORK ANALYSIS

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Educational Leadership

by
Forrest Murray Stuart
August 2016

Accepted by:
Dr. Russ Marion, Committee Chair
Dr. Jon Christiansen
Dr. Robert Knoeppel
Dr. James Satterfield
The primary purpose of this study was to investigate higher education enrollment management (EM) as a complex adaptive system (CAS) and to provide colleges and universities a foundational understanding of what a sustainable EM system looks like from a Dynamic Network Analysis (DNA) perspective. Additionally, I aimed to describe how formal network structures either promote or inhibit sustainable EM. To this end, the following research questions guided this study:

1. To what extent is the research site organized to enable effective and efficient information flow?

2. Which combinations of independent network measures (adaptive leadership, social capital, and clique structure) produce optimal outcome measures for a sustainable EM system?

The research design was an exploratory, sequential mixed methods design, and the research methodologies used for data analysis were DNA and Response Surface Methods (RSM). Two online surveys were used to collect data about the network structure of the EM research site (referred to in the study as Midwestern University or MU), and those data were conditioned and analyzed in order to determine what levels of independent network measures (adaptive leadership, resource capability, and clique structure) produced optimal levels of information flow operationalized using the dependent network measure, average speed.

The results showed that the greatest stability in information flow holds resource capability at a constant high level (0.781) with clustering and closeness centrality at
average levels (0.255 and 0.396, respectively). Resource capability was the main factor influencing the average speed of information flow; clustering had no significant impact.

These results suggested that easy access to resources (a high level of social capital)—regardless of the level of adaptive leadership (closeness centrality) or clique structure (clustering coefficient)—was extremely important for the EM system to sustain itself (and ultimately, the institution) regardless of changes and pressures from within and from outside of the current environment.
DEDICATION

I dedicate this work to my wife, Pam, and to my two daughters, Emily and Katelyn. I also dedicate this work to Clyde Walker, a dear friend of mine who encouraged me as I was taking coursework, yet did not live to see me complete what I had started.
ACKNOWLEDGEMENTS

Obtaining a PhD is about perseverance, and that quality does not come without support from others. The following people were instrumental in this journey.

First and foremost—without question—is my wife, Pam, and my two incredible daughters, Emily and Katelyn. Your encouragement and support over the five years that I have taken classes, gone to the library (especially on Saturday mornings), and, at times, seemed more concerned about my research than family time, were the pillars for my success. Thank you, thank you, thank you. I love you all more than you will ever know.

Second, my eternal gratitude lies with my parents. My mother has always been a cheerleader for me, and she continues to support me in all that I do. Although my dad did not live long enough to see me graduate, I know he is proud nonetheless. I love you both more than I can put into words.

Third, Dr. Russ Marion stepped in to be my major advisor toward the end of my program, mainly because my research interests had changed. I remember arguing about how entity-based leadership is the best style of leadership, and all of this bottom-up stuff that Dr. Marion supported in EDL 905 was just a fad. Well, I was wrong. And, Dr. Marion’s patience with me as I learned an entirely new branch of research was never ending. Through this dissertation, I have merged my passion for enrollment management with a completely new way of understanding what a sustainable enrollment management system is and how it can be empirically studied.
Fourth, Dr. Jon Christiansen has become not only a mentor, but a colleague and friend. I look forward to developing a working relationship as we tackle the continually vexing problems that institutions have with enrollment management and the structures therein. Though you harass me about my love for, and devotion to, the Crimson Tide, I will proudly display the Clemson University flag on our house as I am now a product of this great university.

Fifth, my thanks to Dr. Rob Knoeppel, whom I will fondly refer to as a “Philiconomist.” I always enjoyed our conversations about the economics and finance of education in America, and I especially enjoyed the more philosophical questions we raised and discussed sitting in your office, whether or not those questions dealt directly with economics.

Sixth, Dr. James Satterfield has been with me since the beginning. Not only have I enjoyed your classes, but I appreciate the opportunity you allowed for me to “take over” some classes that focused on private higher education financing, endowments, etc. I hate that you are leaving Clemson, but I wish you and your family the best in your new city and institution.

Finally, I would be remiss if I did not thank Furman University for the flexibility to start and finish my doctorate while also working full time. Perhaps the best advice came from Dr. Elizabeth Davis, president of Furman University: “Just make sure you are the last man standing at your defense.”
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLE PAGE</td>
<td>i</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>DEDICATION</td>
<td>iv</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>x</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xi</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Background of Study</td>
<td>1</td>
</tr>
<tr>
<td>Statement of Problem</td>
<td>2</td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td>2</td>
</tr>
<tr>
<td>Significance of the Study</td>
<td>5</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>5</td>
</tr>
<tr>
<td>Theoretical Framework</td>
<td>6</td>
</tr>
<tr>
<td>Research Questions</td>
<td>8</td>
</tr>
<tr>
<td>Limitations</td>
<td>8</td>
</tr>
<tr>
<td>Assumptions</td>
<td>8</td>
</tr>
<tr>
<td>Organization of the Study</td>
<td>9</td>
</tr>
<tr>
<td>II. THE REVIEW OF LITERATURE</td>
<td>10</td>
</tr>
<tr>
<td>Enrollment Management</td>
<td>11</td>
</tr>
<tr>
<td>Sustainability</td>
<td>19</td>
</tr>
<tr>
<td>Collectivism</td>
<td>20</td>
</tr>
<tr>
<td>Theoretical Framework</td>
<td>22</td>
</tr>
<tr>
<td>Leadership Concepts</td>
<td>30</td>
</tr>
<tr>
<td>Clique Structure</td>
<td>37</td>
</tr>
<tr>
<td>Social Capital</td>
<td>37</td>
</tr>
</tbody>
</table>
Table of Contents (Continued)

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Flow</td>
<td>38</td>
</tr>
<tr>
<td>Networks</td>
<td>40</td>
</tr>
<tr>
<td>Summary</td>
<td>42</td>
</tr>
<tr>
<td>III. METHODOLOGY</td>
<td>43</td>
</tr>
<tr>
<td>Research Design</td>
<td>44</td>
</tr>
<tr>
<td>Ethical Considerations</td>
<td>46</td>
</tr>
<tr>
<td>Role of the Researcher</td>
<td>46</td>
</tr>
<tr>
<td>Setting</td>
<td>47</td>
</tr>
<tr>
<td>Selection of Participants</td>
<td>48</td>
</tr>
<tr>
<td>Data Collection</td>
<td>49</td>
</tr>
<tr>
<td>Software</td>
<td>51</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>51</td>
</tr>
<tr>
<td>Summary</td>
<td>58</td>
</tr>
<tr>
<td>IV. FINDINGS</td>
<td>60</td>
</tr>
<tr>
<td>Research Method and Site</td>
<td>63</td>
</tr>
<tr>
<td>Descriptive Statistics and Network Typology</td>
<td>64</td>
</tr>
<tr>
<td>Network Visualization</td>
<td>75</td>
</tr>
<tr>
<td>Determining Sustainable Enrollment Management</td>
<td>81</td>
</tr>
<tr>
<td>Response Surface Methodology</td>
<td>84</td>
</tr>
<tr>
<td>Response Surface Plots</td>
<td>86</td>
</tr>
<tr>
<td>Summary</td>
<td>95</td>
</tr>
<tr>
<td>V. SUMMARY, DISCUSSION, AND CONCLUSIONS</td>
<td>96</td>
</tr>
<tr>
<td>Research Question 1</td>
<td>98</td>
</tr>
<tr>
<td>Research Question 2</td>
<td>100</td>
</tr>
<tr>
<td>Discussion</td>
<td>101</td>
</tr>
<tr>
<td>Implications for Practice</td>
<td>106</td>
</tr>
<tr>
<td>Implications for Further Research</td>
<td>108</td>
</tr>
</tbody>
</table>
Table of Contents (Continued)

APPENDICES .................................................................................................................. 110

| A. Informed Consent                                      | 111 |
| B. Survey 1                                              | 114 |
| C. Survey 2                                              | 116 |
| D. IRB Notice of Approval                               | 143 |

REFERENCES .................................................................................................................. 144
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Sample Categories for the Response Scale for Knowledge</td>
</tr>
<tr>
<td>3.2</td>
<td>Meta-Matrix for Organizational Design</td>
</tr>
<tr>
<td>3.3</td>
<td>Network Measures</td>
</tr>
<tr>
<td>3.4</td>
<td>Agent x Agent Matrix in Binary Form</td>
</tr>
<tr>
<td>3.5</td>
<td>Optimization Outcomes</td>
</tr>
<tr>
<td>4.1</td>
<td>Network Measures</td>
</tr>
<tr>
<td>4.2</td>
<td>Descriptives of Participants</td>
</tr>
<tr>
<td>4.3</td>
<td>Meta-Network Statistics</td>
</tr>
<tr>
<td>4.4</td>
<td>Nodeset Counts per Network</td>
</tr>
<tr>
<td>4.5</td>
<td>Key Entities Report for Meta-Network</td>
</tr>
<tr>
<td>4.6</td>
<td>Key Entities Report: Degree Centrality by Node</td>
</tr>
<tr>
<td>4.7</td>
<td>Key Entities Report: Closeness Centrality by EM Agent</td>
</tr>
<tr>
<td>4.8</td>
<td>Key Entities Report: Most Knowledge by EM Agent</td>
</tr>
<tr>
<td>4.9</td>
<td>Key Entities Report: Most Resource by EM Agent</td>
</tr>
<tr>
<td>4.10</td>
<td>Key Entities Report: Most Agent by Role</td>
</tr>
<tr>
<td>4.11</td>
<td>Key Entities Report: Most Agent by Knowledge</td>
</tr>
<tr>
<td>4.12</td>
<td>Immediate Impact</td>
</tr>
<tr>
<td>4.13</td>
<td>Network Measures: Current State</td>
</tr>
<tr>
<td>4.14</td>
<td>Optimization Outcomes</td>
</tr>
<tr>
<td>4.15</td>
<td>Results of Box-Behnken Analysis</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Independent Units Within Enrollment Management</td>
<td>3</td>
</tr>
<tr>
<td>1.2</td>
<td>Interdependent Enrollment Management System</td>
<td>4</td>
</tr>
<tr>
<td>2.1</td>
<td>Recruitment Funnel</td>
<td>14</td>
</tr>
<tr>
<td>2.2</td>
<td>Retention Funnel</td>
<td>16</td>
</tr>
<tr>
<td>2.3</td>
<td>Strategic Enrollment Management Funnel</td>
<td>18</td>
</tr>
<tr>
<td>2.4</td>
<td>Simple Network</td>
<td>40</td>
</tr>
<tr>
<td>3.1</td>
<td>Exploratory Sequential Mixed Methods Design</td>
<td>46</td>
</tr>
<tr>
<td>4.1</td>
<td>Visualization of MU’s Meta-Network</td>
<td>75</td>
</tr>
<tr>
<td>4.2</td>
<td>MU’s Enrollment Management Agent x Agent Network</td>
<td>76</td>
</tr>
<tr>
<td>4.3</td>
<td>Community Structure as Calculated by Newman’s Grouping</td>
<td>78</td>
</tr>
<tr>
<td>4.4</td>
<td>Newman’s Grouping by Formal/Informal Leader</td>
<td>79</td>
</tr>
<tr>
<td>4.5</td>
<td>Clusters by Office</td>
<td>80</td>
</tr>
<tr>
<td>4.6</td>
<td>Agent Nodes Colored by Closeness Centrality</td>
<td>81</td>
</tr>
<tr>
<td>4.7</td>
<td>Box-Behnken Surface Plot: Holding Clustering at 0.294</td>
<td>87</td>
</tr>
<tr>
<td>4.8</td>
<td>Contour Plot: Holding Clustering at 0.294</td>
<td>88</td>
</tr>
<tr>
<td>4.9</td>
<td>Box-Behnken Surface Plot: Clustering Coefficient at 0.217</td>
<td>89</td>
</tr>
<tr>
<td>4.10</td>
<td>Contour Plot: Holding Clustering Coefficient at 0.217</td>
<td>90</td>
</tr>
<tr>
<td>4.11</td>
<td>Box-Behnken Surface Plot: Holding Resource Capability at 0.361</td>
<td>91</td>
</tr>
<tr>
<td>4.12</td>
<td>Contour Plot: Holding Resource Capability at 0.361</td>
<td>92</td>
</tr>
<tr>
<td>4.13</td>
<td>Box-Behnken Surface Plot: Resource Capability at 0.781</td>
<td>93</td>
</tr>
</tbody>
</table>
List of Figures (continued)

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.14</td>
<td>Contour Plot: Holding Resource Capability at 0.781</td>
<td>94</td>
</tr>
<tr>
<td>5.1</td>
<td>Box-Behnken Surface Plot: Resource Capability 0.781</td>
<td>103</td>
</tr>
<tr>
<td>5.2</td>
<td>Contour Plot: Holding Resource Capability at 0.781</td>
<td>104</td>
</tr>
<tr>
<td>5.3</td>
<td>Box-Behnken Surface Plot: Resource Capability 0.361</td>
<td>105</td>
</tr>
<tr>
<td>5.4</td>
<td>Contour Plot: Holding Resource Capability at 0.361</td>
<td>106</td>
</tr>
</tbody>
</table>
CHAPTER ONE

INTRODUCTION

Background of Study

Enrollment management (EM) focuses on enrolling and retaining students who, quite frankly, are the lifeblood of higher education institutions. Without students, the institution has no purpose. While some view EM as the purview of the Office of Admission, others suggest a much more expansive role (Huddleston, 2000). Henderson (2001) stated that EM often resembles offices that act independently and at cross-purposes. To this point, previous EM literature focused on the organization of formal EM Departments, such as who reported to whom. According to Kemerer, Baldridge, and Green (1982), these structures are usually created when a significant problem or crisis occurs. However, creating the structures in response to problems tends to exacerbate the problems (Black, 2004). Besides little focus on EM aspects outside of organizational structure, the theoretical foundation to explain the practice of EM is limited.

Hossler and Hoezee (2001) reported that the two dominant theories historically applied to explain the activities of EM programs in higher education include resource dependency theory and systems theory. I propose that complexity theory and network theory, which are not found in the EM literature, can enable researchers to understand EM from new, more powerful perspectives.
Statement of the Problem

Despite Huddleston’s (2000) call to operationalize EM as an integrated, campus-wide effort, examining it as an interdependent function—interdependence being the essence of complex adaptive systems—is non-existent. Further, there are no studies utilizing the more recent methodology of Dynamic Network Analysis (DNA) or Response Surface Methods (RSM) to evaluate the extent to which an EM organization is structured (formally or informally) to enable effective and efficient information flow, a key factor in the success of EM efforts (Kalsbeek, 2001).

Purpose of the Study

The primary purposes of this study were to investigate EM in higher education through the framework of a complex adaptive system (CAS), to provide colleges and universities with a foundational understanding of what a sustainable EM system looks like from a DNA perspective, and to suggest to EM practitioners one method to model (a) their institution’s EM system in its current status and (b) what network structures optimize information flow, thus cultivating a sustainable EM system for their institutions. Additionally, I aimed to describe how formal network structures either promote or inhibit a sustainable EM system within the bounds of the university under study. For example, to what extent are those involved in EM interdependent with, or dependent upon, each other? Are there bottlenecks to the flow of information? Does information flow freely throughout the EM system? In this study, I considered an EM system to be sustainable if the speed at which information flows throughout the system remains stable regardless of changes to, and pressures from, the internal and external environments.
Put another way, does the EM function at the research site resemble offices that act independently and, at many times, at cross-purposes (Henderson, 2001) as illustrated in Figure 1.1? Or does the EM system “bring together often disparate functions of recruiting, funding, tracking, retaining, and replacing students as they move toward, within, and away from the university” (Henderson, 2001, p. 7) as illustrated in Figure 1.2?

Figure 1.1. Independent units within Enrollment Management.
Figure 1.2. Interdependent Enrollment Management System
Significance of the Study

Randall and Coakley (2007) and Walczak and Sincich (1999) contended that EM focuses on more than just admitting students; it also focuses on retention and graduation. Enrollment success is crucial to the financial health of colleges and universities. This study is significant for the formal leaders of EM programs as well as college and university presidents, as it provides one way to model what network conditions optimize information flow, thus promoting a sustainable EM system. Further, this study examined the importance of fostering conditions of interaction and network formation that lead to sustainable creativity, interdependence, information diffusion, productivity, and innovation among those not in formal leadership positions in EM systems (Marion & Uhl-Bien, 2001). In the end, this study’s results will assist institutions of higher education in the evaluation of their own EM structures and their ability to move information throughout; in addition, the results will suggest ways to alter the EM system’s network structure in order to optimize its information flow.

Definition of Terms

The following are definitions of terms used in this study:

- **Agents:** Sometimes called “actors” (van der Hulst, 2011), agents are individual people, groups, or organizations.

- **Enrollment Management:** Enrollment management is not an insular division or department, but a living, CAS whose core strategic function (Wilkinson, Taylor, Peterson, & Machado-Taylor, 2007) is to coordinate people, knowledge, tasks, and resources for identifying, recruiting, enrolling, retaining, and graduating
students (Henderson, 2001) at levels that support the mission (Wilkinson et al., 2007) of the institution. Its end is to create and maintain dynamic, sustainable enrollment conditions that allow the institution to survive and persist, regardless of the forces that push it toward extinction. An effective EM system is anticipatory (Wilkinson et al., 2007) of internal and external pressures, requires input from and cooperation of the entire campus (Wilkinson et al., 2007), and takes into account the physical and instructional capacity of the institution, its current and potential market positions, the financial requirements of the institution, the standards of accreditation, and the limits of regulation.

- **Sustainable System**: A system that “survives and persists” (Costanza & Patten, 1995, p. 193).

**Theoretical Framework**

I utilized complexity theory and network theory to understand the role of interactions among people, knowledge, tasks, and resources and how those interactions help the EM system adapt and evolve based on internal and external pressures, thus creating a sustainable EM system.

Complexity theory attempts to explain the phenomenon that results from the interactions of individual components, interactions that lead to non-linear outcomes, self-organization, and evolution—all of which make fully understanding a complex system impossible (Cilliers, 2000). The common themes found in the complexity theory literature include interaction, interdependency, emergence, non-linearity, self-organization, and dynamism. Hasan (2014) expanded these concepts in complexity theory
to include “emergence, co-evolution, self-direction, and self-organisation” (p. 51).

Interactions among agents are a key component of complexity theory (Abusidualghoul, 2014; Forsman, Linder, Moll, Fraser, & Andersson, 2012; Hasan, 2014; Kezar, Carducci, & Contreras-McGavin, 2006; Marion & Uhl-Bien, 2001; McClellan, 2010; McMurtry, 2008; Salem, 2002).

Network theory, rather than being one discreet theory, refers to a number of frameworks through which to understand the structures and functions of networks. Borgatti and Halgin (2011) contended that scholars should consider the difference between network theory and the theory of networks:

Network theory refers to the mechanisms and processes that interact with network structures to yield certain outcomes for individuals and groups. In the terminology of Brass (2002), network theory is about the consequences of network variables, such as having many ties or being centrally located. In contrast, theory of networks refers to the processes that determine why networks have the structures they do—the antecedents of network properties, in Brass’s terms. This includes models of who forms what kind of tie with whom, who becomes central, and what characteristics (e.g., centralization or small-worldness) the network as a whole will have. (p. 1)

This study considers both conceptions of network theory mentioned by Borgatti and Halgin (2011). Not only will examine outcomes of network mechanisms and processes, but also the types of ties and network measures Borgatti classifies under the theory of networks. Combining network theory with complexity theory provides a way to model
complex social systems and how they evolve based on the types of interaction that occur among and between agents.

**Research Questions**

This study is guided by two overarching questions:

1. To what extent is the research site organized to enable effective and efficient information flow?

2. Which combinations of independent network measures (adaptive leadership, social capital, and clique structure) produce optimal outcome measures (information flow) for a sustainable EM system?

Adaptive leadership was operationalized as the network measure, closeness centrality; social capital was operationalized as resource capability; and clique structure was operationalized as the clustering coefficient. The dependent measure was average speed, which measured the level of information diffusion in the system.

**Limitations**

Limitations of this study include using the EM division of a single university with its own culture. However, the data analysis will utilize simulations that, in effect, create 15 different networks of EM within the research site, thus neutralizing an apparent limitation normally attributed to N = 1 (R. Marion, personal communication, January 7, 2016).

**Assumptions**

The following assumptions for this study included (a) participants would complete both surveys; (b) participants would answer the survey questions accurately,
honestly, and thoroughly; and (c) the resulting analysis would not concentrate on the individual, but on the network of individuals.

**Organization of the Study**

This study contains five chapters with the following titles: Introduction, The Review of Literature, Methodology, Findings, and Summary, Discussion, and Conclusions. The introduction identifies the study’s background, statement of the problem, the purpose of the study, the significance of the study, a definition of terms used in the study, the researcher’s theoretical framework, research questions, limitations of the study, delimitations selected by the researcher, and assumptions made in conducting the research.

Chapter Two reviews the literature on topics related to this study. These topics include an overview of complexity theory, network theory, CASs, adaptive leadership, administrative leadership, enabling leadership, information diffusion, and the methodology used to examine an institution’s EM system in its current state, in addition to how that system can be more adaptive to internal and external forces.

Chapter three details the methodology selected for this study, including the research design, epistemology, selection of participants, specific method of data collection and analysis, and ethical concerns.

Chapter four presents the findings of this study.

Chapter five provides a summary, discussion, and conclusions with implications for formal EM leadership and future research.
CHAPTER TWO

THE REVIEW OF LITERATURE

The primary purposes of this study were to investigate enrollment management (EM) in higher education through the framework of a complex adaptive system (CAS), to provide colleges and universities with a foundational understanding of what a sustainable EM system looks like from Dynamic Network Analysis (DNA) perspective, and to suggest to EM practitioners one method to model (a) their institution’s EM system in its current status and (b) what network structures optimize information flow, thus cultivating a sustainable EM system for their institutions. Additionally, the study aimed to describe how formal network structures either promote or inhibit a sustainable EM system within the bounds of the university under study. For example, to what extent are those involved in EM interdependent with, or dependent upon, each other? Are there bottlenecks to the flow of information? Does information flow freely throughout the EM system? In this study, considered an EM system to be sustainable if the speed at which information flows throughout the system remains stable regardless of changes to, and pressures from, the internal and external environments.

To this end, this study is guided by two overarching questions:

1. To what extent is the research site organized to enable effective and efficient information flow?

2. Which combinations of independent network measures (adaptive leadership, social capital, and clique structure) produce optimal outcome measures (information flow) for a sustainable EM system?
This chapter begins with a discussion of EM, including traditional ways of understanding the flow of students through what are called enrollment funnels, and how the term sustainability applies to EM. Following this, I move to the theoretical underpinnings of collectivism, complexity theory, network theory, CASs, collectivist leadership, information diffusion, and networks.

**Enrollment Management**

Enrollment management “is both an administrative structure and a set of accompanying practices…” (Kraatz, Ventresca, & Deng, 2010, p. 1522) and is critical to the sustainability of higher education institutions. The management of enrollment provides the tuition revenue necessary to operate the institutions (Randall & Coakley, 2007; Walczak & Sincich, 1999). While some view EM as the purview of the Office of Admission, others have argued for the expansion of the role of EM to that of the entire campus (Huddleston, 2000). Quoting Jack Maguire, then dean of EM at Boston College, Henderson (2001) said, “Enrollment management is a process that brings together often disparate functions having to do with recruiting, funding, tracking, retaining, and replacing students as they move toward, within, and away from the university” (p. 7). Maguire continued that EM emerged in order to create a synergy between offices that often acted independently and, at many times, at cross-purposes. The writers concur that EM should function as a set of interdependent activities such as “…marketing, recruiting, admissions, financial aid, orientation, and retention” (Henderson, 2001, p. 11).

Accordingly, Huddleston (2000) defined EM as “…an institution-wide process that
embraces virtually every aspect of an institution’s function and culture” (p. 65). Hossler (1990) defined EM as,

An organizational concept and a systematic set of activities designed to enable educational institutions to exert more influence over their student enrollments.

Organized by strategic planning and supported by institutional research, enrollment management activities concern student college choice, transition to college, student attrition and retention, and student outcomes. (p. 5)

Such interdependency is at the heart of complexity theory, which views complex systems as systems “composed of many interacting parts…” (Newman, 2011, p. 1).

Enrollment managers receive a great deal of attention by the boards of trustees and presidents of American colleges and universities. For example, a recent article in The Chronicle of Higher Education labeled the enrollment manager’s position as “The Hottest Seat on Campus,” noting, “Dozens of enrollment and admission leaders have lost their jobs” (Hoover, 2014). In the Library Journal, Bell (2014) warned that predicted changes in the demographics of graduating high school seniors and their families present “serious challenges” for colleges and universities to meet their enrollment goals. Randall and Coakley (2007) reported, “Colleges and universities compete intensely to attract students and to generate revenues as operating costs rise and government subsidies decline” (p. 325). Walczak and Sincich (1999) contended that an institution’s financial health depended heavily on successful enrollments.

Simply recruiting students to matriculate is no longer sufficient; the entire process from admitting to graduating has become the focus. Henderson (2001) suggested
conceptualizing EM as a “cradle-to-endowment mentality” (p. 35). Huddleston (2000) argued that a collective approach to managing enrollment is necessary; specifically, “The shared missions, primary goals, and the integration and interdependence of these key areas are vital to the successful implementation and operation of enrollment management” (p. 66). Enrollment management should be a collective effort of the entire campus and should permeate the institutional “function and culture” (Dolence, 1992; Huddleston, 2000). Involving the entire campus in EM supports Huddleston’s (2000) argument for interdependency, a core tenet of complexity theory (Uhl-Bien & Marion, 2008b).

**The Enrollment Management Funnel and Pyramid**

Traditional ways of understanding the EM processes included a metaphorical funnel (Figure 2.1) which divided EM into separate purposes: recruitment and retention.
Figure 2.1. Strategic Enrollment Management Funnel Recruitment: The recruitment section of the detailed funnel (Dolence, 2015c). Reprinted with permission.
In Figure 2.1, Dolence (2015c) visualized how numerous institutions view EM: as simply the recruiting and enrolling of students. The image “depicts the flow of learners through the stages of selecting and enrolling in an academic program” (Dolence, 2015a). The idea is that colleges and universities identify potential students, try to entice the students to apply for admission, admit a certain number of those that do apply, work with the Financial Aid Office to put together an adequate and appropriate financial aid package, and finally work with the admitted students to convince them to indicate their intent to enroll by paying an enrollment deposit.

In Figure 2.2, Dolence (2015d) depicted the subsequent purpose of EM—retaining and graduating the enrolled students. However, this phase is completely separate from the first phase of recruitment, as if retention begins where recruitment ends.
Figure 2.2. Strategic Enrollment Management Funnel Retention: The retention section of the detailed funnel (Dolence, 2015d). Reprinted with permission.
Presenting these phases as separate and unrelated, independent functions contradicts the arguments of Henderson (2001), Hossler (1990), and Huddleston (2000) that called for an integrated and campus-wide approach to EM. Dolence (2015b) remedied this by connecting the two figures to suggest the entire “cradle to endowment” (Henderson, 2001, p. 35) flow (Figure 2.3).
Figure 2.3. Strategic Enrollment Management Funnel (Detailed): A detailed view of the Strategic Enrollment Management Funnel (Dolence, 2015b). Reprinted with permission.
Not every EM expert agreed with explaining EM using Dolence’s funnel. Bontrager (2004) warned that a problem with viewing EM as a funnel, “…gives the false impression that students flow automatically through the funnel as if drawn downward by gravity” (p. 10). Bontrager (2004) argued that recruiting and retaining students required “careful planning, effective execution, and technical skill” (p. 10). Such requirements demand the expansion of the role of EM to the entire campus (Huddleston, 2000).

This necessity for an expanded sphere of influence for EM in higher education institutions began in private colleges and universities; however, it has spread to public institutions as well (Huddleston, 2000). Given the arguments for collaborative, interdependent roles in higher education EM, this study moved beyond the formal organizational structure of an EM Department and analyzed the informal interactions and network structures that influence information diffusion, which Kalsbeek (2001) contended is the “most important material driving strategic enrollment management” (p. 189).

**Sustainability**

*Sustainability* may seem a strange concept to describe an optimal EM system, yet sustainability aptly captures the significance of effective EM for an institution. Costanza and Patten (1995) defined a sustainable system as one that “survives and persists” (p. 193), and Holbeche (2005) suggested, “sustainable organizations integrate structures, systems, and processes that have clarity and flexibility built in” (p. 21). As stated earlier, students are the lifeblood of the institution, and EM is the mechanism that recruits and
retains students. For colleges and universities to “persist and survive” (i.e. be sustainable), the EM system itself must be sustainable.

This study utilizes the term Sustainable Enrollment Management to describe optimal network structures that enable regular and efficient information flow and that create capacity to adapt robustly to the many internal and external pressures experienced by EM professionals. Much of the EM literature suggested the term, Strategic Enrollment Management, places EM within the strategic plan of the institution (Wilkinson et al., 2007). Use of sustainable in place of strategic is not to suggest that something is wrong with the latter. For this study, however, sustainable offers a different perspective for understanding an effective EM system, and the word also captures the importance of EM to an institution’s survival and persistence despite pressures forced upon it by internal and external influences.

Collectivism

One of the theoretical frameworks guiding this study is complexity theory. The context within which complexity theory lies is collectivism. Those in the collectivist camp emphasize group dynamics over individual characteristics; more specifically, collectivists emphasize group goals and interests rather than individual goals and interests (Randall, Resick, & DeChurch, 2011; Walumbwa & Lawler, 2003). According to Walumbwa and Lawler (2003), “Collectivists see the self as totally part of the group and interdependent with other members of the group, who are viewed as equal and the same” (p. 1087).
Concern for group achievement is one of the reasons a collectivist perspective enhances interdependent work groups (Randall et al., 2011). Interdependence and survival of the group are key characteristics of collectivism (Carson, 2009). When pressures threaten group identities and/or success, those in collective groups rally around the common goals of the group members and ensure that their responsibilities are met (Carson, 2009). Additionally, collectivist organizations encourage common values and efforts to achieve goals (Luczak, Mohan-Neill, & Hills, 2014). As stated earlier, Huddleston (2000) argued, “The shared missions, primary goals, and the integration and interdependence of these key areas are vital to the successful implementation and operation of enrollment management” (p. 66).

One specific form of collectivism espoused by Marion (2015) is social collectivism, which purports “that agents in a social system are interdependent and that influence is a complex dance involving numerous, networked sources of influence” (R. Marion, personal communication, April 24, 2015). Interdependency and influence of others are additional aspects commonly found in both collectivist and complexity literature. Collectivist approaches to change start with intense environmental pressures that are often overwhelming for organizations that subscribe to traditional, top-down, or centralized, leadership structures. Environmental pressures are common in EM, whether they emanate from inside the institution (e.g. student body size and composition, net revenue, curricular changes) or are introduced by exogenous factors such as regulatory changes, accreditation requirements, economic factors, etc.
Collectivists contend that leaders are agents who take initiatives within the context of networked relationships (i.e. emergent leaders) and that more formal leaders have the ability to enable the formation and development of change initiatives that start in the networked relationships (Marion & Gonzales, 2014; Yammarino, Salas, Serban, Shirreffs, & Shuffler, 2012). Collective leadership thrives in systems where interactions are frequent and exhibit a high degree of interdependency (Yammarino et al., 2012). Leadership influenced by collectivist ideals (collectivistic leadership) also minimizes the individual as a central leader (Yammarino et al., 2012). Collectivistic leadership is:

- not constrained by formal power and authority structure and relationships,
- not limited to leader-to-follower interactions in small groups and teams,
- involve more than typical leader behaviors or team skills,
- incorporate a variety of formal and informal organizational and extra-organizational arrangements,
- tend to be dynamic and non-linear in nature,
- and strive to be responsive to complex, rapidly changing and uncertain problems and environments. (Yammarino et al., 2012, p. 395)

**Theoretical Frameworks**

**Complexity Theory**

The common themes found in the complexity theory literature include interaction, interdependency, emergence, non-linearity, self-organization, and dynamism. Hasan (2014) expounded that dominant concepts in complexity theory include “emergence, co-evolution, self-direction, and self-organisation” (p. 51). Interactions among agents are a key component of complexity theory (Abusidualghoul, 2014; Forsman et al., 2012;
Hasan, 2014; Kezar et al., 2006; Marion & Uhl-Bien, 2001; McClellan, 2010; McMurtry, 2008; Salem, 2002).

Complexity theory, quite logically, is rooted in the science of complexity, defined by Coveney (2003) as “the study of the behaviour of large collections of such simple, interacting units, endowed with the potential to evolve with time” (p. 1058). The interaction of these units result in self-organization, which Coveney (2003) defined as “the spontaneous emergence of non-equilibrium structural organization on a macroscopic level, due to the collective interactions between a large number of (usually simple) microscopic objects” (p. 1058). This self-organization leads to emergence (Coveney, 2003).

Colchester (2015b) defined complexity theory as theoretical frameworks that researchers use for creating models of and analyzing complex systems. There are four related theories that aid in understanding complex systems:

- Systems theory that covers topics including self-organization, adaptation, and complexity (Colchester, 2015b); systems theory is the “mother of complexity theory” (Colchester, 2015b).

- Nonlinear systems theory and chaos theory that have their origins in mathematics and physics. In nonlinear systems, feedback loops are important for adaptation and growth; nonlinear systems do not achieve equilibrium and are better described as “far-from-equilibrium systems” (Prigogine, 1997, p. 64).

- Network theory, which has origins in graph theory and can help one visualize and analytically describe complex systems.
• Complex adaptive systems, defined later under a separate section of this chapter.

Complexity theory is appropriate for studying the operations of organizations (Abusidualghoul, 2014) because organizations develop and change as a result of interacting agents; such change is referred to as evolution (Salem, 2002). Since change and growth are characteristics of organizations, complexity theory offers insight into the elements that “accelerate or amplify change” (Salem, 2002, p. 448). An important point regarding the relationship between complexity and organizational change is that complexity theory does not attempt to evaluate whether a particular change is typically positive or negative; it simply illustrates how and why change occurs (Salem, 2002).

Many formal leaders believe that organizational change is simply cause and effect (i.e. linear) (Hanson, 2009) and is predictable based on patterns of past behavior. However, Regine and Lewin (2000) reasoned that complexity theory moves one away from this linear perspective towards non-linear perspectives where change is organic, unpredictable, and results in outcomes that are uncertain. This perspective flies in the face of classical scientists who argue the world is predictable and stable (Marion & Uhl-Bien, 2001; Prigogine, 1997), perhaps making this a reason that some organizational science researchers have steered away from studies involving complexity theory and its recognition of human interdependency.

Marion and Uhl-Bien (2001) offered this summary of complexity theory:

Organizational structure and behavior are, on the one hand, products of random surprise and nonlinearity, and, on the other hand, products of the unifying effect of correlation. It is inaccurate to define these forces as polar opposites, although it
is accurate to say that they create tension within a system. Rather, like two people who bring different skills to a task, these seemingly opposing dynamics work together to create emergence. Random behavior and nonlinearity provide creative surprises, they apply pressure that creates conflicting constraints, and they are actors in the dynamic that enables different pieces of order to accumulate, interact, and collapse together. Correlation, in turn, provides the structure against which conflicting constraints are arbitrated and organization is built. (p. 402)

**Network Theory**

Rather than being one discreet theory, network theory refers to a number of frameworks from which to understand the structures and functions of networks. Examples include Granovetter’s strength of weak ties theory (Borgatti & Halgin, 2011), and Burt’s structural holes theory (Borgatti & Lopez-Kidwell, 2011). Borgatti and Halgin (2011) contended that scholars should consider the difference between network theory and the *theory of networks*:

Network theory refers to the mechanisms and processes that interact with network structures to yield certain outcomes for individuals and groups. In the terminology of Brass (2002), network theory is about the consequences of network variables, such as having many ties or being centrally located. In contrast, theory of networks refers to the processes that determine why networks have the structures they do—the antecedents of network properties, in Brass’s terms. This includes models of who forms what kind of tie with whom, who becomes central, and what
characteristics (e.g., centralization or small-worldness) the network as a whole will have. (p. 1)

This study considers both conceptions of network theory mentioned by Borgatti and Halgin (2011). Not only will this study examine outcomes of network mechanisms and processes, but also the types of ties and network measures Borgatti classifies under the theory of networks. Combining network theory with complexity theory provides a way to model complex social systems and how they evolve based on the types of interactions that occur among and between agents.

Complex Adaptive Systems

This study presents sustainable EM as a complex adaptive system (CAS), a concept appropriately applied to the context of EM. Henderson (2001) stated “effective enrollment management…begins at home with concerned and knowledgeable administrators and faculty who realize that they possess the capacity to respond creatively to environmental pressures in the interest of long-term institutional health” (p. 11). Newman (2011) stated that a complex system is “a system composed of many interacting parts, often called agents, which displays collective behavior that does not follow trivially from the behaviors of the individual parts” (p. 1). A complex system is one that exhibits a “high degree of systemic interdependence, which, among other things, leads to non-linearity, emergent order creation, and other surprising dynamics” (Hazy, Goldstein, & Lichtenstein, 2007, p. 4). Complex systems constantly change due interactions among internal agents of a network as well as that network’s interactions with the external environment occur (Fraser, Moll, Linder, & Forsman, 2011). Complex systems exhibit
three characteristics: (1) interaction, (2) dynamic, and (3) adaptation (Uhl-Bien & Marion, 2008a).

Colchester (2015a) stated that there are four properties to complex systems:

- Interaction of many different elements or parts;
- Nonlinearity where a system’s inputs and outputs are not proportional to each other. In other words, the traditional linear equation is not applicable. A one-unit change in X does not always result in a predictable change in Y. Additionally, the whole system may be greater than or less than the sum of its parts. Nonlinear systems may grow or die due to the feedback mechanisms (i.e. feedback loops).
- Connectivity between the components of a complex system is usually high or dense. Rather than the properties of the parts of the system, the structures of the connections do more to define a system. At some point, the connectivity level causes increases to a point where a system is no longer understood by looking at the individual parts, but understood by viewing the system as a network of connections. It is at this point that the significance of a system is in the flow throughout a network.
- Autonomy and adaptation indicate the lack of top-down centralized control for coordinating the entire system. Within complex systems, the components (or elements) have a certain degree of autonomy through their ability to adapt to their local environments and according to sets of individual rules. Without the centralized control and with autonomy come the capacity of components to self-organize.
Perony (2014) stated, “Complex systems have many interacting parts which behave according to simple individual rules and result in emergent properties. The behavior of the system as a whole cannot be predicted by looking only at the simple rules.”

Interactions among agents (people, resources) bring about change and evolution (Shakouri, Teimourtash, & Teimourtash, 2014). Complex systems are also dynamic in that they constantly change, evolve, and are often unpredictable (Uhl-Bien & Marion, 2008a). Complex systems adapt, “or make strategic changes that adjust individual or systemic responses to pressures” (Uhl-Bien & Marion, 2008a, p. 6). Buckley (1967) was the first to use CAS “to refer to a class of systems that have a capacity for adapting to a changing environment” (Hazy et al., 2007, p. 4). Further, the Santa Fe Institute aligns with the definition of Buckley (1967) but describes how adaptation to an altered environment occurs (Hazy et al., 2007).

Complex systems’ network structures are decentralized, meaning some components of the network (i.e. nodes) are more connected than others (Forsman et al., 2012). Nodes can also be nested into complex systems themselves. Forsman et al. (2012) stated:

Components within a complex system can be considered to be complex systems themselves, thus complex systems are nested. Each level of such nested complex systems exhibits similar structures and dynamics but operates within different time-scales and/or at different levels of analysis (such as the level of an individual, or of a group of individuals, or of a particular culture, or of all human beings). (p. 72)
Salem (2002), citing Holland (1995) and Kauffman (1993), wrote that complexity theory focused on interactions agents have within CAS. Uhl-Bien, Marion, and McKelvey (2007) defined CAS as “a basic unit of analysis in complexity science” (p. 299). CAS consist of individuals who interact regularly, thus forming networks of agents with common goals, needs, etc. (Uhl-Bien et al., 2007). Complexity Learning stated that a CAS occurs when many parts act and react to each other, is highly dynamic, and tends to self-organize with no formal top-down instruction or coercion. A CAS “places a strong emphasis on an organization's ability to enact successful creative problem solving as matter of routine” (Colchester, 2015b).

Coordination is another special capability of a CAS (Guastello, 2007, p. 364). Salem (2002) argued that “Change is the norm, not the exception” (p. 445) in complexity theory. Though counterintuitive, constant change creates order in complex systems through agent by agent interaction (Plowman et al., 2007). To explain this further, Bulutlar and Kamasak (2012) listed three characteristics of complex systems:

1. The whole is greater than the sum of the parts, therefore dividing the whole does not ease understanding it (Peters, 1992).

2. Understanding all of the inputs does not necessarily predict outputs generated by complex systems.

3. Behavior of complex organizations, which are placed at the edge of chaos, is neither predictable nor unpredictable. In other words, order and chaos exist together. (p. 61)
Though these characteristics of complexity theory trouble those who prefer order and predictability, Hasan (2014) stated, “The message of Complexity Theory is that complexity is not something to fear, but a part of life that needs to be treated in ways that are different to the ways non-complex matters are dealt with” (p. 53). In fact, the connection between CAS theory and knowledge management was acknowledged around 1997 (McElroy, 2003) when the Knowledge Management Consortium International participants agreed “to treat human organizations as living systems—consistent with CAS theory’s definition of CASs; all of the theory’s insights on how knowledge happens in such systems were suddenly seen as entirely applicable to business and industry” (McElroy, 2003, p. 28). Given that the arguments for institutions to consider EM an interdependent and campus-wide effort, viewing EM as a CAS is appropriate. With complexity and network theories established as the framework for this study, now explores the topic of leadership within a CAS.

**Leadership Concepts**

**Complexity Leadership**

Given that complex systems are characterized by interactions, emergence, unpredictability, non-linearity, etc., what are the implications to leadership? In particular, what is the role of a leader in such a system? These questions move scholars to view leadership as more of a process than a characteristic or skill of an individual (DeRue, 2011; Lichtenstein et al., 2007; Marion & Uhl-Bien, 2007a), and, consequently, to seek leadership in the activities of individuals and groups regardless of formal position. This perspective has been labeled *complexity leadership*; it is grounded in complexity science,
but it strays from traditional leadership models that focus on human relations (Marion & Uhl-Bien, 2007b). A knowledge economy demands that we shift from traditional, top-down bureaucratic models of leadership—prevalent in the industrial age and economy—to leadership “as an emergent, interactive dynamic—a complex interplay from which a collective impetus for action and change emerges when heterogeneous agents interact in networks in ways that produce new patterns of behavior or new modes of operating” (Uhl-Bien et al., 2007, p. 299). Though our economies have shifted, EM—and some would argue, higher education in general—still reflects the authority and leadership structure appropriate for the industrial age.

Leadership is a social process characterized by bidirectional mutuality, or reciprocal ties (i.e. agent A is connected to agent B, and agent B is also connected to agent A) (DeRue, 2011; Yukl & Falbe, 1990). This premise derives from sociological theories which view hierarchies in leadership as the result of ongoing social interactions (DeRue, 2011). This does produce leader-follower structures but at informal levels of leadership. Ongoing social interactions result in social structure survival (DeRue, 2011). Whereas traditional leadership roles are seen as formal, top-down organizational structures, leadership that is informal and interactive allows organizations to change and adapt as various environmental pressures arise, both internal and external to the group (DeRue, 2011). The product of this adaptability is organizational resiliency. When various people assume informal leadership roles based on social processes, leadership changes depending on the needs of the group (Uhl-Bien et al., 2007). Top-down hierarchical leadership inhibits adaptability because those not in formal leadership roles
have no authority to use their knowledge and creativity to react to pressures with appropriate changes (DeRue, 2011), thus stifling organizational change and learning.

In complex leadership, “the role of leaders is not to ‘step outside [the system] to operate on it or use it,’” but to foster interaction “which is itself a process of intending, choosing, and acting” (Griffin, 2002, p. 187). In other words, complex leadership is not passive. On the contrary, complex leaders actively foster interaction and networks. Kezar et al. (2006) argued that one of the most important functions of complex leaders is the creation of networks. “Leaders are called on to operate at a systems level, focusing on the connections between organizational roles and tasks as well as fostering interdependent relationships inside and outside the organization” (p. 44). Kezar et al. (2006) wrote, “As a leader, one is encouraged to support grassroots efforts, set up feedback loops for problems, and exert minimal direct control because such efforts are likely to be met with resistance or redirected in the system” (p. 111).

Top-down leadership is not the focus in complexity leadership; rather, the focus is on leadership dynamics that encourage creativity and organizational learning. DeRue (2011) argued that “individualistic and person-centric perspectives emphasize the person as the source of leadership (or followership), and therefore does not fully account for the social and dynamic processes by which patterns of leadership and following develop and evolve” (p. 130). Marion and Uhl-Bien (2001) argued that complexity theorists believe “the greatest creativity, productivity, and innovation comes out of people who are provided opportunities to innovate and network” (p. 401). Encouraging creativity in organizations forces one to allow ideas to “bubble up” (McKelvey, 2001). Some see this
as leaders relinquishing control, and, to some degree, the literature supports that. Marion and Uhl-Bien (2001) stated “Complex leaders understand that the best innovations, structures, and solutions to problems are not necessarily those that they, with their limited wisdom, ordain, but those that emerge when interacting aggregates work through issues” (p. 394).

A significant difference between traditional bureaucratic leadership models and complexity leadership lies in control. Top-down leadership structures encourage the manager to retain control; complexity places control in the adaptive leadership structure (Marion & Uhl-Bien, 2007b). Marion and Uhl-Bien (2007b) argued, “Control lies within an array of subtle and complex coordinating tools, such as tension, interdependency among agent preferences and work productivity, conflicting constraints, simple rules, and need” (p. 156). In other words, control is built into the processes of an adaptive system rather than dictated from the top-down (Marion & Uhl-Bien, 2007b). This promotes creativity and freedom to think outside the box, so to speak, yet places appropriate constraints that keep the outcomes in line with the goals and mission of the organization.

Complex leaders build or promote the emergence of networks (Gnyawali & Madhavan, 2001). Marion and Bacon (1999) suggested that the leader can encourage network formation by providing resources for attending professional development conferences, leaving networks alone as they form, etc. Manz (1984) stated that allowing staff members to make decisions outside of the formal leader and expecting them to use that discretion is another way to foster network construction and creativity in problem
solving. Further, Marion and Uhl-Bien (2001) suggested that even the physical work environments could encourage interaction (e.g. open spaces rather than cubicles).

Marion and Uhl-Bien (2001) summarized complexity leadership as a mode that:
should be viewed as creating conditions that enable the interactions through which the behaviors and direction of organizational systems emerge. Leaders provide control by influencing organizational behavior through managing networks and interactions. They do not delude themselves with the notion that they can determine or direct exactly what will happen within the organization. The dynamics of interaction, guided by complex leaders, help the organization develop appropriate structure, innovation, and fitness. (p. 406)

Complexity leadership provides the conditions for an EM system to be sustainable. More granular leadership styles that complexity leadership offers are adaptive leadership, administrative leadership, and enabling leadership.

**Adaptive Leadership**

Adaptive leadership is a construct that refers to dynamic behaviors that promote information flow, ability to change based on internal and external pressures, and interaction among agents (Uhl-Bien et al., 2007). Yammarino et al. (2012) defined adaptive leadership as “an informal process that emerges out of the interaction of agents with different knowledge, goals, values, beliefs, and perceptions” (p. 392). DeRue (2011) referred to leadership as “a socially complex and adaptive process…[or a] social interactive process” (p.126), views he complained were lacking in most leadership theory
literature. As these interactions evolve, leader-follower identities evolve and change, and the informal leaders change.

Adaptive leadership encourages the flow of ideas and information throughout an organization, allowing the organization to adapt to internal and external pressures for change, to learn and grow as an organization, and to be the most creative it can be (Yammarino et al., 2012). Lichtenstein et al. (2007) defined adaptive leadership as “an interactive event in which knowledge, action preferences, and behaviors change, thereby provoking an organization to become more adaptive” (p. 134). This definition highlights a difference between leadership as a process and individual leaders who influence the process. Leadership is not focused on prodding people to follow; leadership occurs when people interact and generate change for an organization (Lichtenstein et al., 2007). DeRue (2011) emphasized that, “Over time through repeated interaction, these leader-follower identities and relationships emerge to form group-level leadership structures” (p. 126). Over time, and as the needs of the group alter, leader-follower structures change and adapt due to external pressures. This adaptability allows the organization to remain relevant and strong (DeRue, 2011), a key concept in the definition of sustainable EM as presented in this study.

Administrative Leadership

Administrative leadership is the more traditional, formal type of leadership (Yammarino et al., 2012). Marion and Uhl-Bien (2007b) defined administrative leadership as “managerial leadership that occurs in formal, hierarchical roles and is responsible for such things as organizational strategy, resource acquisition and allocation,
policy making, and general management” (p. 153). Though related to traditional leadership models, administrative leadership in a complex leadership setting does recognize the importance of emergence, creativity, interdependence, and other characteristics of CAS (Marion & Uhl-Bien, 2007b). In higher education, examples of administrative leadership include compliance offices, the Boards of Trustees, structural heads of institutional departments, and external accreditation agencies. Administrative leaders, however, do provide appropriate constraints that keep an institution from straying too far from its goals and mission and/or conducting business in ways that are contrary to compliance standards.

**Enabling Leadership**

Enabling leadership fosters the interaction of agents (i.e. people) to increase coordination and interdependence between agents with knowledge relevant and appropriate to the situation (Yammarino et al., 2012). Enabling leaders act as mediators between the wildly creative adaptive leaders and the rule-bound administrative leaders (Uhl-Bien et al., 2007). In other words, enabling leadership provides balance between the policy and regulatory constraints of an organization and the need for creative problem solving. As written by Yammarino et al. (2012), “Enabling leadership is proposed to serve as moderator between administrative and adaptive leadership by modifying some of the authoritative “top-down” control to allow for the more organic flow of information and interaction that gives rise to adaptive leadership” (p. 392).

Marion and Uhl-Bien (2007b) wrote that there are two roles which enabling leadership plays in organizations: (1) fosters conditions that promote emergence, and (2)
mediates the tension between administrative leadership and adaptive leadership. This function promotes conditions that encourage adaptive, complex leadership, yet also recognizes that the outcomes of the adaptive leadership process must fit within the mission and goals of the organization (the purpose of administrative leadership) (Marion & Uhl-Bien, 2007b). Enabling leadership, the researcher argues, is the appropriate leadership style for fostering a sustainable EM system.

**Clique Structure**

In network structures, cliques are cohesive groups of highly interconnected people, often with similar interests, skills, backgrounds, etc. (Haythornthwaite, 1996). Newman (2004) defined a clique as a group of completely connected nodes; Carley, Pfeffer, Reminga, Storrick, and Columbus (2013) concurred with Newman by defining a clique as “…a set of nodes where every node is connected to every other node” (p. 3). Cliques are important for information diffusion because cliques can process large amounts of information about environmental conditions, can communicate to a great extent with other cliques, and are interactive (Marion, Christiansen, Klar, Schreiber, & Erdener, 2016). Whereas societal concepts of cliques are exclusionary and negative, clique structure in networks promotes information diffusion (Cowan & Jonard, 2004).

**Social Capital**

Bolivar and Chrispeels (2010) stated that social capital “consistently refers to the resources (power and information) present in a bounded community’s social relationships that can be used to leverage additional resources” (p. 9). Coleman (1988) compared social capital to “the concepts of financial capital, physical capital, and human capital—
but embodied in the relations among persons” (p. S118). As a proxy for social capital, Kadushin (2004) preferred the term “networked resources” (p. 88). Access to resources (i.e. social capital) via network interactions encourages information flow since people are the “containers” information. Burt (2000) argued that one mechanism for the flow of information is a network.

For this study, social capital is operationalized as resource capability. Since “access to information channels” (Bolivar & Chrispeels, 2011, p. 10) is a key requirement for building social capital, resource capability is the optimal network measure to assess an EM system’s ability to provide access to the resources necessary to perform its role and functions for the benefit of the college or university.

**Information Flow**

As previously referenced, Kalsbeek (2001) contended that strategic EM leaders of today realize that, in knowledge management (i.e. information management and diffusion), “information is the most important material driving strategic enrollment management” (p 189). Haythornthwaite (1996) argued, “By gaining awareness of existing information exchange routes, information providers can act on information opportunities and make changes to information routes to improve the delivery of information services” (p. 323). Henderson (2001) reinforced the argument for interdependency by stating, “Enrollment management was perceived as including eight ‘interdependent’ activities: ‘clarification of institutional mission, program development, marketing, recruiting, admissions, financial aid, orientation, and retention’” (p. 11).
The information flow argument is important to EM because, as Huddleston (2000) argued, “The shared missions, primary goals, and the integration and interdependence of these key areas are vital to the successful implementation and operation of enrollment management” (p. 66). Information about those shared missions needs to move throughout the organization, and social networks are extremely important for information flow. Haythornthwaite (1996) viewed information as a resource and stated that information exchange is prominent in social networks. Further, “Just as roads structure the flow of resources among cities, information exchange relationships structure the flow of information among actors” (p. 323). These structures are relevant to investigations such as determining who controls the flow of information. Therefore, studying a network’s structure, such as cohesiveness, sense of community, and/or cliques is helpful when trying to evaluate an organization’s capacity to move information freely (Haythornthwaite, 1996). Network patterns show who interacts with whom in order to receive or forward information as well as what access the individual has to information, new ideas, and opportunities (Haythornthwaite, 1996).

How tightly knit a network is also impacts the flow of information. Also known as tie strength (Haythornthwaite, 1996), the connectedness of a group has often indicated how efficiently information flows throughout a network or a group of networks. Weng, Menczer, and Ahn (2013) reported that network structure can greatly affect the spread of information, with strongly connected communities running the risk of trapping information. Too much homophily (interaction among agents with similar characteristics
or experiences) for example, can degrade the speed at which information moves between networks (McPherson, Smith-Lovin, & Cook, 2001).

**Networks**

Newman (2010) wrote, “A network is, in its simplest form, a collection of points joined together in pairs by lines” (p. 1). Visually, a network is illustrated in Figure 2.4.

![Simple Network](Image)

*Figure 2.4. Simple Network.*

While some people focus on the nodes, others focus on the lines. However, the patterns of network connections are what inform our understanding of what actually goes on within and between networks (Newman, 2010). Further, networks change over time—a process called *network evolution* (Carley, 1999). These changes result from organizational learning. Carley (1999) contended “To explain organizational behavior we need to understand that the organization, in and of itself, is an intelligent, adaptive and computational entity…” and “the organization’s intelligence, adaptiveness, and computational capability results from the detailed, ongoing, interactions…” (p. 8).
Various types of networks with which people may be familiar are computer networks, neural networks, the internet, and social networks, including Facebook, Twitter, and Yik Yak. Social scientists have studied and analyzed social networks for years, but additional disciplines found this type of work helpful as well; examples include computer science, physics, and biology (Newman, 2010). According to Carley (1999), networks can influence many functions of organizations, including “the rate of information diffusion among individuals and within organizations, the ability of individuals to acquire and use information, and the speed, quality, and accuracy of organizational decisions” (p. 3). Understanding how these networks function requires a familiarity with network measures.

Newman (2010) wrote, “If we know the structure of a network, we can calculate from it a variety of useful quantities or measures that capture particular features of the network typology” (p. 168). Carley (1999) inferred that, in addition to understanding the structures of networks, scientists could also predict the behavior of networks. If one looks at the structure of a computer network, he/she can understand how the connections between computers affect the efficiency with which data are moved between computers. This concept is applicable to social networks as well. The connections of a social network affect how people learn (Carley, 1999), how they gather news, form opinions, etc. (Newman, 2010). Epidemiologists use social networks to predict the spread of disease (Newman, 2010). Newman (2010) summarized that, “Networks are thus a general yet powerful means of representing patterns of connections or interactions between parts of the system” (p. 3).
Summary

The purpose of this chapter was to present the theoretical frameworks guiding the study of EM as a CAS. The theoretical frameworks for this study are complexity theory and network theory, both of which are collectivist perspectives. This chapter, thus, began with an overview of collectivism and then moved to complexity theory, network theory, CASs, collectivist leadership concepts, information diffusion, EM, networks, and the methods of DNA and response surface methods.

Given that the common themes across the complexity theory literature include, among other concepts, interaction and interdependency, complexity theory presents a way to examine EM as a CAS, one that cannot be found in the EM literature. The use of DNA and RSM provide the necessary tools to explore an EM system in its current state and then simulate varying levels of network measures to determine which combinations provide for efficient information flow.
CHAPTER THREE

METHODOLOGY

The primary purposes of this study were to investigate enrollment management (EM) in higher education through the framework of a complex adaptive system (CAS), to provide colleges and universities with a foundational understanding of what a sustainable EM system looks like from Dynamic Network Analysis (DNA) perspective, and to suggest to EM practitioners one method to model (a) their institution’s EM system in its current status and (b) what network structures optimize information flow, thus cultivating a sustainable EM system for their institutions. Additionally, I aimed to describe how formal network structures either promote or inhibit a sustainable EM system within the bounds of the university under study. For example, to what extent are those involved in EM interdependent with, or dependent upon, each other? Are there bottlenecks to the flow of information? Does information flow freely throughout the EM system? In this study, I considered an EM system to be sustainable if the speed at which information flows throughout the system remains stable regardless of changes to, and pressures from, the internal and external environments.

To this end, this study is guided by two overarching questions:

1. To what extent is the research site organized to enable effective and efficient information flow?
2. Which combinations of independent network measures (adaptive leadership, social capital, and clique structure) produce optimal outcome measures (information flow) for a sustainable EM system?

The methodologies used to explore the research questions are presented in this chapter, and the chapter is organized into the following seven sections: (a) research design, (b) ethical considerations, (c) role of the researcher, (d) setting, (e) selection of participants, (f) data collection, and (g) data analysis.

**Research Design**

Because there is no published research on the topic of EM as a CAS, this study followed similar research designs of other dynamic organizations (Bennett, 2011; Christiansen, 2011; Hanson, 2009; Marion & Uhl-Bien, 2003; Mcfarland, 2012). The epistemological perspective for this study is pragmatism which is appropriate in this case because of the focus on “outcomes of the research” and “solutions to problems” (Creswell, 2013, p. 29; 2014, p. 10). While methods are important in pragmatism, the chief aim is to fully understand the problem at hand through appropriate questions (Creswell, 2013, 2014). An excellent summary of pragmatism as stated by Creswell (2013) is, “In practice, the individual using this worldview will use multiple methods of data collection to best answer the research question[s], will employ multiple sources of data collection, will focus on the practical implications of the research, and will emphasize the importance of conducting research that best addresses the research program” (p. 28-29).
Given this study’s epistemological perspective, I selected a mixed-methods research design—specifically, an exploratory sequential mixed methods design that combines both qualitative and quantitative methods (Creswell, 2013, 2014; Plano Cark & Creswell, 2008; Tashakkori & Teddlie, 2003; Teddlie & Tashakkori, 2009). In social science research, mixed methods is considered a strong research design because it bolsters studies by providing multiple data collection methods (Plano Cark & Creswell, 2008). One weakness found in single method research is that of certain limitations. Multiple methods (mixed methods) research “can neutralize or cancel out some of the disadvantages of certain methods (e.g., the detail of qualitative data can provide insights not available through general quantitative surveys)” (Plano Cark & Creswell, 2008, p. 164).

As shown in Figure 3.1, an exploratory sequential mixed methods research design starts with a qualitative phase and follows up with a quantitative phase (Creswell, 2014). The qualitative method helps to develop quantitative measures and instruments (Plano Cark & Creswell, 2008), which is precisely why the exploratory sequential design was appropriate for this study. This design also assists in the generalizability of the findings from the qualitative survey.
Ethical Considerations

Prior to collecting data, I obtained approval by Clemson University’s Institutional Review Board (IRB) under an expedited review process. Since the research setting was an authentic university where I surveyed employees, I used informed consent, and the participants were able to opt out of the study per IRB standards. I ensured strict confidentiality of the participants by anonymizing the data and providing no identifiable information in this dissertation or subsequent publications stemming from this study (Onwuegbuzie & Collins, 2007). Further, I recoded the names and titles into numerical values to provide anonymity. The data are stored on a password-protected laptop with a backup of the data on an encrypted external drive.

Role of the Researcher

Having worked in higher education for 27 years, both in admission and financial aid, I bring a vast amount of experience to this study. However, all of that experience has been in small, private liberal arts colleges and universities. Such experience can be limiting if I approach this study from a myopic viewpoint, failing to remember that public
higher education is structured differently and that the pressures of public universities will differ from private. I must also avoid the temptation to assume that my private college and university experiences are generalizable to publics as well as to other privates. Further, I am accustomed to working in very distinct admission and financial aid departments with little interaction among and between other offices. I must remember what I wrote in Chapters 1 and 2: Henderson (2001) quoted Jack Maguire, “Enrollment management is a process that brings together often disparate functions having to do with recruiting, funding, tracking, retaining, and replacing students as they move toward, within, and away from the university” (p. 7). Maguire continued that EM was brought about in order to create a synergy between offices that often acted independently and, at many times, at cross-purposes (Henderson, 2001). Keeping this in mind will prevent me from trying to force my own view of higher education institutions into the findings from this exploratory study.

**Setting**

The research setting for this study was a small, four-year private, not-for-profit university, which I called Midwest University (MU), located in a large suburban area (Statistics) in the Midwest. The official Carnegie Classification for MU is Baccalaureate Colleges—Arts and Sciences (Statistics). MU is a religiously affiliated institution with 142 full-time faculty and 74 part-time faculty. The 2014-15 enrollment was 1,734 undergraduate students, 99% of whom are full-time, defined as enrolling for at least 12 semester hours per term (Statistics).
MU is accredited by the North Central Association of Colleges and Schools Higher Learning Commission, and its music and education programs are accredited by the National Association of Schools of Music (NASM) and the National Council for Accreditation of Teacher Education (NCATE), respectively. According to the MU website, the student body exhibits the following demographics:

- 53% female; 47% male
- 72% are White; 7% are Black or African American; 7% are non-resident aliens; 5% claim two or more races; 4% Hispanic/Latino; 3% unknown; 2% Asian
- 47% are in-state students and 46% are out-of-state students; 7% come from foreign countries

MU received 3,981 applications for admission, admitted 74% of those applicants, and yielded 15% in Fall 2014. The freshman-to-sophomore retention rate (Fall 2013 to Fall 2014) was 79%, and the six-year graduation rate was 66%. MU’s endowment value, as of FY 2014, was $211,723,000 (National Association of College University Business Officers, 2015).

**Selection of Participants**

The selection of one research site allowed for purposive sampling which involves “selecting certain units or cases ‘based on a specific purpose rather than randomly’” (Tashakkori & Teddlie, 2003, p. 713; Teddlie & Tashakkori, 2009, p. 173). This study was the first that applied complexity theory, network theory, and the methodologies of DNA and response surface techniques to EM. For this reason, purposive sampling was appropriate given that “Purposive sampling addresses specific purposes related to
research questions; therefore, the researcher selects cases that are information rich in regard to those questions” (Teddlie & Tashakkori, 2009, p. 173).

Network analysis typically requires that participants be bounded by role and function. Specifically, I solicited the participation of every full-time employee in the offices that the institution deemed part of their EM model. These were the people who interacted regularly and were part of the network. Purposive sampling involves “selecting units (e.g., individuals, groups of individuals, institutions) based on specific purposes associated with answering a research study’s questions” (Plano Cark & Creswell, 2008, pp. 200-201). Important to note is that the definition of EM used for this study suggested that the agents and resources outside of the institutionally-defined EM division may have become participants as well. However, no one outside of the formal EM structure participated.

**Data Collection**

To gather the data necessary for this study, I utilized two survey instruments (see Figure 3.1). The qualitative survey for this study was designed to identify (1) what interactions between people occurred within the formal EM structure of the research site as well as outside of the formal EM structure, (2) the knowledge and skills required to perform the various roles within the EM system, and (3) the resources required to perform the roles of those in the system. For example, the survey consisted of questions such as, “What do you most need to know or understand to perform your job effectively?” and “What skills do you most need to perform your job effectively?” Using NVivo ("NVivo for Mac," 2015), I categorized the responses using open coding as
described by Corbin and Straus (1990). Examples of coding results for the question asking about first aforementioned question are in Table 3.1. Using these categorized responses from the qualitative survey, I built a subsequent quantitative survey with closed ended, multiple and single choice answers (Creswell, 2014). The categories helped build the response scale for the quantitative survey (see Appendix C).

Table 3.1

<table>
<thead>
<tr>
<th>Question</th>
<th>Categories Assigned from Open Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you most need to know or understand to perform your job effectively?</td>
<td>Academic Majors; Accounting procedures, Residence life procedures, Marketing trends</td>
</tr>
</tbody>
</table>

Additionally, I asked for general demographic information, including gender, alumnus[a] status, and length that the participants worked in the EM division of MU. After both surveys were drafted, I submitted the study proposal to Clemson’s Institutional Review Board (IRB) for approval, which was given (see Appendix D).

The software I used to design, distribute, and collect the survey data was Qualtrics ("Qualtrics," 2015). I collected the names, titles, and email addresses of MU’s EM Department and solicited their participation via the email functionality built into Qualtrics. I waited one week before sending a reminder email to those who had not completed each survey. After two weeks, I closed the surveys and downloaded the responses into Microsoft Excel.
Software

Data analysis for this study included two software packages: ORA (2015b) and Minitab ("Minitab," 2016). As described by Kathleen Carley (2014), “ORA is a network analytic tool developed by CMU and Netanomics, that allows the user to fuse, analyze, visualize, and forecast behavior given network data” (p. 2). Further, ORA is a network analysis tool that detects risks or vulnerabilities of an organization’s design structure. The design structure of an organization is the relationship among its personnel, knowledge, resources, and tasks entities. These entities and relationships are represented by the Meta-Matrix. Measures that take as input a Meta-Matrix are used to analyze the structural properties of an organization for potential risk. (Carley et al., 2013, p. iii)

Since researchers previously used ORA to visualize the interactions within and between networks as well as perform “what-if scenarios” (Christiansen, 2011, p. 52), ORA was the appropriate tool for exploring EM as a CAS where effects of changes in the network structures at MU could provide useful information about the efficiency of information flow throughout the EM system.

Minitab ("Minitab," 2016) is a statistical software package useful for design of experiments methodologies such as RSM.

Data Analysis

Dynamic Network Analysis

Dynamic Network Analysis (DNA) was the primary method for analyzing the network data supplied by the two surveys. Because I studied EM as a CAS, DNA
provided the appropriate method for my research in that DNA provides for “modeling and analyzing organizations as complex adaptive systems” (Schreiber & Carley, 2006, p. 61). DNA allows one to study the structure of organizations and how that structure inhibits or promotes learning, adapting, information processing, and communication. In fact, “…information processing, communication, and knowledge management are keys to effective organizational performance and adaptability” (Carley & Kamneva, 2004, p. 1).

Through DNA, we can learn how networks will evolve, change, and adapt (Carley, Martin, & Hancock, n.d.). DNA can serve as a risk analyzer for organizations, looking at various levels of the organization including departments, divisions, teams, etc. (Schreiber & Carley, 2005). Traditionally, examining social networks resulted in static, unchanging snapshots of interactions. These serve little purpose when trying to understand an organization that is dynamic (Berger-Wolf & Saia, 2006). Thus, DNA provides a method of examining networks of people that change, learn, adapt, etc. As Carley (forthcoming) argued, using a method that just “connects the dots” (p. 2) to try to understand a setting in which those dots may change, move, leave, or reappear is extremely limiting. Further, “social network analysis (SNA) has focused on small, bounded networks, with 2-3 types of links (such as friendship and advice) among one type of node (such as people), at one point in time, with close to perfect information” (Carley, forthcoming, p. 2). DNA can analyze very large networks, different types of nodes (e.g. knowledge, tasks, advice) as well as simulate the effects of changes within a network (Carley, forthcoming) or between networks. DNA investigates the meta-matrix,
defined as the depiction of the relationships between people, knowledge, tasks, and resources (Carley, forthcoming).

Carley and Kamneva (2004, p. 2) presented the information in Table 3.2 to reflect a meta-matrix:

Table 3.2

Meta-Matrix for Organizational Design

<table>
<thead>
<tr>
<th></th>
<th>People</th>
<th>Knowledge</th>
<th>Resources</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>People</td>
<td>Interaction Network</td>
<td>Knowledge Network</td>
<td>Resource Network</td>
<td>Assignment Network</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Information Network</td>
<td>Resource Skill Needs Network</td>
<td>Task Skill Needs Network</td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>Substitutes and Coordinated Resources Network</td>
<td>Task Resource Needs Network</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tasks</td>
<td>Task Precedence Network</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Adapted from Carley and Kamneva (2004)*

In Table 3.2, the first row represents that part of the organization that can be changed rather quickly: interaction, knowledge, resources, and tasks. The contents of the other rows are more constrained because of capital and other requirements necessary to change those aspects (Carley & Kamneva, 2004).
Network Measures

The network measures, both independent and dependent, are specified in Table 3.3.

Table 3.3

<table>
<thead>
<tr>
<th>Network Structure</th>
<th>Measure</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptive Leadership</td>
<td>Closeness Centrality</td>
<td>Indicates a “node that is closest to all other nodes and has rapid access to all information” (Carley et al., 2013, p. 3).</td>
</tr>
<tr>
<td>Clique Structure</td>
<td>Clustering Coefficient</td>
<td>A measure indicating clique structure in organizations. Cliques are information processing network structures with the characteristic of agents interacting within cliques rather than outside of cliques (Marion et al., 2016). The clustering coefficient “Measures the degree of clustering in a network by averaging the clustering coefficient of each node, which is defined as the density of the node's ego network” (Carley, 2015b)(Carley, 2015).</td>
</tr>
<tr>
<td>Social Capital</td>
<td>Resource Capability</td>
<td>Direct and indirect access to resources (Briley, Stuart, &amp; Marion, forthcoming)</td>
</tr>
</tbody>
</table>

Before I could run the network analyses, I had to code the multiple choice responses into a binary format where “1” would indicate a relationship between agents (who interacted with whom), the knowledge required to perform their tasks (who selected which categories of knowledge), etc. A “0” would indicate no relationship. Once this coding was complete, I built matrices that would allow ORA to identify links between
nodes (agent x agent; agent x resource; etc.). An example of a partial agent-by-agent matrix used in this study is in Table 3.4.

Table 3.4

*Agent x Agent Matrix in Binary Form*

<table>
<thead>
<tr>
<th></th>
<th>Enrollment MGMT Staff_1</th>
<th>Enrollment MGMT Staff_2</th>
<th>Enrollment MGMT Staff_3</th>
<th>Enrollment MGMT Staff_4</th>
<th>Enrollment MGMT Staff_5</th>
<th>Enrollment MGMT Staff_6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrollment MGMT Staff_1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Enrollment MGMT Staff_2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Enrollment MGMT Staff_3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Enrollment MGMT Staff_4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Enrollment MGMT Staff_5</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Enrollment MGMT Staff_6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

After all the matrix data were appropriately entered into ORA, I ran network measures for this study to get a sense of the network structures that existed in MU’s EM Department and between individuals in the EM Department and other individuals outside of EM. The specific independent measures for this study were closeness centrality (adaptive leadership), resource capability (social capital), and clustering coefficient (clique structure); the dependent measure was average speed (information flow). I also visualized the networks using ORA’s visualization tools. These images provided another perspective of the network typology.
Response Surface Methods

Response Surface Methods (RSM) is a design of experiments (DOE) methodology. Researchers utilize DOE “for studying any response that varies as a function of one or more independent variables” (Mathews, 2005, p. xii); Mathews contended it is essential for studying complex systems. The purpose for using RSM is to predict responses (outcomes) as a function of multiple controllable factors (Anderson & Whitcomb, 2005). Carley, Kamneva, and Reminga (2004) defined RSM as “a collection of statistical and mathematical techniques useful for developing, improving, and optimizing processes” (p. 1). Kenett, Steinberg, and Yoskovich (2015) indicated that RSM “can be a great tool in experimentally optimizing conditions” (p.1). Originally, chemists developed RSM when they sought to determine the optimal conditions for chemical reactions (Box & Wilson, 1951). Carley and Kamneva (2004) applied optimization methods like RSM to network structures in corporate and other organizations, structures such as interaction networks, knowledge networks, resource networks, and assignment networks. According to Anderson and Whitcomb (2005),

Response surface methods offer statistical design of experiment tools that lead to peak processing performance. RSM produces precise maps based on mathematical models. It can put all your responses together via sophisticated optimization approaches, which ultimately lead to the discovery of sweet spots where you meet all specifications at a minimal cost. (p. 1)

This lends credence to the purpose of my use of RSM in this study of EM as a CAS: I wanted to determine optimum levels of the adaptive leadership, social capital, and clique
structure— independent network measures—that will most effectively promote information diffusion, my dependent network measure.

To conduct the Response Surface Methodology (RSM) analysis, I used Minitab Version 17.3.1 for Mac ("Minitab," 2016). Minitab facilitates Design of Experiments analyses such as RSM. To prepare the data necessary for RSM, I utilized ORA’s optimizer. In short, the optimizer added and removed links until the network reached the target levels of closeness centrality, resource capability, and clustering coefficient (the independent measures). For example, I set one optimization run for a high level of closeness centrality, and average level of clustering coefficient, and a minimum level of resource capability. For another variation, I set an average level of closeness centrality, an average level of clustering coefficient, and a maximum level of resource capability. All of the combinations of independent measures I selected are listed in Table 3.4.
Table 3.4

*Optimization Outcomes*

<table>
<thead>
<tr>
<th>Clustering</th>
<th>Centrality</th>
<th>Resource Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Average</td>
<td>Minimum</td>
</tr>
<tr>
<td>Average</td>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
<td>Average</td>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
<td>Minimum</td>
<td>Average</td>
</tr>
<tr>
<td>Average</td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>Average</td>
<td>Average</td>
<td>Average</td>
</tr>
<tr>
<td>Minimum</td>
<td>Average</td>
<td>Maximum</td>
</tr>
<tr>
<td>Average</td>
<td>Average</td>
<td>Average</td>
</tr>
<tr>
<td>Average</td>
<td>Maximum</td>
<td>Maximum</td>
</tr>
<tr>
<td>Maximum</td>
<td>Maximum</td>
<td>Average</td>
</tr>
<tr>
<td>Maximum</td>
<td>Average</td>
<td>Minimum</td>
</tr>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td>Average</td>
</tr>
<tr>
<td>Minimum</td>
<td>Minimum</td>
<td>Average</td>
</tr>
<tr>
<td>Average</td>
<td>Average</td>
<td>Average</td>
</tr>
</tbody>
</table>

After the optimizer finished, each of the independent and dependent measures resulting from the 15 optimization runs were entered into an Excel spreadsheet and then uploaded into Minitab. The RSM results were plotted, and the combinations of independent measures that produced the most stable flow of information were selected.

**Summary**

The primary purposes of this study were to investigate EM in higher education through the framework of a CAS, to provide colleges and universities with a foundational understanding of what a sustainable EM system looks like from a DNA perspective, to suggest to EM practitioners one method to model (a) their institution’s EM system in its current status and (b) what network structures optimize information flow, thus cultivating...
a sustainable EM system for their institutions. Additionally, I aimed to describe how formal network structures either promote or inhibit a sustainable EM system within the bounds of the university under study. To this end, this study is guided by two overarching questions:

1. To what extent is the research site organized to enable effective and efficient information flow?

2. Which combinations of the independent network measures (adaptive leadership, social capital, and clique structure) produce optimal outcome measures (information flow) for a sustainable EM system?

The participants in this study were bound by role.

Using purposive sampling, I solicited the participation of every full-time employee in the offices that the institution deemed part of their EM Department. These are the people who interact regularly and are part of the network. I presented the arguments supporting the research design for this study (exploratory sequential mixed-methods), the software used for data collection (Qualtrics), and the software used to analyze the data (ORA and Minitab).
CHAPTER FOUR

FINDINGS

The primary purposes of this study were to investigate Enrollment Management (EM) in higher education through the framework of a complex adaptive system (CAS), to provide colleges and universities with a foundational understanding of what a sustainable EM system looks like from Dynamic Network Analysis (DNA) perspective, and to suggest to EM practitioners one method to model (a) their institution’s EM system in its current status and (b) what network structures optimize information flow, thus cultivating a sustainable EM system for their institutions. Additionally, aimed to describe how formal network structures either promote or inhibit a sustainable EM system within the bounds of the university under study. For example, to what extent are those involved in EM interdependent with, or dependent upon, each other? Are there bottlenecks to the flow of information? Does information flow freely throughout the EM system? This study considered an EM system to be sustainable if the speed at which information flows throughout the system remains stable regardless of changes to, and pressures from, the internal and external environments.

To this end, this study is guided by two overarching questions:

1. To what extent is the research site organized to enable effective and efficient information flow?
2. Which combinations of independent network measures (adaptive leadership, social capital, and clique structure) produce optimal outcome measures (information flow) for a sustainable EM system?

Adaptive leadership was operationalized as closeness centrality; social capital, as resource capability; and clique structure as clustering. Table 4.1 details the definitions of these measures.

Table 4.1

Network Measures

<table>
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<th>Measure</th>
<th>Definition</th>
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</tr>
<tr>
<td>Clique Structure</td>
<td>Clustering Coefficient</td>
<td>A measure indicating clique structure in organizations. Cliques are information processing network structures with the characteristic of agents interacting within cliques rather than outside of cliques (Marion et al., 2016). The clustering coefficient “Measures the degree of clustering in a network by averaging the clustering coefficient of each node, which is defined as the density of the node's ego network” (Carley, 2015b).</td>
</tr>
<tr>
<td>Social Capital</td>
<td>Resource Capability</td>
<td>Direct and indirect access to resources (Briley, Stuart, &amp; Marion, forthcoming)</td>
</tr>
</tbody>
</table>
Before discussing the findings of this research, a reminder of the guiding definition of EM is appropriate:

Enrollment management is not an insular division or department, but a living, complex adaptive system whose core strategic function (Wilkinson et al., 2007) is to coordinate people, knowledge, tasks, and resources for identifying, recruiting, enrolling, retaining, and graduating students (Henderson, 2001) at levels that support the mission (Wilkinson et al., 2007) of the institution. Its end is to create and maintain dynamic, sustainable enrollment conditions that allow the institution to survive and persist, regardless of the forces that push it toward extinction. An effective EM system is anticipatory (Wilkinson et al., 2007) of internal and external pressures, requires input from and cooperation of the entire campus (Wilkinson et al., 2007), and takes into account the physical and instructional capacity of the institution, its current and potential market positions, the financial requirements of the institution, the standards of accreditation, and the limits of regulation.

A CAS relies on interactions of agents to sustain its existence. In network analysis, agents may be individual groups, people, or organizations. The system must be nimble to both internal and external changes and pressures. As such, this study moved beyond the formal organizational structure of an EM Department and focused on the informal interactions and network structures that influence information diffusion, which Kalsbeek (2001) contended is the “most important material driving strategic enrollment management” (p. 189).
Since human agents contain information in a social network, our understanding of an agent’s position in the network as well that agent’s connectivity to other agents is vital. The higher an agent’s (or, in network terminology, node’s) connectivity, the more likely that agent (node) is to receive information. Additionally, with network analysis, we can see what happens if any particular node is removed. If that node is critical to the flow of information throughout the network, we need to see what will happen to the network structure when that node is removed. Later in the chapter, we will see later why this is important specifically to MU. This study examined the network structure of an EM system at a small, private university in the Midwest (named, for the purposes of this research, Midwestern University, abbreviated as MU). This chapter begins with a reminder of the research method and the research site. Descriptive statistics and typology of the network follows, and the chapter concludes with the findings of both the network analysis and the response surface methodology.

Research Method and Site

Two survey instruments were used to gather the network data necessary for this study. The first survey was qualitative; its purpose was to identify (1) what interactions between people occurred within and outside of the formal EM structure of the research site, (2) the knowledge required to perform the various roles within the EM system, and (3) the resources required to perform the roles of those in the system as well as the agents’ access to those resources. See Appendices A and B for the surveys used for this study.
Using NVivo ("NVivo for Mac," 2015), the responses were categorized using open coding as described by Corbin and Straus (1990). Using the categorized responses from the qualitative survey, a subsequent quantitative survey was built with multiple and single choice answers (Creswell, 2014). Further, respondents were asked for general demographic information such as gender, alumnus[a] status, and how long the participants worked in the EM division of MU. The intention of gathering demographic data was to see if a certain demographic was more central to information flow throughout the network.

Qualtrics ("Qualtrics," 2015) software was used to design, distribute, and collect the survey data. The participants’ responses were exported to the quantitative survey from Qualtrics into Microsoft Excel to process those data for import into a DNA software named ORA (2015b). To conduct the response surface analysis, including producing the response surface plots, I utilized Minitab ("Minitab," 2016).

**Descriptive Statistics and Network Typology**

Twenty out of 21 invited participants completed both surveys for a response rate of 95.2%. Table 4.2 shows the descriptive statistics of the participants.
Table 4.2

Descriptives of Participants

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>5 (25%)</td>
<td>15 (75%)</td>
</tr>
<tr>
<td>Alumnus(a)</td>
<td>2 (10%)</td>
<td>18 (90%)</td>
</tr>
<tr>
<td>Worked at MU</td>
<td>Less than one year</td>
<td>4 (20%)</td>
</tr>
<tr>
<td></td>
<td>1 – 3 years</td>
<td>7 (35%)</td>
</tr>
<tr>
<td></td>
<td>4 – 6 years</td>
<td>3 (15%)</td>
</tr>
<tr>
<td></td>
<td>7 – 10 years</td>
<td>3 (15%)</td>
</tr>
<tr>
<td></td>
<td>10+ years</td>
<td>3 (15%)</td>
</tr>
</tbody>
</table>

Surprisingly, few employees of the MU EM Department were alumni. Experience would lead one to think that close to 50% of the enrollment staff would be alumni of MU, given their knowledge of the institution and their emotional ties to their alma mater. Fifty-five percent of the staff have three or fewer years’ experience at MU.

I distinguished formal leaders from and informal leaders based on title. Those with the titles of director or vice-president are formal leaders for the purposes of reporting demographics. Two formal leaders have less than one year of tenure at MU; two have one to three years of tenure at MU; two have four to six years of tenure at MU. As shown in Table 4.3, there are 285 nodes in the MU EM meta-network, and those nodes were classified into five networks. Though there were 20 respondents, 285 total nodes existed in the meta-network, as shown in Table 4.3.
Table 4.3

*Meta-Network Statistics*

<table>
<thead>
<tr>
<th>Nodeset Count</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node Count</td>
<td>285</td>
</tr>
<tr>
<td>Network Count</td>
<td>5</td>
</tr>
<tr>
<td>Total Density</td>
<td>0.170</td>
</tr>
</tbody>
</table>

The density of the meta-network reveals the ratio of the number of ties divided by the total number of possible ties. Put another way, density is a measure of connectivity, or “how easy or how difficult it is for any two nodes to form a connection” (Colchester, 2015c). As barriers to interactions diminish, the network becomes denser. The denser a network, the faster information can flow through it. When solely examining the network consisting of the EM staff (agent x agent), the density increases to 0.249 (see *social density* in Table 4.4). This makes sense as the EM staff network consists of 21 people. When examining the whole meta-network, all of the resources (who are agents outside of EM) dilute the density as there is an inverse relationship between network size and density (Carley, 2015a). Finally, the average communication speed of 0.433 demonstrates that interaction within the meta-network is fairly high (see Table 4.5).

Table 4.4 displays the nodeset counts within the meta-network. *Resources* are people to whom members of the EM Department go to when they need specific information to perform their roles at MU. *Knowledge* represents what people need to know in order to do their jobs. *Role* classifies the many people outside EM by the office
in which they work (e.g. Provost, Communications, etc.). Finally, \textit{Task} refers to skills that the enrollment staff need to perform their roles.

Table 4.4

\textit{Nodeset Counts per Network}

<table>
<thead>
<tr>
<th>Resources</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrollment Management Staff</td>
<td>21</td>
</tr>
<tr>
<td>Knowledge</td>
<td>53</td>
</tr>
<tr>
<td>Role</td>
<td>9</td>
</tr>
<tr>
<td>Task</td>
<td>16</td>
</tr>
</tbody>
</table>

ORA’s Key Entity Report “Identifies key entities and groups who by virtue of their position in the network are critical to its operation” (Carley, 2015b). Table 4.4 presents some of the performance indicators of the EM network, as calculated by the Key Entities Report.

Table 4.5

\textit{Key Entities Report}

<table>
<thead>
<tr>
<th>Measure</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Complexity</td>
<td>0.170</td>
<td>The overall density of the network (Wasserman &amp; Faust, 1994).</td>
</tr>
<tr>
<td>Social Density</td>
<td>0.249</td>
<td>Density of the agent x agent networks (Wasserman &amp; Faust, 1994).</td>
</tr>
<tr>
<td>Social Fragmentation</td>
<td>0.000</td>
<td>Amount of disconnectivity of nodes (Borgatti, 2003; Breiger, Carley, &amp; Pattison, 2003).</td>
</tr>
<tr>
<td>Average Communication Speed</td>
<td>0.433</td>
<td>The average speed with which any two (reachable) nodes can interact (Carley, 2002).</td>
</tr>
</tbody>
</table>
Focusing down into the node-level Key Entities, agents who are most critical to the network’s operation are presented in the tables 4.6 – 4.9.

Table 4.6

Key Entities—Degree Centrality: “Individuals or organizations who are in the know are those who are linked to many others and so, by virtue of their position have access to the ideas, thoughts, beliefs of many others” (Carley et al., 2013, p. 1053).

<table>
<thead>
<tr>
<th>Rank</th>
<th>EM Staff Agent</th>
<th>Value</th>
<th>Unscaled</th>
<th>Context*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>0.610</td>
<td>25</td>
<td>3.816</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>0.390</td>
<td>16</td>
<td>1.419</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>0.390</td>
<td>16</td>
<td>1.419</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>0.366</td>
<td>15</td>
<td>1.233</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>0.341</td>
<td>14</td>
<td>0.975</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>0.317</td>
<td>13</td>
<td>0.716</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>0.317</td>
<td>13</td>
<td>0.716</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>0.293</td>
<td>12</td>
<td>0.458</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>0.268</td>
<td>11</td>
<td>0.200</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>0.244</td>
<td>10</td>
<td>-0.059</td>
</tr>
<tr>
<td>Min</td>
<td>0.098</td>
<td>Max</td>
<td>0.610</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.254</td>
<td>Mean in random network</td>
<td>0.249</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.120</td>
<td>SD in random network</td>
<td>0.094</td>
<td></td>
</tr>
</tbody>
</table>

*Note. Context refers to the number of standard deviations from the mean of a random network of the same size and density.*

With a degree centrality score of 0.610, Enrollment MGMT Staff_8 is greater than 3.8 standard deviations from the mean of a random network of 0.249. A level of degree centrality greater than 3.8 standard deviations suggests that, though this agent has good access to the ideas and beliefs of many other agents in the network, he or she is too central in that information may be trapped and/or controlled by this individual.
Table 4.7

Key Entities—Closeness Centrality: Indicates a “node that is closest to all other nodes and has rapid access to all information (Carley et al., 2013, p. 3).

<table>
<thead>
<tr>
<th>Rank</th>
<th>EM Staff Agent</th>
<th>Value</th>
<th>Unscaled</th>
<th>Context*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21</td>
<td>0.526</td>
<td>0.026</td>
<td>0.252</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>0.488</td>
<td>0.024</td>
<td>-0.416</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>0.426</td>
<td>0.021</td>
<td>-1.495</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>0.417</td>
<td>0.021</td>
<td>-1.649</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>0.392</td>
<td>0.020</td>
<td>-2.073</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>0.392</td>
<td>0.020</td>
<td>-2.073</td>
</tr>
<tr>
<td>7</td>
<td>14</td>
<td>0.385</td>
<td>0.019</td>
<td>-2.204</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>0.377</td>
<td>0.019</td>
<td>-2.330</td>
</tr>
<tr>
<td>9</td>
<td>19</td>
<td>0.351</td>
<td>0.018</td>
<td>-2.789</td>
</tr>
<tr>
<td>10</td>
<td>16</td>
<td>0.339</td>
<td>0.017</td>
<td>-2.995</td>
</tr>
<tr>
<td>Min</td>
<td>0.048</td>
<td>Max</td>
<td>0.526</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.310</td>
<td>Mean in random network</td>
<td>0.512</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.121</td>
<td>SD in random network</td>
<td>0.058</td>
<td></td>
</tr>
</tbody>
</table>

Note. Context refers to the number of standard deviations from the mean of a random network of the same size and density.

In closeness centrality, Enrollment MGMT Agent_21 has the highest value, indicating that he/she has rapid access to information because of this person’s closeness to all other nodes in the network. (Carley et al., 2013). Although Enrollment MGMT Agent_8 has the highest number of connections throughout the network, Enrollment MGMT Agent_21 is actually closest to all other agents in the sense of the number of paths it takes for Agent_21 to reach all other agents and vice-versa. The scores of agents at the lower end of the closeness centrality are of interest. The bottom eight are all greater than 1 standard deviation below the mean, which indicates that these agents are peripheral to the
information exchange network—and the remaining, unranked agents are even more
distant from the information network. It appears that agents in this network may not be
well linked, but further information is needed.

Table 4.8

*Key Entities—Most Knowledge:* “Individuals or organizations who are
high in out-degree for knowledge have more expertise or are associated
with more types of knowledge than are others” (Carley et al., 2013, p. 967).

<table>
<thead>
<tr>
<th>Rank</th>
<th>EM Staff Agent</th>
<th>Value</th>
<th>Unscaled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>0.811</td>
<td>43</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>0.660</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>0.547</td>
<td>29</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>0.528</td>
<td>28</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>0.509</td>
<td>27</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>0.434</td>
<td>23</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>0.415</td>
<td>22</td>
</tr>
<tr>
<td>8</td>
<td>14</td>
<td>0.377</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>0.358</td>
<td>19</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>0.358</td>
<td>19</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>Max</td>
<td>0.811</td>
</tr>
<tr>
<td>Mean</td>
<td>0.346</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.189</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Enrollment MGMT Agent_8 has the highest access to knowledge in the network, and
Enrollment MGMT Agent_21 is in second place. Both of these agents’ knowledge
measures are > 1 standard deviation above the mean of all agents in the network,
indicating again that they have much higher access to knowledge than any other person.
For anyone to access information, this finding suggests that people must interact with
these two agents; this may indicate that knowledge is hard to access for the rest of the staff.
Table 4.9

*Key Entities—Most Resource*: “Individuals or organizations who are high in out-degree for resources have more resources or are associated with more types of resources than are others” (Carley et al., 2013, pp. 967-968).

<table>
<thead>
<tr>
<th>Rank</th>
<th>EM Staff Agent</th>
<th>Value</th>
<th>Unscaled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>0.199</td>
<td>37</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>0.177</td>
<td>33</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>0.172</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>0.167</td>
<td>31</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>0.156</td>
<td>29</td>
</tr>
<tr>
<td>6</td>
<td>21</td>
<td>0.145</td>
<td>27</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>0.113</td>
<td>21</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>0.113</td>
<td>21</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>0.091</td>
<td>17</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>0.091</td>
<td>17</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>Max</td>
<td>0.199</td>
</tr>
<tr>
<td>Mean</td>
<td>0.102</td>
<td>SD</td>
<td>0.049</td>
</tr>
</tbody>
</table>

Enrollment MGMT Staff_17 has the greatest access to resources in the network. As a reminder, resources for this study are individuals in departments outside of MU’s EM Department. An agent’s interaction with the resources is a key indicator of resource capability. Interestingly, Enrollment MGMT Staff_8 and Enrollment MGMT Staff_21 are in the middle of the ranking despite their high levels of degree and closeness centralities displayed in the previous tables.

Moving the focus of our analysis from specific agents to that of offices or departments who serve as resources (Table 4.10), the Key Entities Report shows the offices whose personnel were, themselves, key resources in the network.
Table 4.10

Key Entities—Most Agent: “For any node, e.g. an individual or a resource, the out-links are the connections that the node of interest has to other nodes. For example, imagine an agent by knowledge network where the number of out-links an agent would have is the number of pieces of knowledge it is connected to” (Carley, 2015b).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Office</th>
<th>Value</th>
<th>Unscaled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Communications Agent_82</td>
<td>0.810</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>Information Services Agent_28</td>
<td>0.619</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>Information Services Agent_19</td>
<td>0.476</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Communications Agent_85</td>
<td>0.476</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Athletics Agent_103</td>
<td>0.429</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>Athletics Agent_106</td>
<td>0.429</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>Advancement/Alumni Agent_75</td>
<td>0.381</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>Athletics Agent_104</td>
<td>0.381</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>Academic Affairs Agent_11</td>
<td>0.381</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>Finance and Administration Agent_161</td>
<td>0.091</td>
<td>8</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>Max</td>
<td>0.810</td>
</tr>
<tr>
<td>Mean</td>
<td>0.102</td>
<td>SD</td>
<td>0.137</td>
</tr>
</tbody>
</table>

All of the top ten resources were more than one standard deviation above the mean.

Expanding the report to the top 50 resources revealed that resource agents 11 –26 were also more than one standard deviation above the mean, and resource agents 27 – 103 were within one standard deviation of the mean. This indicates that personnel in many offices provide information necessary for EM to perform its roles at MU; this is a positive finding. The more important consideration is how many of the EM staff have direct access to these resources?
The Student Affairs office was not represented in the top sources of resources. Since EM does not stop when an incoming student matriculates, it is surprising that no personnel in the Student Affairs division served as an important resource for EM staff. This means that few EM staff identified residence life, Greek life, student involvement for leadership, career services, or public safety personnel as resources. (Note that this does not indicate that such functions are unimportant, only that they are not considered resources by respondents). Given the importance of these offices to parents of prospective students, this is puzzling.

The Key Entities Report also ranks the top ten knowledge sets that the participants identified as important to performing their roles in EM. Table 4.11 presents those data.
Table 4.11

*Key Entities—Most Agent:* “For any node, e.g. an individual or a resource, the out-links are the connections that the node of interest has to other nodes. For example, imagine an agent by knowledge network where the number of out-links an agent would have is the number of pieces of knowledge it is connected to” (Carley, 2015b).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Knowledge Set</th>
<th>Value</th>
<th>Unscaled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interpersonal communication</td>
<td>0.810</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>Customer service skills</td>
<td>0.714</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>Admission policies and procedures</td>
<td>0.619</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Electronic communication</td>
<td>0.619</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Telephone etiquette</td>
<td>0.619</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>Ability to explain to parents and students the “value equation” of MU</td>
<td>0.571</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>How students and parents choose a college</td>
<td>0.571</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>Academic majors</td>
<td>0.524</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>How the University can be differentiated</td>
<td>0.524</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>Working knowledge of Slate software</td>
<td>0.524</td>
<td>8</td>
</tr>
<tr>
<td>Min</td>
<td>0.095</td>
<td>Max</td>
<td>0.810</td>
</tr>
<tr>
<td>Mean</td>
<td>0.346</td>
<td>SD</td>
<td>0.164</td>
</tr>
</tbody>
</table>

All of the top 10 knowledge sets were more than one standard deviation above the mean.

Expanding the report to the top 50 knowledge sets revealed that knowledge sets 11 – 46 were within one standard deviation of the mean, and 47 – 50 were more than one standard deviation below the mean. One may notice that a key knowledge set that EM staff must possess in order to perform their roles for MU involve communication of some
kind; actual oral or written communication skills are ranked 1, 2, 4, and 5, while knowledge such as admission policies and procedures and academic majors (ranked 3 and 8, respectively) are key to information flow as well. Being able to communicate inside and outside of the EM Department, is well recognized by the EM staff.

**Network Visualization**

Looking at the statistics is one way to understand how the network is structured, but network graphs help to visualize network structures. Figure 4.1 provides a view of the meta-network that includes not only the EM staff, but resource networks and knowledge networks.

![Figure 4.1. Visualization of MU’s Meta-Network.](image)
As shown in Figure 4.2, removing the resource and knowledge nodes and focusing on just the EM staff agent x agent network shows the general network structure of that department.

Figure 4.2. MU’s Enrollment Management Agent x Agent Network.

In MU’s EM Department, every agent interacts with at least one other agent (i.e. there are no isolates). As one looks toward the center of the visualization, you see that agents such as Enrollment MGMT Staff_8 appear very well connected. In fact, the closeness centrality of Enrollment MGMT Staff_8 is 0.488, while the closeness centrality of Enrollment MGMT Staff_9, for example, is 0.048. Remember that the measure \textit{closeness} “reveals how long it takes information to spread from one individual to others.”
in the network” (Carley et al., 2013, p. 841). A node with high closeness centrality indicates the “node that is closest to all other nodes and has rapid access to all information” (Carley et al., 2013, p. 3), so Enrollment MGMT Staff_8 is extremely well connected to other agents and is a large conduit for information flow throughout the EM network. Enrollment MGMT Staff_9 is not.

To see just how central Enrollment MGMT Staff_8 is to the EM network at MU, we removed this person from the network in order to see the resulting effects. ORA’s Immediate Impact Analysis demonstrates the effects on the EM network, and those changes are displayed in Table 4.1.

Table 4.12

<table>
<thead>
<tr>
<th>Measure</th>
<th>Before</th>
<th>After</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Complexity (Density)</td>
<td>0.170</td>
<td>0.161</td>
<td>-5.33%</td>
</tr>
<tr>
<td>Diffusion</td>
<td>0.805</td>
<td>0.532</td>
<td>-33.97%</td>
</tr>
<tr>
<td>Resource Capability</td>
<td>0.222</td>
<td>0.288</td>
<td>+29.73%</td>
</tr>
<tr>
<td>Closeness Centrality</td>
<td>0.467</td>
<td>0.714</td>
<td>+52.89%</td>
</tr>
<tr>
<td>Clustering Coefficient</td>
<td>0.348</td>
<td>0.282</td>
<td>-18.97%</td>
</tr>
<tr>
<td>Average Communication Speed</td>
<td>0.433</td>
<td>0.530</td>
<td>+22.40%</td>
</tr>
</tbody>
</table>

According to ORA’s simulation, the average communication speed actually increased after removing this agent. Even more remarkable is the large increase in the closeness centrality of the network. Removing this node forced the network to become more connected, thus increasing the adaptive leadership of the EM network.
Newman Grouping

Another characteristic of networks that describes the topology is *Newman Grouping* which identifies clusters of communities in the network. To discover where clusters may exist in the EM network, a method of coloring nodes by Newman Grouping was utilized. In this context, a community “consists of a subset of nodes within which the node to node connections are dense, and the edges [links or ties] to nodes in other communities are less dense” (Carley, 2015a).

*Figure 4.3.* Community Structure as Calculated by Newman’s Grouping Algorithm.
One can see that three clusters exist: one indicated by the color red, another indicated by the color blue, and the third indicated by the color green. Within these groups/clusters, information flows rather easily.

Varying node sizes by certain attributes allows one to see community structure in a different way. Figure 4.4 displays the same data as Figure 4.3, but the size of the nodes indicates whether that agent is a formal leader (director, vice president) or an information leader (all others). The larger nodes are the formal leaders.

Figure 4.4. Newman’s Grouping with Formal/Informal Leaders Indicated by Node Size.
The attribute that may explain the clustering results is *office*. Figure 4.5 colors nodes by the office in which that person works. The formal EM Department is divided into four discreet functions: (a) enrollment (the red nodes), (b) admission (the blue nodes), (c) financial aid (the green nodes), and (d) data support (the yellow nodes).

*Figure 4.5. Clusters by office.*

One can easily see that each function clusters together, and this is not surprising given that cliques are cohesive groups of highly interconnected people, often with similar interests, skills, backgrounds, etc. (Haythornthwaite, 1996). Clique structure in networks promotes information diffusion (Cowan & Jonard, 2004).
Another useful tool for understanding the agent x agent network is coloring the nodes by network measure. Figure 4.6 shows the varying levels of closeness centrality in the EM Department at MU. Light blue indicates the agent with the lowest closeness centrality level and red indicates the agent with the highest closeness centrality level.

Figure 4.6. Agent Nodes Colored by Closeness Centrality.

Determining Sustainable Enrollment Management

The independent measures for this study are adaptive leadership (operationalized by closeness centrality), social capital (operationalized as resource capability), and clique structure (operationalized as clustering coefficient). The dependent measure is
information flow (operationalized as average speed). Table 4.13 presents those measures in the MU enrollment management system’s current state.

Table 4.13

<table>
<thead>
<tr>
<th>Network Measures—Current State</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Independent Measures</strong></td>
</tr>
<tr>
<td>Closeness Centrality</td>
</tr>
<tr>
<td>Resource Capability</td>
</tr>
<tr>
<td>Clustering Coefficient</td>
</tr>
<tr>
<td><strong>Dependent Measure</strong></td>
</tr>
<tr>
<td>Average Speed</td>
</tr>
</tbody>
</table>

Following a design by Marion et al. (2016), 15 variants of the meta-network were simulated using ORA’s optimizer routine. In short, the optimizer added and removed links until the network reached the target levels of closeness centrality, resource capability, and clustering coefficient (the independent measures). For example, I set one optimization run for a high level of closeness centrality, an average level of clustering coefficient, and a minimum level of resource capability. For another variation, I set an average level of closeness centrality, an average level of clustering coefficient, and a maximum level of resource capability.

ORA offers two optimization methods: Monte Carlo and simulated annealing. Marion et al. (2016) stated,

In the Monte Carlo approach, ORA generates multiple version of the desired network (default, 1000 trials) by slightly varying the initial values for each version based on a probability distribution. ORA then reports the average values
of the resultant independent measures across the trials and produces a simulated network for these average values. (p. 249)

Carley et al. (2004) found that simulated annealing typically produced more accurate results than Monte Carlo, so both methods were used in order to determine which fit these data better. The simulated annealing process in ORA produced closeness centrality values at levels greater than one when the closeness centrality measure should fall within a zero to one range. Because of a now-identified defect in the simulated annealing algorithm in ORA (per Carnegie Mellon University), and since the Monte Carlo method resulted in such a strong adjusted $R^2$ measure of .9345 (the independent measures account for 93.45% of the variance in average speed), I decided to use Monte Carlo. The results of the 15 optimization routines are in Table 4.14.
One may look at Table 4.13 and argue that the optimal levels of the independent measures are those that result in the highest speed of 0.518. However, we are looking for stability in information flow, not necessarily the highest speed of information flow. Therefore, we now plot out the data to determine which combinations of independent measures actually produce stable results across variations in the independent variables.

### Response Surface Methodology

According to www.onlinecourses.science.psu.edu, the “objective of Response Surface Methods (RSM) is optimization, finding the best set of factor levels to achieve some goal.” Lenth (2009) stated that RSM is used for “exploring…optimum operating conditions across combinations of experimental methods” (p. 1). For this study, the factor
levels are closeness centrality (closeness), resource capability (capability), and clustering coefficient (clustering), while the goal is the highest average speed of information flow (speed) that is also at a stable state. After importing the optimized data from ORA into Minitab, a Box-Behnken response surface method analysis was completed to look at the regression of the independent measures (closeness centrality, resource capability, and clustering) on speed, the dependent measure.

The results showed a $R^2$ of .9777, with an adjusted $R^2$ of .9375. The adjusted $R^2$ accounts for the potential of overfitting that can happen as one adds more independent measures. According to Kirby (2004), an $R^2$ of 0.90 or above indicates a good fit. The standard error of residuals (S) was .0028, a desired low value. With the exception of Clustering (a linear relationship) and Clustering$^2$ (curvilinear), all independent measures were significant at the $P < .10$ level, as were the interactions.
Table 4.15

Results of Box-Behnken analysis

S = 0.0028; R² = 97.77%; R² (adj) = 93.75%

Estimated Regression Coefficients for Average Speed

<table>
<thead>
<tr>
<th>Term</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.512</td>
<td>0.002</td>
<td>254.18</td>
<td>0.000</td>
</tr>
<tr>
<td>Clustering</td>
<td>0.002</td>
<td>0.006</td>
<td>0.31</td>
<td>0.770</td>
</tr>
<tr>
<td>Closeness</td>
<td>0.017</td>
<td>0.005</td>
<td>3.63</td>
<td>0.015</td>
</tr>
<tr>
<td>Capability</td>
<td>0.020</td>
<td>0.006</td>
<td>3.31</td>
<td>0.021</td>
</tr>
<tr>
<td>Cluster²</td>
<td>-0.008</td>
<td>0.006</td>
<td>-1.33</td>
<td>0.242</td>
</tr>
<tr>
<td>Closeness²</td>
<td>-0.020</td>
<td>0.006</td>
<td>-3.23</td>
<td>0.023</td>
</tr>
<tr>
<td>Capability²</td>
<td>-0.040</td>
<td>0.009</td>
<td>-4.34</td>
<td>0.007</td>
</tr>
<tr>
<td>Cluster*Closeness</td>
<td>-0.041</td>
<td>0.014</td>
<td>-2.97</td>
<td>0.031</td>
</tr>
<tr>
<td>Cluster*Capability</td>
<td>-0.043</td>
<td>0.018</td>
<td>-2.45</td>
<td>0.058</td>
</tr>
<tr>
<td>Closeness*Capability</td>
<td>-0.061</td>
<td>0.009</td>
<td>-6.51</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Response Surface Plots

Response surface analysis creates visualizations of the data in Table 4.14 and identifies combinations of independent variable measures that allow optimal, stable flow of information. The RSM term for the stable zone (notated in Figure 4.12 as light green) is “saddle.” The broad area (plateau) over the saddle “represent regions in which systems have significant latitude to change without compromising [sustainability]” (Marion et al., 2016, p. 255).

For example, Figure 4.7 shows the resulting plot when holding clustering constant at a high level (0.294) with closeness centrality and resource capability at average levels.
Figure 4.7. Box-Behnken surface plot: closeness centrality by resource capability with clustering coefficient held at a high value (0.294).

This “Batman” plot in Figure 4.7 reveals that speed is optimized when either closeness centrality is high and resource capability is low, or closeness centrality is low and resource capability is high. If both measures are either low or high, speed drops off drastically. The contour plot in Figure 4.8 makes this even more pronounced, with the darker green areas indicating the region information flow (speed) is most stable to changes in the environment.
Figure 4.8. Box-Behnken contour plot: resource capability by closeness centrality with clustering coefficient held at a high value (0.294).

In the next example, clustering is held constant at a low level. Figures 4.9 and 4.10 display the resulting plots.
Figure 4.9. Box-Behnken surface plot: closeness centrality by resource capability with clustering coefficient held at a low value (0.217).
Figure 4.10. Box-Behnken contour plot: closeness centrality by resource capability with clustering coefficient held at a low value (0.217).

As shown in Figures 4.10 and 4.11, speed is much more volatile when clustering is low. To achieve maximum speed, both closeness and capability must be high and cannot vary without a substantial drop speed.

**Resource Capability as a Constant**

When resource capability is held at a low level, closeness centrality becomes much more important for stability (Figures 4.11 and 4.12). With low resource capability, speed is highest (> 0.50) when closeness centrality is high at a level of about 0.60, regardless of the clustering coefficient. As shown in Figure 4.13, the stable bands (the
lightest green bands) are not particularly broad. Decreases in closeness centrality beyond this band will cause rapid deterioration of speed.

**Figure 4.1.** Box-Behnken surface plot: closeness centrality by clustering coefficient with resource capability held at a minimum value (0.361).

*Figure 4.11.* Box-Behnken surface plot: closeness centrality by clustering coefficient with resource capability held at a minimum value (0.361).
Figure 4.12. Box-Behnken contour plot: closeness centrality by clustering coefficient with resource capability held at a minimum value (0.361).

Figure 4.13 presents the combination of measures that result in the greatest stability in information flow. Resource capability is held at a constant high level (0.781) while clustering coefficient and closeness centrality are at average levels (0.255 and 0.396, respectively). After running numerous plots, we find that resource capability is the main factor influencing the sustainable movement of information at MU; as already noted in Table 4.14, clustering has no significant impact. This finding differs from that of Marion et al. (2016) where the clustering coefficient supported their hypothesis that “Moderate levels of agent engagement in cliques, operationalized as the network analysis measure, clustering coefficient, enhances the capacity of organizations to perform their
tasks” (p. 248). In the Marion et al. (2016) study, the moderate clustering value was 0.272. One explanation of this difference is that the clustering coefficient of the EM network at MU had little variation (Table 4.6), and clustering was significant only when it interacted with resource capability and closeness centrality. Additionally, the dependent measure for Marion et al. (2016)’s research was task accuracy and not average speed. In this study, speed was the dependent measure, which forced the network to align in ways that maximized that outcome. In other words, speed in Marion et al. (2016)’s study was the influencer, not the responder. Maximum impact occurs when agents have high resource capability most any variance in clustering and closeness.

![Figure 4.13](image)

**Figure 4.13.** Box-Behnken surface plot: clustering coefficient by closeness centrality with resource capability held at a high value (0.781).
Figure 4.14 displays a Box-Behnken contour map, which supports the findings in the surface plot above (Figure 4.11), but it also shows areas that one cannot see in the 3-D plot (Figure 4.12). The darker green shades indicate the areas of greatest sustainability, while the blue-shaded area (high clustering and high closeness centrality) marks a sharp drop off in speed. The blue areas represent network conditions that are not able to sustain adequate information flow needed to adjust to changes.

![Box-Behnken contour map: clustering coefficient by closeness centrality with resource capability held at a high value (0.781)](image)

*Figure 4.14. Box-Behnken contour map: clustering coefficient by closeness centrality with resource capability held at a high value (0.781).*
Summary

This chapter presented the descriptive statistics of the MU meta-network and then proceeded with network-level and node-level measures, offering some context of their meanings. Finally, the results of the RSM which plots a 3-D graph of the effects of various levels of independent network measures on a dependent measure were shown. For this study, the independent measures were adaptive leadership (operationalized as closeness centrality), social capital (operationalized as resource capability), and clique structure (operationalized as clustering coefficient). The dependent measure, information flow, was operationalized as average speed.

The density of meta-network and the social (agent x agent) network were 0.17 and 0.249, respectively, resulting in an average speed of 0.433. It was found that removing the most connected node, Enrollment MGMT Agent_8, resulted in an increase in average speed of information flow from 0.433 to 0.530. Such an increase indicates that many people interact more with Enrollment MGMT Agent_8 than others which impedes information flow throughout the rest of the network. The response surface plots indicated that holding resource capability at a high level (0.781 in this case) provided the widest area of the plot’s spine as indicated in Figures 4.12 and 4.13.
CHAPTER FIVE

SUMMARY, DISCUSSION, AND CONCLUSIONS

The primary purposes of this study were to investigate Enrollment Management (EM) in higher education through the framework of a complex adaptive system (CAS), to provide colleges and universities with a foundational understanding of what a sustainable EM system looks like from Dynamic Network Analysis (DNA) perspective, and to suggest to EM practitioners one method to model (a) their institution’s EM system in its current status and (b) what network structures optimize information flow, thus cultivating a sustainable EM system for their institutions. Additionally, this study aimed to describe how formal network structures either promote or inhibit a EM system within the bounds of the university under study. For example, to what extent are those involved in EM interdependent with, or dependent upon, each other? Are there bottlenecks to the flow of information? Does information flow freely throughout the EM system? This study considered an EM system to be sustainable if the speed at which information flows throughout the system remains stable regardless of changes to, and pressures from, the internal and external environments.

To this end, this study is guided by two overarching questions:

1. To what extent is the research site organized to enable effective and efficient information flow?

2. Which combinations of independent network measures (adaptive leadership, social capital, and clique structure) produce optimal outcome measures (information flow) for a sustainable EM system?
Before discussing the findings of this research, a reminder of the premises undergirding this study is helpful.

First, EM is not an insular division or department, but a living, CAS whose core strategic function (Wilkinson et al., 2007) is to coordinate people, knowledge, tasks, and resources for identifying, recruiting, enrolling, retaining, and graduating students (Henderson, 2001) at levels that support the mission (Wilkinson et al., 2007) of the institution. Its end is to create and maintain dynamic, sustainable enrollment conditions that allow the institution to survive and persist, regardless of forces that push it toward extinction. An effective EM system is anticipatory (Wilkinson et al., 2007) of internal and external pressures, requires input from and cooperation of the entire campus (Wilkinson et al., 2007), and takes into account the physical and instructional capacity of the institution, its current and potential market positions, the financial requirements of the institution, the standards of accreditation, and the limits of regulation.

Second, a CAS relies on interactions of agents to sustain its capacity to adapt robustly with its environment. In network analysis, agents are individual groups, people, or organizations. The system must be nimble to both internal and external changes and pressures. As such, this study moved beyond the formal organizational structure of an EM Department and focused on the informal interactions and network structures that influence information diffusion, which Kalsbeek (2001) contended is the “most important material driving strategic enrollment management” (p. 189). Since human agents possess information in a social network, our understanding of an agent’s network position and that agent’s connectivity to other agents is vital. The higher an agent’s (node’s)
connectivity, the more likely that agent (node) will receive information. Additionally, we can see what happens if any particular node, particularly a critical node, is removed.

This study examined the network structure of an EM system at a small, private university in the Midwest (named, for the purposes of this research, *Midwestern University*, abbreviated as *MU*). This chapter synthesizes the findings in relation to the research questions and offers implications of the research on both the EM system at Midwestern University (MU) and EM across higher education. Finally, suggestions for further research are offered.

**Research Question 1:**

*To What Extent is the Research Site Organized to Enable Effective and Efficient Information Flow?*

Complex systems survive and thrive on information flow. The total network density, a measure of the potential for such flow, at the EM research site was 0.170; the system displayed an average communication speed of 0.433. Several studies of K-12 schools consistently find densities of 0.04 to 0.10 (Marion et al., 2016), while data from public health organizations in Canada show densities of 0.35 (Carley, 2011). I found no comparison data for network-level speed. These measures suggest adequate communication flow in the system.

Interactions among agents are a key component of complexity theory (Abusidualghoul, 2014; Forsman et al., 2012; Hasan, 2014; Kezar et al., 2006; Marion & Uhl-Bien, 2001; McClellan, 2010; McMurtry, 2008; Salem, 2002). At MU, one of the most central actors is Enrollment MGMT Staff_8. When this agent was removed from the
EM network, the immediate impact was an increase in the network closeness centrality from 0.467 to 0.714, and average speed of information flow increased from 0.433 to 0.530. Such findings are important in understanding information flow. Haythornthwaite (1996) argued, “By gaining awareness of existing information exchange routes, information providers can act on information opportunities and make changes to information routes to improve the delivery of information services (p. 323). Network patterns show who interacts with whom in order to receive or forward information as well as what access the individual has to information, to new ideas, and to opportunities (Haythornthwaite, 1996). Enrollment MGMT Staff_8 may have such effect on the average speed of information flow because he or she traps information as suggested by Weng et al. (2013). There is insufficient interaction among other agents within EM due to the presence of Enrollment MGMT Staff_8.

In order to determine if other agents had similar effects on average speed, other highly central agents were removed, and the resulting impact was calculated. For example, removing Enrollment MGMT Staff_1 resulted in an average speed of 0.430, and removing Enrollment MGMT Staff_21 resulted in an average speed of 0.429, both of which are no different than the original average speed. Clearly, Enrollment MGMT Staff_8 is the dominant agent affecting information flow throughout the EM network.

In summary, MU’s EM Department has a structure that suggests an adequate level of information flow. However, the network is far from optimized to sustain its capacity to adapt robustly with its environment.
Research Question 2:

Which Combinations of Independent Network Measures (adaptive leadership, social capital, and clique structure) Produce Optimal Outcome Measures for a Sustainable Enrollment Management System?

In this study, sustainability is presented as a state of information flow (speed) that is robust or stable against changes in its environment, specifically in adaptive leadership (closeness centrality), social capital (resource capability), and/or clique structure, (clustering coefficient). Based on the response surface plots, the greatest stability occurs when resource capability is at its maximum value regardless of closeness and clustering. In other words, resource capability seems to be the main factor influencing information flow. This is a significant finding for MU. Regardless of how much clique activity exists within the formal EM Department, access to resources outside of EM is vital for a stable information flow. This supports the argument provided by McPherson et al. (2001) that too much homophily (interaction among agents with similar characteristics or experiences) can degrade the speed at which information moves between networks.

The finding that clustering has no independent impact on information flow differs from that of Marion et al. (2016) where the clustering coefficient supported their hypothesis that “Moderate levels of agent engagement in cliques, operationalized as the network analysis measure, clustering coefficient, enhances the capacity of organizations to perform their tasks” (p. 248). In the Marion et al. (2016) study, the moderate clustering value was 0.272. Clustering did interact significantly with closeness (p < 0.05) but, as Figure 4.11 shows, that interaction showed no saddle and plateau effects attributable to
clustering. One explanation of this difference is that the clustering coefficient of the EM
network at MU had little variation (Table 4.14), and clustering was significant only when
it interacted with resource capability and closeness centrality. Additionally, the dependent
measure for Marion et al.’s (2016) research was task accuracy and not average speed. In
this study, average speed was the dependent measure, which forced the network to align
in ways that maximized that outcome. In other words, speed in the Marion et al. (2016)
study was the influencer, not the responder.

Discussion

Kalsbeek (2001) contended that information is the “most important material
driving strategic enrollment management” (p. 189). At MU, an average speed of 0.433
suggests an adequate level of information flow throughout the EM system. However, one
purpose of this study was to determine if MU is organized in such a way to enable
effective and nimble information flow. ORA’s Immediate Impact Report referenced in
Chapter IV (Table 4.11) provided evidence that the removal of Enrollment MGMT
Staff_8 would increase average speed of information flow by 22.4%. Such an increase
suggests that Enrollment MGMT Staff_8 is capturing or centralizing knowledge in the
network; this may hinder the nimbleness of information flow and access to resources
(social capital) by other agents. Complexity leadership theory provides a perspective that
might remedy this.

I argued that studying EM as a CAS is revealing. As such, a new perspective of
leadership is necessary—Complexity Leadership. DeRue (2011), Lichtenstein et al.
(2007), and Marion and Uhl-Bien (2007a) contended that leadership is more of a process
than a characteristic or skill of any one individual, and leadership is grounded in the activities of individuals and groups regardless of formal position in the organization. Whereas traditional leadership roles are seen as formal, top-down organizational structures, leadership that is informal and interactive allows organizations to change and adapt as various environmental pressures arise, both internal and external to the group (DeRue, 2011). In this study, information leadership and adaptive leadership are the same. Top-down hierarchical leadership inhibits adaptability because it inhibits information flow among agents, and those not in formal leadership roles have no authority to use their knowledge and creativity to react to pressures with appropriate changes (DeRue, 2011). This stifles organizational change and learning, and the centrality of Enrollment MGMT Staff_8 may contribute to a static EM system.

A second purpose of this study was to determine Which combinations of adaptive leadership, social capital, and clique structure produce optimal outcome measures for a sustainable EM system. Based on the results of the response surface plot (Figure 5.1), social capital (resource capability) is the key component of a sustainable EM system for MU. When access to resources is strong, adaptive leadership (closeness centrality) and clique structure (clustering coefficient) can vary quite a bit without dramatic and risky reduction in the speed of information. This finding is supported by the contour plot (Figure 5.2) as well. In contrast, the effects of low access to resources are displayed in Figures 5.3 and 5.4.
Figure 5.1. Box-Behnken surface plot: clustering coefficient by closeness centrality with resource capability held at a high value (0.781).
Figure 5.2. Box-Behnken contour map: clustering coefficient by closeness centrality with resource capability held at a high value (0.781).
Figure 5.3. Box-Behnken surface plot: clustering coefficient by closeness centrality with resource capability held at a minimum value (0.361).
Figure 5.4. Box-Behnken surface plot: clustering coefficient by closeness centrality with resource capability held at a minimum value (0.361).

Implications for Practice

High social capital (resource capability) is the key to MU creating and maintaining a sustainable EM system. At MU, social capital is provided by access to agents in departments outside of the formal EM Department, such as Student Affairs, Finance, Registrar, and Bursar (see Appendix C). Currently, resource capability measures an average 0.222, much lower than the optimal suggested by the RSM calculations.

The researcher suggests that positional leaders deliberately encourage others to interact with personnel in other departments and that they even facilitate those
interactions. This does not mean that formal leaders’ access to resources are not important. However, as Marion et al. (2016) argued, formal leaders, use their access to resources and to organizational authority to enable interaction among diverse agents and groups. They organize workflow, interdependencies, and formal relationships (e.g., committee work) to generate interactions and information flow across agents and groups…They are able to identify individuals with little access to the system’s information flow, and find ways to integrate them. (p. 257)

This shifting of leadership characteristics to an Enabling Leadership perspective would assist the formal (positional) leaders (Enrollment MGMT Staff 6, 8, 14, 17, and 20) to foster the interaction of agents (i.e. people) outside of EM to increase coordination and interdependence between all agents with knowledge relevant and appropriate (Yammarino et al., 2012) to the EM functions of MU. As stated by Yammarino et al. (2012), “Enabling leadership is proposed to serve as a moderator between administrative and adaptive leadership by modifying some of the authoritative ‘top-down’ control to allow for the more organic flow of information and interaction that gives rise to adaptive leadership” (p. 392). These interactions need not be social in nature, but they should be purposeful to engaging the rest of campus in the EM efforts as Huddleston (2000), Henderson (2001), Hossler (1990), and Hossler and Hoezee (2001) argued.

Hiring practices are another way to address less-than-optimal information flow in the EM system. For example, recruiting staff who are not only competent in the skills and backgrounds necessary for the job, but also display the ability and mentality to engage in
the broader EM system at MU, would be strategic. As stated by Marion et al. (2016), “Networks of informal leaders who can readily access and move information in a network are crucial to the level of productivity that complex systems can achieve” (p. 257). Jack Maguire (as cited by Henderson, 2001), argued that EM emerged in order to create a synergy between offices that often acted independently and, many times, at cross-purposes. Henderson (2001) furthered this by suggesting that EM should function as a set of interdependent activities such as “…marketing, recruiting, admissions, financial aid, orientation, and retention” (p. 11). By hiring the right staff that can work with others outside of their immediate positions, and by encouraging interacting networks both inside and outside of the formal EM Department, positional leaders can become enabling leaders that support sustainable enrollment management at MU.

**Implications for Further Research**

One limitation of this study is the inclusion of an EM division of a single university. However, the data analysis utilized simulations that, in effect, created 15 different networks of EM within the research site (R. Marion, personal communication, January 7, 2016). This reduces the concern of a DNA at single research site. However, subsequent research should utilize the EM system at a larger university in order to support, elaborate, or add to the findings of this study.

Further, I would suggest using semi-structured interviews for the qualitative data collection. Interviews would allow for gleaning more precise categories, as the interviewer can follow-up with the participants as the interviews progress in order to
clarify answers that may be too ambiguous. It would also provide valuable insights into the organization that may aid data interpretation.

Finally, a subsequent analysis of the same EM system would allow the testing of changes to the network suggested by the first study. Replications of DNAs after interventions are non-existent. Without doing follow-up research, this type of study stays at a theoretical level and is useless to the practitioner.
APPENDICES
Appendix A

Informed Consent

Information about Being in a Research Study
Clemson University

Sustainable Enrollment Management: A Dynamic Network Analysis

Description of the Study and Your Part in It

Russ Marion, PhD and Forrest Stuart, both from Clemson University, invite you to take part in a research study. Russ Marion, the principal investigator, is a professor at Clemson University, and Forrest Stuart is a PhD candidate. The purpose of this research is to investigate higher education enrollment management as a complex adaptive system and provide colleges and universities a foundational understanding of what a sustainable enrollment management system looks like from network and complex adaptive system perspectives.

Your part in the study will be to complete two online surveys about with whom you interact and the knowledge, resources, and tasks required in performing your role at Midwestern University. The survey questions will help the researchers understand the interactions that occur within and outside of the enrollment management division and how information flows throughout those areas. Information flow is essential for an enrollment management system to adapt to the internal and external pressures experienced by the institution.

The first survey will take you about 15 minutes to complete and the second survey will take about 20 minutes to complete.

Risks and Discomforts

We do not know of any risks or discomforts to you in this research study, other than your providing your name and title. As noted below under Protections, we have implemented measures to avoid this risk. Your answers are no longer available on your computer once the survey has been completed and sent. If you do not complete the survey, the program will time-out and responses will no longer be on your computer. While we necessarily request your names, they will be deleted as soon as the data are prepared for analysis. These measures are intended to protect the confidentiality of your responses.
Possible Benefits

Information flow is essential for an enrollment management system to adapt to the internal and external pressures experienced by the institution. This study will help these researchers understand the interactions that occur within and outside of the enrollment management division and how information flows throughout those areas. In the end, the researchers will suggest alternative structures that will enable efficient information diffusion throughout the enrollment management division.

Protection of Privacy and Confidentiality

We will do everything we can to protect your privacy and confidentiality. While we must request your name and title when the data are collected in order to prepare the data for analysis, no one other than the research team will have access to your name and title. All response data will be anonymized after exporting the responses from Qualtrics into Microsoft Excel; no participants will leave data on their computers due to Qualtrics being an online survey instrument; any personally identifiable information will be anonymized so that readers cannot identify the participants nor the institution at which the participants work; no personally identifiable information will be revealed during the study, in the write up, during the dissertation defense, or in subsequent presentations. The data exported from the online surveys will be stored on a password-protected computer until the dissertation is finished. After that, the data will be stored on an encrypted external hard drive used for such purposes. The data will remain on the hard drive for 5 years, per APA requirement.

We might be required to share the information we collect from you with the Clemson University Office of Research Compliance and the federal Office for Human Research Protections. If this happens, the information would only be used to find out if we ran this study properly and protected your rights in the study.

Choosing to Be in the Study

You do not have to be in this study. You may choose not to take part and you may choose to stop taking part at any time. You will not be punished in any way if you decide not to be in the study or to stop taking part in the study. If you choose to stop taking part in this study, the information you have already provided will be used in a confidential manner.

Incentive

Participants who complete both this survey and the second survey will receive a ten dollar ($10.00) gift card.
Contact Information

If you have any questions or concerns about this study or if any problems arise, please contact Russ Marion at Clemson University at marion2@clemson.edu.

If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-0636 or irb@clemson.edu. If you are outside of the Upstate South Carolina area, please use the ORC’s toll-free number, 866-297-3071.

Clicking on the "agree" button indicates that:

• You have read the above information
• You voluntarily agree to participate
• You are at least 18 years of age

You may print a copy of this informational letter for your files.
Appendix B

Survey 1

This short survey will provide insight into the specific knowledge and resources you need to perform your role at Midwestern University. Please answer each question as honestly and as detailed as you can. Your answers are confidential and only will be used to design a subsequent network analysis survey.

1. From the list below, please select your name. NOTE: As stated above, your name and title are only for data analysis, and they will be anonymized after exporting the data from this survey into Excel. No one but the researchers will see your name. Additionally, this will ensure we have the correct names for the gift cards that we will send to participants who complete both surveys.

   🌐 Names removed

2. What specialized knowledge is needed to perform your work in enrollment management? Your answer can list more than one knowledge set.

3. What specific skills are necessary to perform your work in enrollment management (e.g. public speaking, research, spreadsheets, time management, etc.)? List as many as appropriate.

4. Inside your enrollment management department, what major resources (specific people, tools, and/or materials) are readily available to help you perform your work? List as many as appropriate. If you list people, please include their departments (e.g. student life, housing, billing, etc.)

5. Outside your enrollment management department, what major resources (specific people, tools, and/or materials) are readily available to help you
perform your work? If you list people, please include their departments (e.g. student life, housing, billing, etc.)

6. If you were to write up a job description for your job, what specific tasks would you include? NOTE: Please do not copy your current job description, as it may or may not reflect your actual responsibilities.

7. Enrollment management scholar, Dr. David Kalsbeek, stated, "Information is the most important material driving strategic enrollment management." What does Dr. Kalsbeek's statement mean to you, and in your role in enrollment management at OWU, what specific experiences have you had that relate to Dr. Kalsbeek's claim?

Thank you for participating in this survey. Please look for a follow-up survey within two weeks.
Appendix C

Survey 2

Please take the time necessary to answer all survey questions thoughtfully and honestly. Each one is important to the validity of our research.

1. What is your gender?
   ○ Male
   ○ Female

2. Did you graduate with a degree from Midwestern University?
   ○ Yes
   ○ No

3. How many years have you worked in enrollment management at Midwestern University?
   ○ Less than 1 year (1)
   ○ 1 - 3 Years (2)
   ○ 4 - 6 Years (3)
   ○ 7 - 10 Years (4)
   ○ 10+ Years (5)
The following questions focus on interactions within the Enrollment Management Division at Midwestern University University. Please note: We are not analyzing individual behaviors, but rather we are looking at the network as a whole. Knowing the collective of all relationships is imperative to understanding what is important for effective and sustainable enrollment management in general. By understanding this, we hope to show how enrollment management efforts can be optimized.
4. Who do you regularly seek or reach out to for information or knowledge relating to your job? Please select all individuals that apply.

- Names removed

5. Who regularly seeks or reaches out to you for information or knowledge relating to his/her job? Please select all that apply.

- Names removed

6. Who do you regularly share problems or issues with that you encounter in your job? Please select all individuals that apply.

- Names removed

7. Who comes to you regularly to share problems that he/she encounters in his/her job? Please select all individuals that apply.

- Names removed

8. Who do you regularly seek out for confidential work advice? Please select all individuals that apply.

- Names removed

9. Who regularly reaches out to you for confidential work advice? Please select all individuals that apply.

- Names removed

10. With whom do you regularly socialize? Please select all individuals that apply.

- Names removed

11. Who do you regularly seek out for creative ideas or solutions to problems or issues that you encounter in your job? Please select all that apply.

- Names removed
12. Who regularly seeks you out for creative ideas or solutions to problems or issues that he/she encounters in his/her job?

☐ Names removed
The following questions ask you about the specific knowledge and skills you most need to perform your role at Midwestern University.
13. What do you most need to know or understand to perform your job effectively? Please select all items below that apply.

- Academic majors
- Accounting procedures
- Analyze and understand data
- How to complete surveys
- Use of internet for research purposes
- An understanding of demographic data
- Trends in higher education
- How to do a SWOT analysis
- Residence Life procedures
- Athletics
- Ability to explain to the "value equation" and return on investment to parents and students
- Higher education market trends
- Design and copy editing
- e-marketing for "Generation Z"
- How students and their parents choose a college
- Knowledge of different parts of the country
- Socioeconomic and cultural factors that might affect what a person is looking for in a college
- Interpersonal communication
- Telephone etiquette
- Electronic communication
- Competitor colleges and universities
- University facilities
- Experiential learning opportunities
- How the university can be differentiated from other institutions
- Recruitment territory high schools
- Recruitment territory enrollment history
- University admission statistics
- Geomarkets
- Microsoft Office Suite
- Google Mail features
- Adobe products
- Working knowledge of the Slate software
- Customer service skills
- PowerFaids
- Which students are admitted
- Awards given by Admission Office
- Planning an effective visit for a prospective student
- Event planning
- Federal financial aid regulations
- State financial aid regulations
- Specific financial aid programs (e.g. student loans, Pell Grant, state scholarships/grants)
- Financial aid policies and procedures
- Financial aid strategy
- Packaging student financial aid awards
- Awarding of endowed scholarships
- Awarding of external scholarships
- Admission policies and procedures
- International education for each country around the world
- Intercultural sensitivity in conducting the admission process
- Marketing trends
- Social media interactions
- SAT and ACT testing processes and scoring
- Financial Aid Appeals
14. What skills do you most need to perform your job effectively? Please select all items below that apply.

- Working with spreadsheets
- Problem solving
- Time management
- Creativity
- Listening skills
- Customer service
- Learn new processes
- Multi-tasking
- Organization
- Public speaking
- Data management
- Research skills
- Social media
- Strategic planning
- Student worker supervision
- Calendar management
The following questions focus on interactions between Enrollment Management and the Provost/Academic Affairs Office. As you answer, please think about your interactions with the choices presented, not Enrollment Management’s interactions.
15. Who do you regularly seek or reach out to for information or knowledge relating to your job? Please select all individuals that apply.

☐ Names removed

16. Who regularly seeks or reaches out to you for information or knowledge relating to his/her job? Please select all individuals that apply.

☐ Names removed
The following questions focus on interactions between Enrollment Management and the Information Services Office. As you answer, please think about your interactions with the choices presented, not Enrollment Management's interactions.
17. Who do you regularly seek or reach out to for information or knowledge relating to your job? Please select all individuals that apply.

☐ Names removed

18. Who regularly seeks or reaches out to you for information or knowledge relating to his/her job? Please select all individuals that apply.

☐ Names removed
The following questions focus on interactions between Enrollment Management and the President's Office. As you answer, please think about your interactions with the choices presented, not Enrollment Management's interactions.
19. Who do you regularly seek or reach out to for information or knowledge relating to your job? Please select all individuals that apply.

☐ Names removed

20. Who regularly seeks or reaches out to you for information or knowledge relating to his/her job? Please select all individuals that apply.

☐ Names removed
The following questions focus on interactions between Enrollment Management and the Advancement/Alumni Office. As you answer, please think about your interactions with the choices presented, not Enrollment Management's interactions.
21. Who do you regularly seek or reach out to for information or knowledge relating to your job? Please select all individuals that apply.

☐ Names removed

22. Who regularly seeks or reaches out to you for information or knowledge relating to his/her job? Please select all individuals that apply.

☐ Names removed
The following questions focus on interactions between Enrollment Management and the Registrar's Office. As you answer, please think about your interactions with the choices presented, not Enrollment Management's interactions.
23. Who do you regularly seek or reach out to for information or knowledge relating to your job? Please select all individuals that apply.

☐ Names removed

24. Who regularly seeks or reaches out to you for information or knowledge relating to his/her job? Please select all individuals that apply.

☐ Names removed
The following questions focus on interactions between Enrollment Management and the University Communication's Office. As you answer, please think about your interactions with the choices presented, not Enrollment Management's interactions.
25. Who do you regularly seek or reach out to for information or knowledge relating to your job? Please select all individuals that apply.

☐ Names removed

26. Who regularly seeks or reaches out to you for information or knowledge relating to his/her job? Please select all individuals that apply.

☐ Names removed
The following questions focus on interactions between Enrollment Management and Athletics. As you answer, please think about your interactions with the choices presented, not Enrollment Management's interactions.
27. Which coaches of the following sports do you regularly seek or reach out to for information or knowledge relating to your job? Please select all sports that apply.

- Baseball
- Men's Basketball
- Women's Basketball
- Men's Cross Country
- Women's Cross Country
- Football
- Men's Golf
- Men's Lacrosse
- Women's Golf
- Women's Lacrosse
- Men's Soccer
- Women's Soccer
- Men's Swimming & Diving
- Women's Swimming & Diving
- Men's Tennis
- Women's Tennis
- Men's Track & Field
- Women's Track & Field
- Women's Field Hockey
- Women's Volleyball
- Softball
28. Which coaches of the following sports regularly seek or reach out to you for information or knowledge relating to their jobs? Please select all individuals that apply.

- Baseball
- Men's Basketball
- Women's Basketball
- Men's Cross Country
- Women's Cross Country
- Football
- Men's Golf
- Men's Lacrosse
- Women's Golf
- Women's Lacrosse
- Men's Soccer
- Women's Soccer
- Men's Swimming & Diving
- Women's Swimming & Diving
- Men's Tennis
- Women's Tennis
- Men's Track & Field
- Women's Track & Field
- Women's Field Hockey
- Women's Volleyball
- Softball
The following questions focus on interactions between Enrollment Management and the Student Affairs Office. As you answer, please think about your interactions with the choices presented, not Enrollment Management's interactions.
29. Who do you regularly seek or reach out to for information or knowledge relating to your job? Please select all individuals that apply.

☐ Names removed

30. Who regularly seeks or reaches out to you for information or knowledge relating to his/her job? Please select all individuals that apply.

☐ Names removed
The following questions focus on interactions between Enrollment Management and the Finance and Administration Office. As you answer, please think about your interactions with the choices presented, not Enrollment Management's interactions.
31. Who do you regularly seek or reach out to for information or knowledge relating to your job? Please select all individuals that apply.

☐ Names removed

32. Who regularly seeks or reaches out to you for information or knowledge relating to his/her job? Please select all individuals that apply.

☐ Names removed
Appendix D

IRB Notice of Approval

Dear Dr. Marion,

The Clemson University Institutional Review Board (IRB) reviewed the protocol identified above using expedited review procedures and has recommended approval. The approval is for all sites with a research site letter on file. **Your approval period is February 29, 2016 to February 28, 2017.**

Your continuing review is scheduled for January 2017. Please contact the office if your study has terminated or been completed before the identified review date.

No change in this approved research protocol can be initiated without the IRB’s approval. This includes any proposed revisions or amendments to the protocol or consent form. Any unanticipated problems involving risk to subjects, any complications, and/or any adverse events must be reported to the Office of Research Compliance immediately. All team members are required to review the IRB policies on "Responsibilities of Principal Investigators" and the "Responsibilities of Research Team Members" available at [http://www.clemson.edu/research/compliance/irb/regulations.html](http://www.clemson.edu/research/compliance/irb/regulations.html).

The Clemson University IRB is committed to facilitating ethical research and protecting the rights of human subjects. Please contact us if you have any questions and use the IRB number and title in all communications regarding this study.

Sincerely,

Elizabeth

*B. Elizabeth Chapman '03, MA, CACII*
*IRB Coordinator*
*Clemson University*
*Office of Research Compliance*
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