

A Diagnosis of Supply Chain Integration in Healthcare

by

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## ABSTRACT

Despite significant growth in research about supply chain integration, many questions remain unanswered regarding the path to integration and the benefits that can be accrued. This dissertation examines three aspects of supply chain integration in the health sector, leveraging the healthcare context to extend the theoretical boundaries, as well as applying supply chain knowledge to an industry known to be immature in terms of its supply chain practices.

In the first chapter, a supply chain operating model that breaks away from the traditional healthcare supply chain structures is examined. Consolidated Service Centers (CSCs) embody a shared services strategy, consolidating supply chain functions across multiple hospitals (i.e. horizontal integration) and disintermediating several key roles in healthcare supply chains such as the group purchasing organizations and national distributors. Through case studies, key characteristics of CSCs that enable them to reduce the level of supply chain complexity are examined.

The second chapter investigates buyer-supplier relationships in healthcare (i.e. supplier integration), where a high level of distrust exists between hospitals and their suppliers. This context is leveraged to study both enablers and barriers to buyer-supplier trust. The results suggest that contracting counteracts the negative effects of dependence on trust. Furthermore, the study reveals that hospital buyers may, in some situations, perceive dedicated resource investments made by suppliers as trust barriers, associating such investments with supplier upselling and entrenchment tactics. This runs contrary to how dedicated investments are perceived in most other industries.

In the third chapter, the triadic relationship between the hospital, supplier, and physician is taken into consideration. Given their professional autonomy and power, physicians commonly undermine hospital efforts in supply base rationalization

and standardization. This study examines whether physician-hospital integration (i.e. customer integration) can drive physicians towards supply selection practices that align with the hospital's sourcing strategies and ultimately result in better supply chain performance. This study utilizes theory on agency triads and professionalism and tests hypotheses through a random effects regression model applied to data about hospital financial performance and physician-hospital arrangements.

## DEDICATION

*I dedicate this work to my parents, Dr. Jasem Abdulsalam and Dr. Muna Altaqi, for providing me with a lifetime worth of inspiration.*

*I also dedicate this work to the Health Sector Supply Chain Research Consortium (HSRC) and its members for providing me with the purpose and motivation.*

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## TABLE OF CONTENTS

	Page
LIST OF TABLES.....	vii
LIST OF FIGURES.....	viii
PREFACE.....	ix
CHAPTER	
1 THE EMERGENCE OF CONSOLIDATED SERVICE CENTERS IN HEALTHCARE .....	1
Abstract.....	1
Introduction .....	2
Literature Review.....	5
Complexity Science .....	5
Healthcare Supply Chains as Complex Systems .....	7
Methodology .....	10
Sample .....	10
Data Collection.....	11
Coding and Data Analysis.....	12
Within-Case Analysis.....	14
Case 1: Alpha .....	14
Case 2: Beta.....	16
Case 3: Gamma .....	17
Cross-case Analysis .....	21
Selectivity of New Customers.....	21
Enforcing High Contract Compliance .....	22
Realignment of the Reporting Structure .....	23
Managing Supply Chain Complexity.....	24
Discussion.....	26
Concluding Remarks .....	29

CHAPTER	Page
2	MANAGING BUYER-SUPPLIER TRUST IN A MOST DISTRUSTING INDUSTRY ..... 31
	Abstract..... 31
	Introduction ..... 32
	Literature Review..... 34
	Trust..... 34
	Distrust and Barriers to Trust..... 42
	The Perspectives of Buyers and Suppliers ..... 44
	Methodology ..... 45
	Analysis ..... 48
	Measurement Model..... 48
	Structural Equation Model ..... 52
	Hypotheses Support ..... 53
	Mediation Analysis ..... 54
	Measruement and Structural Invariance..... 54
	Discussion..... 57
	Comparing Buyer and Supplier Perceptions ..... 57
	Dependence-Contracts-Trust Mediation..... 58
	Information Sharing and Dedicated Resources..... 23
	Post-hoc Analysis ..... 24
	Limitations and Future Research ..... 24
	Concluding Remarks ..... 29
3	THE ROLE OF PROFESSIONAL BUYERS IN A SUPPLY CHAIN TRIAD ..... 65
	Abstract..... 65
	Introduction ..... 66
	Literature Review..... 69



CHAPTER	Page
Professionals as Surrogate Buyers.....	69
Agency Triads .....	72
The Physician Hospital Supplier Triad.....	74
Hypothesis Development .....	76
Bureaucratic Pressures.....	77
Professional Hierarchy Pressures .....	78
Methodology .....	81
Sample .....	81
Variables .....	82
Analysis.....	88
Results .....	90
Accounting for Endogeneity .....	92
Omitting Single-Hospital Health Systems .....	94
Discussion.....	94
Theoretical Implications .....	94
Practical Implications .....	97
Limitations and Future Research .....	98
Conclusion .....	100
REFERENCES .....	102
APPENDIX	
A REPRESENTATIVE PROOF QUOTES ABOUT CSCS .....	119
B TRUST MODEL CONSTRUCTS AND SURVEY ITEMS .....	122
C VARIABLE DEFINITIONS AND SOURCES .....	124
D TYPES OF PHYSICIAN-HOSPITAL ARRANGEMENTS .....	126
E AHA HEALTH SYSTEMS TAXONOMY .....	128

## LIST OF TABLES

Table	Page
1. General Information About The Three Essays .....	xii
2. Case Observations .....	13
3. CSC's Impact on a Hospital's Supply Chain Complexity .....	21
4. Constructs Used in the Study [Chapter 2] .....	35
5. Descriptive Statistics About the Buyer and Supplier Data Samples .....	47
6.1 Reliability and Inter-Construct Correlations for the Buyer Sample .....	50
6.2 Reliability and Inter-Construct Correlations for the Supplier Sample .....	50
7. Mediation Analysis .....	54
8. Invariance Models Fit Statistics.....	55
9. Observation Filtering Criteria.....	82
10. Supply Expense Related Metrics.....	84
11.1 Hospital-Level Descriptive Statistics .....	88
11.2 Health System-Level Descriptive Statistics .....	88
12. Random Effects Model Estimation .....	91
13. Supplementary Analysis.....	93

## LIST OF FIGURES

Figure	Page
1. Supply Chain Integration Dimensions in Healthcare.....	x
2. Components and Interrelatedness in a Hospital's Supply Chain.....	8
3. Hospital's Supply Chain Network After the CSC Intervention .....	20
4. Conceptual Model .....	45
5. Buyer (Healthcare Providers) Model Results.....	51
6. Supplier (Distributors, Medical Device Manufacturers) Model Results .....	52
7. The Buyer-Professional-Supplier Triad in Healthcare Purchasing .....	76
8. Distributions of Supply Metrics .....	85

## PREFACE

“Integration” is a term that is used in many different contexts, and it may refer to the assimilation of people, organizations, genetics, mathematical functions, and so on. In the management domain, integration is generally defined as the coordination between entities with the purpose of achieving a higher level of performance.

Supply chain integration literature looks extensively at both the inter- and intra-organizational coordination across supply networks in ways that add value to one or more of the stakeholders. Two recent meta-analyses that review the relationship between supply chain integration and performance reveal that significant nuances exist in this relationship. They also conclude that numerous exogenous factors have a significant influence on the outcomes (Leuschner, Rogers, and Charvet 2013; Mackelprang et al. 2014). Based on these meta-analyses and numerous other studies, supply chain integration is generally broken down into three sub-dimensions: supplier integration, customer integration, and internal integration (Flynn, Huo, and Zhao 2010; C. W. Lee, Kwon, and Severance 2007; Leuschner, Rogers, and Charvet 2013; Mackelprang et al. 2014).

Each of the three essays that make up this dissertation focuses on one of the three dimensions of integration as it applies to the health sector supply chain (as illustrated in Figure 1). The collective contribution that this dissertation provides is two-fold. First, healthcare supply chains represent a significant departure in business operations compared to other industries, providing a rich context to test theoretical boundaries and bring in new insights into the supply chain management field.

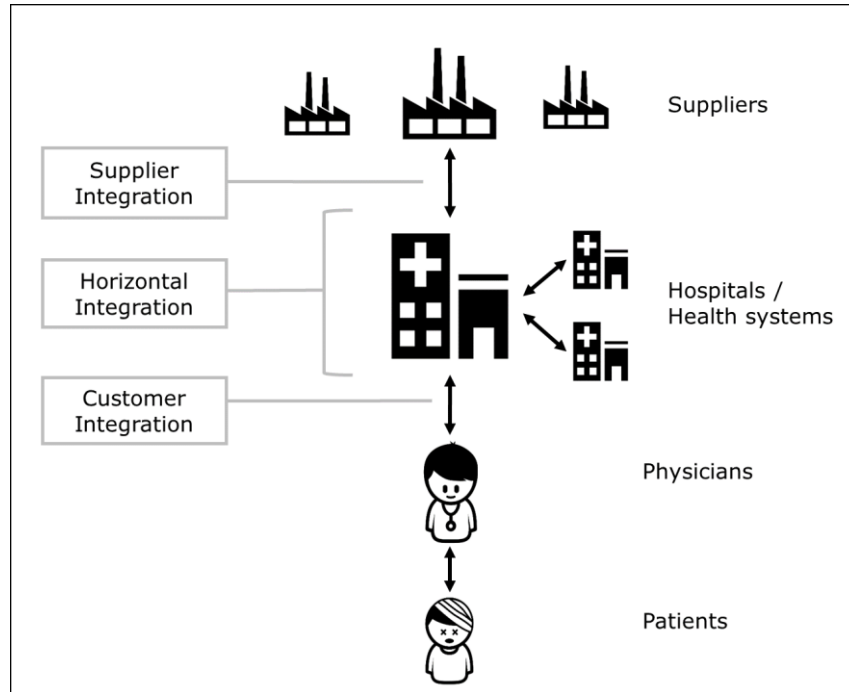


Figure 1. Supply chain integration dimensions in healthcare

Second, by applying existing supply chain theory in the healthcare context, this work aims to reveal mechanisms for improving healthcare supply chains.

In 2013, the cost of healthcare in the U. S. amounted to \$2.9 trillion or 17.4% of GDP. Yet, U.S. healthcare outcomes were noticeably worse than those of other developed countries, according to Organization for Economic Co-operation and Development (OECD) metrics (Davis et al. 2014). With 15-30% of typical hospital budgets comprises procurement and supply chain activities (Nachtmann and Pohl 2009), health care supply networks are an obvious target for improvement initiatives and innovations.

The uniqueness of the healthcare industry's supply chain arises, in part, from the high level of complexity in the healthcare industry. Prominent factors that contribute to the complexity in healthcare supply chains include:

- *The Mission of Healthcare Organizations.* The overriding goal of the organization is to improve and even save lives, in many cases regardless of profit. In the United States, over 60% of hospitals (about 70% total bed capacity) are nonprofit (Mossialos et al. 2015). The nonprofit status of hospitals often leads to misaligned or conflicting incentives with suppliers, who answer to shareholders and generally operate at higher profit margins than hospitals.
- *Supply Chain Intermediation.* Health sector supply chains, even more than most, involve numerous actors across the supply chain including patients, clinicians, provider organizations (hospitals, clinics, etc.), group purchasing organizations (GPOs), independent distributors, insurers, and suppliers. These various actors are jointly responsible for supply chain effectiveness and efficiency. In a typical hospital, 75% of stock-keeping units (SKUs) “owned” by the hospital are off site (Darling and Wise 2010). Additionally, many hospitals use group purchasing organizations (GPOs) to negotiate pricing for over 50% of their supply spend (L. Burns and Yovovich 2014).
- *Range and Criticality of Products.* Hospitals have diverse clinical departments, each requiring specialized medical devices and pharmaceutical products. In some cases, specific products are the only option for treating a patient; a stock-out may quickly result in patient death or long-term disability.
- *Product Complexity.* The supplies, particularly physician preference items (PPIs) like orthopedic implants and heart assistive devices, are extremely expensive, highly complex, often require special handling (sterilization, safety precautions, etc.), and change frequently due to medical and technological innovations. These realities, especially the diverse physician choices and relative lack of objective product performance data, make it difficult for many

hospitals to limit SKUs and build strategic supplier relationships. Furthermore, products come to market through a highly regulated environment. Multiple agencies including the Food and Drug Administration (FDA), state health departments, and accreditation bodies set rules on packaging, storage requirements, recommended usage, etc.

- *Physician Involvement in Supply Selection.* The physician plays many roles in health care delivery such as the knowledgeable professional, perceived customer to the hospital, patient’s agent, and treatment selector. Most physicians are still in private practice and believe in professional autonomy. Many physicians maintain strong relationships with medical device manufacturers and are strongly influenced by suppliers in their choice of product and treatment (Burns et al. 2009). These factors exacerbate the obstacles facing standardization and cost reduction efforts by the hospital.

While individual characteristics of healthcare supply chains are present in other contexts (e.g., professionalized workforce, regulatory pressures, and purchasing-user tensions), the collective characteristics of health care and their interactions make the health care supply chain an exceptional case in its level of complexity.

Table 1 provides information about the three chapters of this dissertation.

Table 1. General information about the three essays

Chapter	Focus	Theory	Methodology
Chapter 1: The Emergence of Consolidated Service Centers in Healthcare	Horizontal Integration	Complex Systems	Case Studies
Chapter 2: Managing Buyer-Supplier Trust in a Most Distrusting Industry	Supplier Integration	Buyer-Supplier Trust	Structural Equation Model
Chapter 3: The Role of Professional Buyers in a Supply Chain Triad	Customer Integration	Service Triads, Agency Theory	Random Effects Regression

## CHAPTER 1

### THE EMERGENCE OF CONSOLIDATED SERVICE CENTERS IN HEALTHCARE

#### **ABSTRACT**

Hospital supply chains can be conceptualized as complex systems with a large number of players and a high degree of interrelatedness among them, creating an environment that is difficult to optimize and manage. In recent years, a consolidated service center (CSC) strategy has emerged in some healthcare systems, showing a strong potential for reducing the complexity in a hospital's supply chain to achieve high levels of performance and innovation. We examine three CSCs using a qualitative case method to understand the unique characteristics of this supply chain strategy, and how CSCs move hospital supply chains towards a less complex state. We find that CSCs demonstrate characteristics that distinguish them from other supply chain strategies. These characteristics enable the CSC to orchestrate supply base rationalization and disintermediation initiatives in the hospital's supply chain to effectively reduce the number of components and interrelatedness in this complex system.



## **INTRODUCTION**

Healthcare supply chains have been described as highly fragmented and complex, showing limited improvements in cost and quality over the years (McKone-Sweet, Hamilton, and Willis 2005; Nachtmann and Pohl 2009; Schneller and Smeltzer 2006). Supply chain expenses include medical supplies, pharmaceuticals, equipment, distribution, and warehousing. This expense category is the second largest category after labor expense, and accounts for up to one-third of the total annual expenses incurred by hospitals (Nachtmann and Pohl 2009).

The Efficient Healthcare Supply Chain Response Report of 1996 identified large opportunities for supply chain savings available through addressing redundancies among stakeholders, lack of transparency, and ongoing issues with service levels (Consulting CSC 1996; Landry and Beaulieu 2013). Even though the report motivated many players in the healthcare supply chain to act, an update to the report 15 years later found little evidence of improvements in cost and quality. The follow-up report concluded that: "We do not know where the fundamental inefficiencies and associated costs subsist within this complex supply chain. We also do not know where the opportunities for the greatest increases in quality exist within the healthcare supply chain." (Nachtmann and Pohl 2009, 2).

These challenges have persisted in healthcare supply chains for decades, and one of the responses in the 1970's was to centralize purchasing and materials management across the enterprise through shared service organizations (Griffin and Adams 1981; Mason 1979). However, many of the challenges faced by shared service organizations (SSOs) in that period (as identified by Griffin and Adams 1981), such as difficulty in quantifying cost savings, issues with supplier selection, and inability to standardize products, are still considered top priorities in the industry. It appeared that SSOs tackled symptoms of supply chain complexity, rather

than resolving the complexity itself. SSO performance has also been constrained by its lack of influence on major policy decisions and the historically limited attention senior management has given to supply chain (purchasing in particular) in many industries, including healthcare (Bales and Fearson 1993; Landry and Beaulieu 2013; Markham and Lomas 1995).

A new type of centralized distribution organization, the consolidated service center (CSC), has since emerged to address the complexity in healthcare supply chains. CSCs are a form of shared service organizations that service multiple geographically dispersed organizations (Landry and Beaulieu 2013). Unlike many other centralization strategies, CSCs do not heavily concern themselves with achieving significant economies of scale to drive higher performance. Instead, they have the potential to drive performance by way of supply chain complexity reduction, through supply base rationalization and disintermediation.

The specific form of the CSC can be characterized as both emergent and contingent, since an organization's history and setting influence the specific structure of the CSC. For example, some CSCs emerged as departments within individual healthcare systems while others were formed as joint ventures between independent systems. A Gartner report identified various structures of CSCs and predicted that such organizations will only grow in numbers to represent 15% to 20% of the total healthcare supply market from a revenue perspective (O'Daffer and Mooraj 2011).

This research attempts to explore how CSCs improve the management of complex hospital-based supply chains. To frame this research, we conceptualize hospital supply chains as *complex systems*. A complex system, as defined by the complexity science discipline, is a system having numerous components that are interrelated (Simon 1962). Both healthcare systems and supply chains have been conceptualized using this framework (Begun, Zimmerman, and Dooley 2003; Choi,

Dooley, and Rungtusanatham 2001; Kannampallil et al. 2011; McDaniel, Lanham, and Anderson 2009). Building upon this stream of work, we examine the role of CSCs from the perspective of a hospital's complex supply chain, and how it impacts the components and interrelatedness in that system. Our research questions address the future research calls laid out in Landry and Beaulieu (2013), which seek to understand the role of CSCs in improving healthcare supply chain performance in healthcare:

*"The emergence of centralized distribution platforms also generates interesting research possibilities. For example, does a better model exist between shared services and third party logistics (3PL) providers, or under what conditions should one or the other organizational mode or governance structure be selected? Does a third option exist? Given the emergence of distribution platforms, which often are region-wide, what impact might these platforms have on upstream partners in the supply chain, primarily GPOs [group purchasing organizations] and distributors?"*  
(Landry and Beaulieu 2013, 480).

We approach these questions through a case study methodology and investigate three CSCs to understand their emergence and how they have improved supply chain performance of the hospitals they served. First, we observe similar characteristics of CSCs across our three cases that distinguished them from other distribution platforms. We find that the CSCs reduce complexity in the system through (1) supply base reduction, which reduces the number of components in the system and (2) hospital-supplier relationship management, which reduces the interrelatedness in the system. By reducing the supply chain complexity, CSCs have enabled hospitals to achieve higher levels of supply chain performance, in terms of the documented cost of operations.

The following section presents a literature review of complexity science, as it relates to complex systems and their characteristics, followed by our conceptualization of a hospital's supply chain as a complex system. The methodology section follows, elaborating on case selection process, data collection, and analysis. Then, the three cases are first presented individually, describing each CSC and how it has impacted its customer hospitals. This is followed by a cross-case analysis. We conclude with a discussion of the findings, implications, and future research directions.

## **LITERATURE REVIEW**

### **Complexity Science**

Complexity science is a multidisciplinary field that conceptualizes a wide variety of phenomena as complex systems (from flocking birds to chemical reactions to supply chains) providing a useful lens to understand the characteristics of these phenomena. It is applied in a variety of disciplines including physics, biology, computer science, and sociology. Entire journals dedicated to research and applications in complexity science have also emerged (e.g. *Journal of Complexity*, *Complexity*). Complexity science has proven to be a potent framework for organizational science, applied in strategic management (Levinthal and Warglien 1999), economics (Kauffman and Macready 1995), supply chain management (Choi, Dooley, and Rungtusanatham 2001), and healthcare management (Begun, Zimmerman, and Dooley 2003).

In complexity science, a complex system is defined by the number of *components* in the system and the *interrelatedness* of these components (Simon 1962). This definition is also congruent with the NK model, where N and K represent the number of components and interrelatedness, respectively (Kauffman and Levin

1987). Depending on the context and level of analysis, a component can be operationalized as an individual, an inanimate object, a department, or an organization that acts autonomously and interacts with other components. The interrelatedness between components refers to the influence components can have on one another. While there have been many extensions and variants to this basic definition of complexity, Simon's definition continues to be the most prominent in the social sciences and is still applied in recent complexity research (e.g., Kannampallil et al. 2011; Kim, Chen, and Linderman 2015).

A complex system can be visualized as a "fitness landscape" with hills and valleys that represent varying degrees of performance outcomes (Kauffman and Levin 1987). A simple system—with a small number of components and low degree of interrelatedness—represents a smooth landscape where it is easy to identify and move towards the highest peak. The higher the degree of interrelatedness between the components of a system, the more rugged the landscape becomes and the more demanding it becomes to identify and reach the peak. Hence, reducing the number of components in the complex system and the degree of interrelatedness among components simplifies the landscape such that high levels of operating performance can be more easily pursued (Levinthal 1997; Levinthal and Warglien 1999). This representation of complex systems was originally devised in the context of evolutionary biology (Kauffman and Weinberger 1989; Kauffman and Levin 1987), but has since been applied to many other areas including organizational theory and supply chain management (Choi, Dooley, and Rungtusanatham 2001; Choi and Krause 2006; Kim, Chen, and Linderman 2015; Matos and Hall 2007).

A signature feature of complex systems that has motivated researchers in many different fields to apply complexity science is *emergence*. Emergence is when the interrelationships between components lead to self-organizing patterns (Goldstein

2000). The flocking of birds or social structures in ant colonies are classic examples of self-organizing behaviors (Sigmund 1993) while the “invisible hand of the market” is another example of self-organizing behavior in economics (Dodder and Dare 2000). Supply chains are also considered to show emergent behavior when “individual firms partake in the grand establishment of the supply network by engaging in their localized decision-making.” (Choi, Dooley, and Rungtusanatham 2001, 358).

### **Healthcare Supply Chains as Complex Systems**

In the healthcare supply chain systems studied here, the system is viewed from the perspective of a hospital. Components around the focal hospital include its suppliers, GPOs, distributors, parent corporation, sister hospitals, and the CSC. These components interrelate with the focal hospital (and with each other) in multiple ways. For example, suppliers may be connected with a hospital through direct sourcing contracts or through contracts mediated by GPOs. Similarly, interrelatedness is present in the storage and physical distribution of supplies, which is often mediated by distributors. Interrelatedness may also occur between the focal hospital and other hospitals in its network. In complex systems, it is acceptable that independent components demonstrate correlated behavior (Kannampallil et al. 2011). Such is the case for hospitals operating under centralized systems or alliances. This does not compromise the independence of the hospitals, which continue to operate under independent operating licenses (Bazzoli et al. 2004). In terms of supply chain activities, hospitals (even ones in centralized systems) most often have a Supply Chain Director (or Director of Materials Management) who has some level of decision-making autonomy at the hospital-level, to be able to respond to local needs.

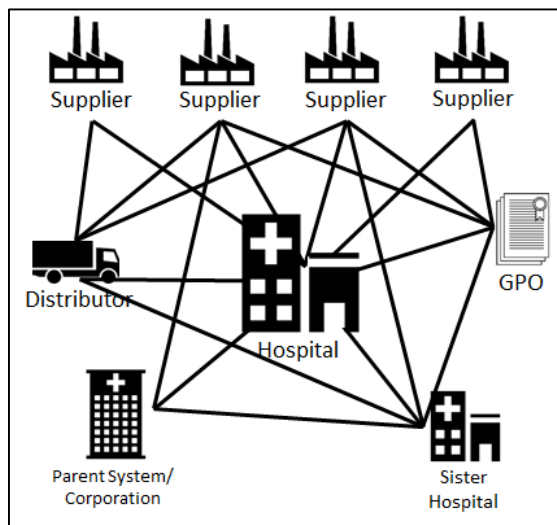


Figure 2. Components and interrelatedness in a hospital's supply chain

Thus, a hospital's supply chain can be described as a complex system with many components and a high level of interrelatedness between them (as we illustrate in Figure 2). Rivard-Royard et al. (2002, 413) present a similar conceptualization of complexity in healthcare "which results on the one hand from the multitude of different supplies used by the institutions and the myriad distribution channels through which they flow". They present the healthcare supply chain as a complex system with numerous components (manufacturers, distributors and vendors) all interrelated as the supplies flow through them and into the hospital's internal chain.

This complexity in healthcare supply chains is a consequence of several characteristics largely unique to the health sector. First, there is a high degree of heterogeneity in the departments and facilities within a hospital. Clinical departments such as emergency, cardiology, surgery, oncology, and laboratories (in addition to affiliated physicians' offices and satellite facilities) all have differing materials requirements, many of which are critical for patient safety and public health (Beier 1995; Landry and Beaulieu 2013). Second, there is a high level of product variety in healthcare, meaning that even for products that are common across multiple

departments, each department or physician may prefer a different alternative (Schneller and Smeltzer 2006). Ongoing medical product innovations combined with differing rates of adoption further drives this diversity. From an information perspective, a universal coding system for the medical device industry is in its very early stages, making it difficult to identify equivalent products (The Brookings Institute 2015). Third, physicians play an important role in product and supplier selection because of their medical training and experience, particularly for the aptly labeled physician preference items (PPIs) (Chen, Preston, and Xia 2013; Roark 2005). The professional power of physicians causes tension between them and organizational buyers (i.e. the hospital's purchasing department), making it difficult for the hospital to address product standardization (Montgomery and Schneller 2007; Roark 2005).

The sources of complexity discussed above result in a highly rugged landscape, with a large number of interrelated components. A hospital generally maintains a large supply base and many intermediaries in order to maintain high service levels, translating to a high number of components in the system. Many intermediaries, such as GPOs and distributors, become involved in the supplier-hospital interactions. In the United States, over 80% of hospitals source at least 50% of their commodity and pharmaceutical products through GPOs, and 41% of hospitals are affiliated with more than one GPO (L. R. Burns and Lee 2008). Adding to the complexity is the distributors' interrelatedness with this large supply base and the hospital. To add perspective to this matter, consider that a typical hospital owns about 35,000 SKUs, but only 6,000 to 8,000 are located at the hospital (Darling and Wise 2010).

Healthcare supply chains also exhibit "emergent" characteristics. Landry and Beaulieu (2013, 470) describe the evolution of the health sector supply chain function as follows: "the *emergence* of the materials management or logistics



department in its current form is the result of many changes that have taken place over a 100-year period within the hospital environment [emphasis added]". The emergence and ongoing evolution of GPOs for many decades is another example (M. D. Thill 1989). More recently, the emergence of CSCs in a few healthcare supply chains has sparked a huge discussion in the industry about "self-distribution" (Brooks 2015; Health Industry Distributors Association 2012; M. Thill 2012; O'Daffer and Mooraj 2011). The CSCs that emerged in various regions of the United States have different governance structures and growth trajectories while exhibiting some universal features, which this research attempts to uncover.

## **METHODOLOGY**

To address our research questions, we adopted a qualitative approach to allow for a deep, yet flexible exploration of the role of CSCs. We followed guidance from Ellram (1996) and Miles and Huberman (1994) in conducting the research, and Fawcett et al.'s (2014) "trail guide" for articulating the analysis and findings. In this section, we will discuss our sample, data collection process, and the data analysis process.

### **Sample**

To understand the effect of a CSC on a hospital's supply chain, we investigated three different CSCs and considered how the supply chains of their customer hospitals changed after the CSC intervention. A theoretical sampling approach was taken to select three cases with CSC interventions to be examined in detail (Barratt, Choi, and Li 2011; Eisenhardt 1989b). A theoretical sampling approach implies that the cases to be studied were deliberately chosen (rather than randomly sampled) to maximize the potential for gaining useful insights out of them. First, we identified eleven prominent CSCs based on media articles, conferences, and reports (e.g.,

Health Industry Distributors Association 2012; M. Thill 2012; O'Daffer and Mooraj 2011). We further restricted this sample to make it feasible to hold face-to-face interviews with the stakeholders and conduct site visits in each of the cases. We chose to examine CSCs of different types to examine how different governance models emerge and what their influence was on supply chain operations. The second selection criterion was to have CSCs that were mature organizations of significant size. This criterion provides us assurance that any effects CSCs have had on hospitals are long-term and sustainable, as well as providing a longer history to examine.

The pseudonyms Alpha, Beta, and Gamma are used to refer to the three CSCs in the selected cases. Each of the three CSCs in our study has operated for more than ten years and serves, at least, seven acute-care hospitals. They differed on governance structure and ownership status. Alpha was established as a joint venture between two independent healthcare systems and acts as a stand-alone entity that serves external customers. Beta operates within the bounds of a single healthcare system, acting as a cost center. Finally, Gamma started operations as an internal supply chain division to a healthcare system (like Beta), but later expanded into a profit center that serves hospitals in its parent healthcare system as well as external customers.

### **Data Collection and Sources**

Primary data was collected in 2013 through semi-structured interviews with multiple respondents in each of the three cases. An interview instrument was used to guide the interview, but the questioning was not limited to the interview protocol, and issues were raised and discussed based on observations or previous responses. In all cases, multiple key executives of the CSC were interviewed (i.e. CEO, COO, CFO, Vice President etc.). In two of the cases (Alpha and Gamma), CEOs of hospitals

being served by the CSCs were also interviewed, to get their perspective of supply chain complexity and the CSC's role over the years. Twelve interviews were conducted across the three cases, each lasting one hour or longer. All but one of the interviews was face-to-face (one interview was conducted via teleconference), with two researchers present during the interviews. Onsite tours of the CSCs' organization and warehouses were conducted as well, gaining first-hand observations of some of their distribution and operations processes.

Documents, such as reports and presentations about the services, performance, and history of the CSCs were also gathered and reviewed. In addition to publically available information, some documents were collected before the site visits to help enrich the interview discussions, while others were obtained as a result of requests for more information based on interview outcomes. Subsequent to the site visits and interviews, we sent out a short questionnaire to the leader of each CSC to verify some of our findings and fill in gaps in our data.

### **Coding and Data Analysis**

Our investigation generated a large amount of data from semi-structured interviews, supplementary materials, publically available information, and first-hand observations from the site visits. Throughout the collection process, the data was organized and coded to draw out coherent constructs and relationships (Miles and Huberman 1994). During the first several iterations, the data was coded based on constructs drawn from our theoretical framework (number of components, interrelatedness, rugged landscapes, emergence, etc.). From the discussions among the research team, additional themes began to materialize, which triggered a process of revisiting data and applying additional codes. We mapped these emerging constructs back to our theoretical framework, assessing whether the data supported, contradicted, or extended our preconceived understanding of this phenomenon.

After several coding iterations, the emphasis was shifted from data probing towards a cross-case analysis to help bring cohesion between the observed

Table 2. Case Observations

	Case 1: Alpha	Case 2: Beta	Case 3: Gamma
<b>Year CSC was Initiated</b>	1998	2002	2000
<b>Region Served</b>	Southeast U.S.	Southwest U.S.	Midwest U.S.
<b>Governance Model</b>	Joint Venture (serves external customers)	Cost Center (serves internal customers only)	Profit Center (internal & external customers)
<b>Number of Acute-care Hospitals Served</b>	7 Hospitals (95% of total revenue)	14 Hospitals (80% of total revenue)	71 Hospitals (61% of total revenue)
<b>Number of Supplier Contracts</b>	300 contracts	111 contracts	Over 1,000 contracts
<b>Number of Product SKUs Managed</b>	4,500 SKUs	2,100 SKUs	Over 100,000 SKUs
<b>Supply Chain IT Integration</b>	Develops software interfaces to connect with the different systems of customers	Integrated ERP system across the managed customer base	Integrated ERP system across the managed customer base
<b>Purchasing</b>	Direct Sourcing, CSC is also a GPO	~50% Direct Sourcing, ~50% through National GPO	Direct Sourcing, CSC is also a GPO
<b>Warehousing / Inventory Management</b>	Central warehouse serves hospitals in multiple states	Central warehouse serves one metro area	Two central warehouses, serves hospitals in multiple states
<b>Outbound Transportation (from CSC to hospitals)</b>	Owns and operates a trucking fleet	Outsourced to 3 <sup>rd</sup> party logistics provider	Owns and operates a trucking fleet
<b>Examples of manufacturing-type services managed by the CSC</b>	Surgical Packs, Pharma Repackaging, IV Compounding, Food Preparation, Sterilization, Instrument Repair	Surgical Packs, Drug Compounding, IV Packing, Pharma Repackaging	Self-branded products, Surgical Packs, Pharma Repackaging, IV Compounding, Printing Services, Instrument Repair

constructs and relationships in each case. Where there were gaps or inconsistencies between cases, we attempted to identify the potential sources of variance that may have resulted in such deviations. This process facilitated the development and iterative refinement of testable propositions.

## **WITHIN CASE ANALYSIS**

In this section, we discuss each case in terms of the history, structure, and operations of the CSC. The role of the CSC in a hospital's supply chain is also described based on the perspective of both the CSCs and the customers that were interviewed. Additional information about the three CSCs is summarized Table 2.

### **Case 1: Alpha**

Alpha is a CSC that operates as an independent, non-profit organization. It was founded in 1998 by two small healthcare systems (totaling four hospitals) in the Southeastern region of the United States. Several environmental factors, including profitability pressures and limited strategic control over procurement, motivated the CEOs of the two healthcare systems to establish the CSC. At the time of our interviews, Alpha served seven acute-care hospitals, which account for 95% of its total revenue. Alpha operates a "membership model", where all member hospitals (i.e. customers) are considered external customers and are charged cost plus a fixed markup on all supplies and services. The materials management director (typically the highest supply chain authority) at each member hospital reports to Alpha's executive team.

Alpha initially started with purchasing activities, providing value to member hospitals by negotiating purchasing contracts with better terms than the general contracts offered through national GPOs. Soon after, Alpha established a centralized warehouse with logistics operations to better support the direct relationships with

suppliers. As the CSC matured, it extended additional service offerings to its member hospitals. In addition to contracting, distribution, and logistics services, the additional services included pharmaceutical repackaging, custom surgical pack assembly<sup>1</sup>, medical instrument repairs, IV (intravenous) therapy bag mixing service, and food preparation.

When receiving Alpha's services, a hospital's supply chain changes in a number of ways. The most pronounced change is the significant decrease in the number of contracts negotiated at the hospital level. A large majority of the hospital's purchasing transactions get routed and fulfilled directly through Alpha, eliminating much of the interrelatedness that was previously required in the supply chain. This also allows Alpha to largely displace the hospital's national GPO and distributors. The high level of purchasing being routed through Alpha is achieved by aligning supply chain governance between the hospital and Alpha, i.e. having the hospital's supply chain authority report to Alpha's leadership rather than the hospital's CEO.

The hospital's supply base is further reduced through product standardization, driven by Alpha's "value analysis teams" and demand aggregation efforts across different departments and hospitals in the systems they serve. For example, Alpha's standardization effort cut the number of different orthopedic implantable medical devices sourced from different suppliers by more than half. Physician preference items, such as orthopedic implants, are known to be among the hardest medical products to standardize (Montgomery and Schneller 2007). Alpha successfully influenced its member hospitals to limit the number of product alternatives available to their surgeons. The additional manufacturing-type services provided by Alpha also reduce the hospital's need to engage with third-party service providers. A reduction

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<sup>1</sup> Surgical packs are packaged bundles of surgical instruments put together for a specific type of surgical procedure. The CSC customizes the surgical packs to the specifications of the physician that requests it.

in the number of suppliers and 3PLs for the hospital translates to a reduction in the number of components in the complex system.

## **Case 2: Beta**

Beta operates within the boundaries of a single healthcare system located in the Southwestern region of the United States. In the late 1990's, a merger between two healthcare systems led to organizational restructuring, which also resulted in establishing a CSC (Beta) to focus on the supply chain functions of the hospitals. Beta serves hospitals (and other clinical facilities) within the parent healthcare system with no immediate intentions of serving hospitals from other healthcare systems. In that regard, Beta resembles a shared service organization, but with two key distinctions from "traditional" SSOs (e.g., Griffin and Adams 1981; Mason 1979). SSOs generally serve multiple information-intensive functions (e.g. Finance, HR, IT), with supply chain being the least common function served by SSOs (Deloitte 2013). Conversely, Beta's prime focus is on supply chain services (the same is also true for Gamma and Alpha). Second, the reporting structure between hospitals and Beta is tightly integrated, giving Beta a much higher degree of control over supply chain activities than is typically observed with SSOs in healthcare (Markham and Lomas 1995). The directors of materials management at the hospitals report to the CSC's leadership, who in turn report to leadership at the parent healthcare system.

With regards to purchasing, Beta manages purchasing for 14 acute-care hospitals. Beta uses GPOs for about 50% of its total spend, particularly for commodity-type items. It was explained that *"GPOs still do a good job negotiating commodity items for us... GPOs have a hard time in controlling [member use of contracts for] PPIs."* In terms of distribution services, Beta operates a warehouse that serves a smaller subset of hospitals that are within a feasible proximity to the warehouse. Beta cited two advantages of operating its own centralized warehouse.

First, the central warehouse provides a platform to host additional supply chain support services such as repackaging products into low units of measure, surgical pack assembly, and pharmaceutical compounding. Second, Beta can directly negotiate and receive products from some suppliers, which improves contract compliance with those suppliers. From a supplier's perspective, contracting and fulfilling orders directly to Beta reduces both the payment cycles and risk for suppliers (relative to consignment structures with distributors).

Beta also promotes product standardization by working closely with value analysis teams (sometimes referred to as "clinical consensus teams") representing physicians, nurses, and procurement officers. These teams systematically target product categories with high volume and total cost, to reduce the number of product alternatives being sourced and focus on negotiating more cost-effective contracts with fewer suppliers. The team assesses all the current alternatives based on price, volume, effectiveness, and supplier support. For commodity products, value analysis teams reduce product alternatives down to between one to three choices, and are generally fulfilled through GPO-negotiated contracts. With physician preference items, the product alternatives are typically reduced from over ten product choices to four or five, satisfying the significant majority of stakeholders. Product standardization naturally leads to supply base reduction for a hospital, translating to fewer components in the system, and more focused contracting efforts that yield higher value. The CSC is more successful in product standardization than attempts to do so during the previous operating structure of the system, because the CSC is able to better coordinate value analysis teams with its downstream customers and at the same time implement change upstream, with the suppliers.

### **Case 3: Gamma**



Gamma is a CSC that emerged from restructuring efforts at a large healthcare system in the Midwest. Prior to the restructuring, the state of supply chain operations at the hospitals within the system was described as having a high level of complexity and no strategic focus. Purchasing and inventory management processes were not well integrated nor standardized across the system's hospitals. For example, the COO of the parent healthcare system described the purchasing process at one hospital when he first joined the organization (before Gamma was formed) as follows: *"The hospital administration almost intentionally wanted the [purchasing] process to be slow, to slow down the spending and prevent people from going on shopping sprees."* Upon its inception, Gamma first focused on integrating supply chain information systems across hospitals. This effort revealed many missed purchasing opportunities, such as identical items being purchased by sister hospitals at different unit prices. Gamma then expanded its scope to incorporate logistics and distribution services.

In 2010, Gamma expanded beyond the confines of its parent health system and began offering their services to external hospitals and clinical facilities. About half of the acute-care hospitals served by Gamma belong to its parent healthcare system. However, the CSC is very selective in choosing its clients, as Gamma's CEO explained: *"We are very picky when it comes to choosing customers..."*, *"[Gamma] goes through a rigorous screening process to ensure that the potential customer is willing to comply with our initiatives and expectations."* For example, Gamma integrates its customer's supply chain IT with its own to track the supply spend, and requires that customer hospitals maintain at least 80% contract compliance. This required level of compliance streamlines the purchasing process and significantly reduces the interrelatedness between the hospital and other actors such as suppliers and GPOs. Furthermore, the reporting structure for the hospital's director of material

management changes to a matrix structure, where he must report to both Gamma in addition to the hospital's leadership (similar to Alpha and Banner's cases).

Beyond purchasing and logistics services, Gamma provides hospitals with a wide array of other supply chain services and products. Of our three case examples, Gamma demonstrated the largest portfolio of services provided to customers. For example, Gamma provides a private label portfolio of clinical products with more than 1,000 SKUs, and continues to push for more: "*We started by manufacturing garbage bags, now we are manufacturing medical devices.*" These factors shrink a hospital's supply base and disintermediate some of the 3PLs, translating to less components in a hospital's supply chain system. In summary, Gamma significantly reduces a hospital supply chain's number of intermediaries and suppliers through product standardization and by insourcing many functions and products.

### **Summary**

Figure 3 provides a simple illustration of how CSCs in our three cases influence the supply chain network from the perspective of a hospital. In the first case, Alpha significantly reduced the interrelatedness between the hospital and its suppliers, while also reducing the supply base. Beta (Case 2) works with a national GPO and distributor rather than have the hospital interface with these entities. Beta also works closely with the parent health system and value analysis teams of the different clinical specialties to increase product and process standardization. In Case 3, Gamma has insourced multiple supply chain functions including assembly and manufacturing of some commodity products. Similar to the other two CSCs, Gamma also focused on supply base reduction and disintermediation for its customer hospitals.

As seen in Table 2, the scope of supply chain functions at Alpha and Gamma is greater than Beta. Both Gamma and Alpha operate as GPOs while Beta continues to

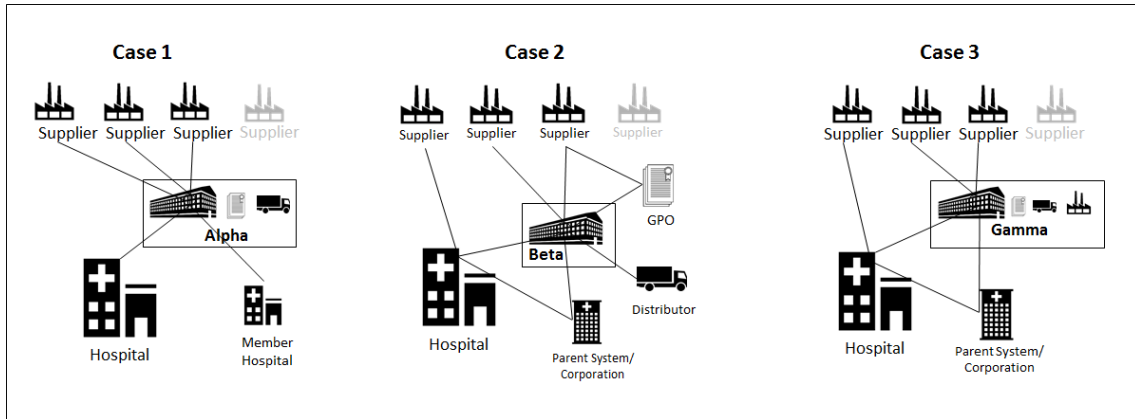


Figure 3. Hospital's supply chain network after the CSC intervention

work with a national GPO. At the time of our study, Beta did not operate its own trucking fleet like Alpha and Gamma, but rather outsourced it to a distributor. Alpha and Gamma also demonstrated a wider scope of manufacturing-type services compared to Beta. Gamma is significantly larger than Alpha and Beta in terms of hospitals served, contracts, and SKUs and also operates two centralized warehouses. Gamma also serves a much wider range of facilities, with acute-care hospitals accounting for 61% of its revenue, compared to 95% and 80% for Alpha and Beta respectively.

Finally, to verify our observations about the CSCs' ability to reduce the complexity in a hospital's supply chain, we asked the leaders of the CSCs to estimate their impact on a hypothetical customer's supply chain landscape (Table 3). We asked about the reduction in the number of suppliers to gauge the reduction in the number of components in this complex system. The reduction in direct hospital-supplier contracts was used as a proxy for interrelatedness reduction. Responses to these questions were provided by the leader of each CSC almost a year after our face-to-face interviews as a verification tool. The results from this verification are discussed in more detail in following sections.

Table 3. CSC's impact on a hospital's supply chain complexity

Suppose a 500-bed hospital enrolls as a new customer to your CSC (previously having a “traditional” SC operating model including a mix of GPO and self-initiated contracts). How do you *expect* the hospital’s supply chain landscape to change one year after you take over their SC operations?

	Alpha	Beta	Gamma
a. Percentage reduction in total number of med/surg. <i>suppliers</i> :	Reduced by 10 %	Reduced by 20%	Reduced by 10 %
b. Percentage reduction of med/surg. <i>direct contracts</i> (non GPO).	Reduced by 90 %	Reduced by 10%	Reduced by 50-75%
c. Expected <i>reduction</i> in FTEs at the hospital	5+ FTEs	15 FTEs	3 FTEs
d. Expected <i>additional</i> FTEs needed at CSC to service the hospital	2 FTEs	8 FTEs	1 FTEs

### CROSS-CASE ANALYSIS

Several interesting commonalities characterize all three CSCs and differentiate them from other centralized distribution platforms, such as shared service organizations. Three characteristics, in particular, were repeatedly observed throughout our interviews across all three cases and were important for the CSCs to effectively manage supply chain complexity. Appendix A presents proof quotes that support our observations regarding characteristics of CSCs and their role in reducing supply chain complexity.

#### Selectivity of New Customers

All three CSCs were very cautious about expanding their customer base. It is worth noting that we entered this study expecting economies of scale to be crucial to the success of CSCs. Many industries achieve economies of scale through increasing volume and customer-base (Chandler 1994), whereas CSCs were not concerned about increasing their customer base to improve their scale advantage. This was stated more than once in each of the three cases with comments like: "*National distributors have the scale and talent, but we have the trust from both upstream and downstream [the suppliers and the hospital]*", "*suppliers do not penalize [Beta] for*

*smaller orders compared to a distributor's economies of scale," and "We run a very different model from the national distributors."*

CSCs did increase their economies of scale by increasing volume with their existing customers but were judicious about increasing their customer base. Upon a deeper search in the healthcare management literature, we found that this strategy aligns with research that has looked at economies of scale in the health sector and concluded that: *"economies are achieved at low rather than high levels of hospital scale, with more modest cost savings"* (Alexander, Halpern, and Lee 1996; L. R. Burns and Pauly 2002, 132; Dranove 1998; Dranove and Shanley 1995).

Executives at Alpha and Gamma discussed a rigorous process in selecting prospective customers. Alpha emphasized that they do not have a sales or marketing department to reach out to potential customers. Even with its current size of over 70 hospitals, Gamma's rigorous customer selection process was clearly articulated. For prospective customers that sought Gamma's services but were not deemed to be an adequate "fit" by Gamma, they were presented with the option to receive consulting services from Gamma instead. In Beta's case, there were simply no aspirations to serve customers outside the boundaries of its parent healthcare system.

The high selectivity of the customer base in all three CSCs also reflects on the relatively limited regions that each CSC serves when compared to GPOs, national distributors, and even shared services organizations, who all typically provide nationwide services (L. Burns and Yovovich 2014; Deloitte 2013).

### **Enforcing High Contract Compliance**

In the context of healthcare purchasing, contract compliance relates to how well the buyer lives up to its negotiated commitments on volume and market share that were the basis of the contract agreement. Previous research has shown that hospitals source about 50% of their commodity and pharmaceutical products through

GPO contracts, and only about 30% of physician preference items and capital items (L. R. Burns and Lee 2008; L. Burns and Yovovich 2014). In contrast to these statistics, our observations showed that over 80% of hospital supply spend goes through the CSC, in all three cases. In fact, with Alpha and Gamma, a critical clause in their contract agreements with customers is that the customer must maintain a certain level of contract compliance. This is enforced by monitoring the hospital's supply spend activity. Beta manages contract compliance issues through the chain of command within its healthcare system.

Higher contract compliance encourages long-term partnerships (Doucette 1997), and reduces demand uncertainty for suppliers, which translates into a willingness to offer better prices (L. R. Burns and Lee 2008). Contract compliance motivates suppliers to have a close working relationship with the CSC, rather than sell through GPO contracts or promote their products directly to physicians. With high contract compliance, the CSC is able to follow through in purchasing the negotiated volume, offering suppliers more predictable delivery and payment scheduling cycles.

All three CSCs integrated the reporting structure with the hospitals they served such that the reporting structure for the highest supply chain authority at each hospital changed to a matrix structure that included reporting to CSC leadership in addition to the hospital's CEO. Interestingly, this modified reporting structure was not planned at the onset of any of the three CSCs' establishment but was an emergent adjustment in response to the resistance from materials management departments at the hospitals against the CSC's complexity reduction efforts. The challenges in implementing this reporting structure modification was discussed in depth in Alpha's case. A CEO of one of Alpha's customers admitted to a significant pushback from materials management directors, some of whom opted to leave their position rather than yield to this reporting structure. Today, prospective customers

entering into agreements with Alpha (and Gamma) must fully agree to this condition in order to be served.

### **Managing Supply Chain Complexity**

The aforementioned characteristics allow the CSCs to orchestrate the hospitals' complex supply chain systems in ways that result in reduced complexity and lead to higher supply chain performance for the hospitals. CSCs reduce the number of components and reduce the interrelatedness among the remaining components in the complex system. The reduction in the number of components is largely conveyed through supply base reduction efforts. Reduction of interrelatedness is demonstrated with the role of the CSC as a centralized distribution hub, by both disintermediating third parties as well as managing the direct relationships between hospitals and suppliers.

*Supply base reduction.* A prominent objective for all three CSCs is to reduce the supply base of the customers they serve. CSCs are heavily involved with value analysis teams, which usually consist of stakeholders (namely physicians, nurses and purchasing managers) that examine product options in a category and agree to reduce the number alternatives to be sourced. Multiple interviewees reaffirmed the idea that physicians have traditionally had the discretion and power to choose almost any product brand they preferred, leading the healthcare system to source up to ten different brands for essentially the same product (Montgomery and Schneller 2007). Unsurprisingly, the introduction of product standardization was initially received with heavy resistance from the physicians. This resistance was overcome by ensuring the adequate representation of physicians in the value analysis teams and providing scientific evidence of the equivalency of the clinical outcomes (or as one interviewee put it simply: "*Overwhelm them with data*"). Furthermore, value analysis teams in these arrangements combined stakeholders from multiple hospitals, providing a

larger pool of intelligence and experiences to draw from. This observation is consistent with the findings from a previous study that looked at strategies for sourcing physician preference items (Montgomery and Schneller 2007).

In all three cases, the CSCs facilitated a significant reduction in the number of suppliers, with no indication of compromising clinical processes or quality. This finding is validated through Question A in Table 3. Beta provided the highest estimate for supply base reduction, possibly because all hospitals operate within a single healthcare system, and, therefore, standardization initiatives are supported directly by both the CSC and clinical leadership at the system level.

*Proposition 1: The CSC reduces the number of components in the hospital supply chain by facilitating supply base reduction initiatives for the hospital.*

#### *Disintermediation*

In all of our cases, CSCs reduced the interrelatedness in the complex system. For hospitals served by Alpha and Gamma, the role of the national GPO and distributor was replaced by the CSC. While Beta did not replace the existing GPO and distributor, it serves as a mediator between them and the hospitals. Beta is also gradually moving towards shrinking their dependence on these third parties. Not only did this free up resources for the hospital (Table 3, Question C), it also significantly reduced the number of interactions with suppliers and other third parties that the hospital previously had to manage directly.

The CSCs also mediated direct relationships between hospitals and suppliers. In a traditional supply chain operating model in this context, direct contracts with suppliers generally account for about half of a hospital's total supply spend (L. R. Burns and Lee 2008; L. Burns and Yovovich 2014). Many of these direct hospital-supplier relationships are likely to be driven by physician relationships with supplier representatives, thus amplifying the level of interrelatedness in the system. By



acting as an intermediary, the CSC replaces these multiple relationships with a single point of contact and allows for demand aggregation to negotiate better contracts and enforce contract compliance.

These observations are validated by the responses provided in Question B in Table 3, where the CSCs estimated that they are able to significantly reduce the number of direct contracts between a customer hospital and suppliers within the first year of serving a hospital. What stands out is Alpha's high estimate, which is partially explained by Alpha's full discretion in selecting customers (i.e. no obligations to serve hospitals in a parent healthcare system like Gamma or Beta), and opting only to pursue compliant customers that are willing to undergo drastic changes early in the process. Beta, on the other hand, estimated less of a reduction within the first year than either Alpha or Gamma. While the observed variance in provided estimates certainly stands as a future research issue, there is little question that CSCs reduce the interrelatedness in the supply chain.

*Proposition 2: The CSC reduces the interrelatedness in the hospital's supply chain by disintermediating GPOs and national distributors, while managing hospital-supplier relationships.*

## **DISCUSSION**

All three CSCs discussed the need for a clear integration strategy to be able to manage supply chain complexity on behalf of hospitals. The "rigorous screening process" during customer selection ensures that customers willingly align themselves with the CSC, which includes reorganizing their internal supply chain reporting structure. Accordingly, the modified reporting structure allows the CSC to actively orchestrate the hospital's supply chain and reduce the number of components and interrelatedness in a hospital's supply network. This orchestration allows the CSC to

enforce a high level of contract compliance with suppliers, which translates to better outcomes for both suppliers and hospitals. Viewed in this light, it makes sense that the need to realign the reporting structure had emerged in all three cases to complement the other key success factors.

Taken together, these characteristics distinguish the operating model of CSCs from national distributors and traditional SSOs. Outsourcing of supply chain services (as typically seen when hospitals work with national distributors) provides supply chain specialization and economies of scale for the distributor but often fails to reduce the hospital's supply chain complexity. From the hospital's perspective, the distributor becomes one of many components in the complex system, with limited influence over actors in that system (such as physician-influenced direct contracts). Insourcing, through a shared service strategy, does not typically provide the necessary supply chain expertise, and SSOs in the health sector have traditionally struggled to achieve product standardization, and the necessary stakeholder buy-in to reduce complexity (Griffin and Adams 1981). Even contemporary spin-offs of the shared services concept in the health sector, such "Integrated Delivery System" structures, had largely failed to achieve substantial cost savings (Bazzoli et al. 2004; L. R. Burns and Pauly 2002). Therefore, we strongly subscribe to Landry and Beaulieu's (2013) notion of a "third option" between 3PLs (outsourcing) and shared services (insourcing). Alternatively, CSCs that have emerged in healthcare can be thought of as an "internal outsourcing" strategy (Aksin and Masini 2008).

The CSCs' ability to develop service and process innovations is a major source of value for their customers, and was a recurring topic of discussion in our interviews. On multiple occasions, the CEO of Alpha described his organization as a "*supply chain think tank*". Alpha demonstrated a strong entrepreneurial culture across multiple layers of the organization. Executives and managers were encouraged to

propose and champion projects they were passionate about. Similarly, the CEO of Gamma's parent organization stated that, "*I would be disappointed if a year went by and there wasn't a major innovation introduced by [Gamma]*". Innovation can be gauged by the additional services that the CSCs have developed for hospitals (often proactively rather than responding to customer demands) that organically emerge over time to capitalize on supply chain opportunities.

Another common thread across the three cases was the strong leadership teams that operate the CSCs. From our observations, we can hypothesize that "transformational leadership" (Bass et al. 2003) is a necessary condition to successfully deploy a CSC strategy. This observation is also consistent with findings from previous research showing that transformational leadership moderates the role between buying centers (which resemble CSCs in structure and function) and supply chain performance (Hult, Ketchen, and Chabowski 2007).

Proof quotes about innovation and transformational leadership are provided in Appendix A. The complexity reduction, along with innovation and transformational leadership, lead to achievements well beyond cost reduction (O'Daffer and Mooraj 2011).

### **Study Limitations**

As with any research effort, this study is not without limitations. First, our theoretical sampling approach was both a source of strength and weakness. Since our theoretical sample focused on mature and successful CSCs, we could not directly compare outcomes of this strategy against alternative distribution models. We also did not examine hospitals that have considered a CSC strategy but found other strategies more suitable, or emulated some of the features of a CSC with their national distributor (e.g. Narayanan and Brem 2009). In addition to comparing

multiple supply chain strategies, future studies may want to examine cases of CSC implementations that have failed.

This study did not have a strong financial focus to quantify cost savings from complexity reduction. Customers of CSCs only provided anecdotal evidence and general cost-savings estimates related to the success of CSC initiatives. There is ample opportunity to conduct quantitative studies on the effectiveness of different distribution models (or different types of CSCs), either as a cross-sectional or longitudinal study. Such effort may begin to explain the variance of the estimates in Table 3 regarding reduction in supply base and contracts. A larger sample can better generalize the impact of a CSC strategy.

Another potential area of weakness in this study is the limited number of cases examined, which poses some risk to the external validity of the findings. However, Voss (2002) indicated the trade-off between the number of cases and the depth taken in each case. We believe that we have addressed each case with adequate depth: interviewing top-level CSC executives, onsite tours of the facilities, interviews with hospital CEOs, and post hoc validation of our observations (Table 3). We were also able to capture the longitudinal aspect of these organizations by interviewing co-founders of all three CSCs. The emergence of similar themes across all three cases gave more credence to the external validity and generalizability of this study.

## **CONCLUDING REMARKS**

A hospital's supply chain is a complex system with a large supply base and a high degree of interrelatedness between players. Different types of CSCs have emerged in a number of healthcare systems to manage the supply chain complexity, with the goal of more efficient and effective hospital performance. Conceptualizing hospital supply chains as complex systems provides a fitting framework to identify why CSCs

are able to effectively orchestrate this highly complex system beyond what other centralized operating models have been able to achieve. CSCs change the conversation by pursuing mechanisms for achieving supply chain effectiveness beyond the traditional economies of scale approach, which appears to have nuances in the health sector (L. R. Burns and Pauly 2002; Dranove 1998; Dranove and Shanley 1995).

The CSC's positioning as an orchestrator of a hospital's supply chain appears to alleviate many of the previously identified barriers to supply chain success (McKone-Sweet, Hamilton, and Willis 2005). For example, barriers such as "conflicting incentives" and "inconsistent relationship with GPOs" were addressed by the inherent structure and mission of the CSC. The CSC addresses "lack of executive support" by having transformational leaders with direct authority over supply chain activities through the modified reporting structure. We found the CSCs to be centers for supply chain expertise and innovation, breaking the critical barrier of "limited education on supply chain" (McKone-Sweet, Hamilton, and Willis 2005), and solidifying their role as supply chain innovators.

Lessons learned from healthcare CSCs hold out great promise for improved supply chain coordination and the management of complex systems in healthcare as well as other settings. The health sector's supply chain, with its institutional reliance on GPOs and large distributors, provides a rich context to further understand the nature of CSCs and the evolving roles for GPOs and distributors who, themselves, have been honing their supply chain competencies for decades. Future research will be needed to better understand the prerequisites for establishing a CSC and how it compares to other operating models, with respect to sustaining high levels of service and innovation for healthcare.

## CHAPTER 2

### MANAGING BUYER-SUPPLIER TRUST IN A MOST DISTRUSTING INDUSTRY

#### **ABSTRACT**

While buyer-supplier collaboration is widely recognized as a source of sustainable competitive advantage, the path to buyer-supplier trust remains elusive. This research examines factors that influence buyer-supplier trust in a supply chain context characterized by adversarial relationships and lack of trust among partners. Importantly, this research adds to the existing literature by examining both enablers (information sharing, contracts, and dedicated investment) as well as barriers (conflicting views and dependence) to buyer-supplier trust. Using structural equation modeling, the proposed trust model is applied to survey data from both buyers and suppliers in the healthcare industry. The findings reveal that while some of the constructs associated with trust are perceived in healthcare as they are in other contexts, some interesting nuances emerge. Dependence, although having a negative connotation to trust, becomes associated with a higher level of contracting, which in turn improves trusting relationships in the long-run. Furthermore, we find that dedicated resource investments by supply chain partners do not increase trust, and may in some cases act as a barrier to trust if ulterior motives, such as entrenchment and upselling, behind such investments are suspected.

## **INTRODUCTION**

Collaboration among supply chain partners has been recognized as a viable source of competitive advantage with substantial empirical support from the research community. Dyer and Singh's (1998) "relational view" provides a theoretical perspective on how buyer-supplier relationships provide a source of competitive advantage. They argue that with collaborative relationships generate relational rent by reducing transaction costs and stimulating innovation. Despite the potential benefits of supply chain collaboration, many organizations remain hesitant to make themselves vulnerable to the risks associated with collaborative supply chains. Furthermore, even when organizations have the intention to collaborate, these intentions fall short of achieving value for the partners due to the presence of relationship barriers or failure to transform collaborative efforts into mutual value (Fawcett and Magnan 2002; Frankel, Goldsby, and Whipple 2002). There continue to be questions about the extent to which relationship barriers undermine the influence relationship enablers and negate performance benefits accrued from collaboration.

The struggle to realize value from collaborative relationships is particularly apparent in healthcare supply chains. The healthcare supply industry is characterized by the prevalence of adversarial relationships and low levels of trust between supply chain partners compared to other industries (Conway 2011; McKone-Sweet, Hamilton, and Willis 2005; Schneller and Smeltzer 2006). A survey by Gartner Research reports that 93% of supply chain executives in healthcare perceive a lack of trust among trading partners (Dominy and O'Daffer 2011). Several complexities in the health sector significantly influence buyer-supplier relationships. These complexities include regulatory pressures and reform policies, intensity of both knowledge and capital in the business, physician influence in supply selection, and the high level of supply chain intermediation. This study answers calls for more

context-specific research (Beckman and Sinha 2005) by examining relationship antecedents in a context that is distinctly different from other industries in terms of relationships and supply chain complexity (McKone-Sweet, Hamilton, and Willis 2005).

This paper attempts to extend previous research on buyer-supplier trust by assessing the combined effect and moderation of enablers and barriers in an industry that is known for a high level of distrust among supply chain partners. The three facilitators of trust to be examined are aligned with the relational view and include information sharing, dedicated resource investments, and contracts as a formal governance mechanism. The two barriers to trust to be examined are conflicting views and dependence. We develop our constructs and model based on previously used constructs and models, drawing mainly from the work of Nyaga et al. (2010), Handfield and Bechtel (2002), and Whipple et al. (2010). Finally, the similarity of our constructs and model with previous trust research allows for a comparison between our context-specific findings and findings from previous work that has captured trust perceptions from a more general sample of the population.

This study provides several insights into the literature on buyer-supplier relationships. One significant finding is the role of contracting as a mediator between trust and dependence (Handfield and Bechtel 2002). This aligns with other research that has taken different approaches to examine the contracting-trust virtuous spiral (Autry and Golicic 2010; Cuevas, Julkunen, and Gabrielsson 2015). This study also sheds more light on the fickle perceptions of dedicated resource investments in the partnership. Our results suggest that, in a healthcare context, supply chain partners appear to be more cynical about dedicated resource investments compared to other contexts (e.g., Dyer 1996b). A posthoc analysis suggests that from the buyers' perspective, dedicated resource investments can hinder trust in certain situations, as



such investments by the supplier can be associated with supplier upselling and entrenchment (Robinson 2015). This observation is in agreement with the recent press in the healthcare industry about substituting supplier resources with internally developed capabilities or by receiving equivalent services from third-party providers (Lee 2014; Thill 2015). The findings in this paper demonstrate an interesting context and provide grounds for impactful research in the role of contracting in relationship governance (e.g., Katok and Pavlov 2013), and about the dark-side of supplier entrenchment that develops through excessive investment in buyer operations (e.g., Day et al. 2013).

The next section provides the background literature to support our hypotheses and theoretical model. This is followed by the research methodology and data analysis. The managerial and theoretical implications of the findings are then discussed, and the paper closes with limitations and opportunities for future research.

## **LITERATURE REVIEW**

This section will first discuss inter-organizational trust (with a focus on buyer-supplier relationships), followed by a review of the positive antecedents considered in this study. This is followed by a discussion of distrust and the negative antecedents of trust. These antecedents are discussed with the healthcare context in mind. The key constructs employed in this study are summarized in Table 4. The references in the table refer to the works we have resorted to for developing the measurement scales.

### **Trust**

Inter-organizational trust is an intensely studied topic in multiple disciplines including marketing, strategy, supply chain management, and organizational behavior. To a

large extent, trust research is developed through two perspectives: the social perspective and the economic perspective (Whipple, Griffis, and Daugherty 2013). The *social perspective* develops knowledge on trust through the social capital and relational embeddedness frameworks. Social Exchange Theory considers trust as a relational governance mechanism to achieve collaboration between two parties

Table 4. Constructs used in the study

<b>Construct</b>	<b>Definition</b>	<b>Measurement Reference</b>
<b>Trust</b>	A firm's belief that the partner will act in the best interest of the firm and the relationship	(Chen et al., 2013; Klein, 2007; Nyaga et al., 2010; Whipple et al., 2010)
<b>Performance</b>	The strategic-level performance of the focal firm, that is enabled by the relationship with the exchange partner (i.e. meeting the organization's mission, financial and service effectiveness)	(Corsten and Felde, 2005; Geiger et al., 2012; Richey et al., 2010; Vesalainen and Kohtamäki, 2015)
<b>Contracts</b>	The level of detail and clarity that partners have in the formalized, legally-binding contracts that govern their relationship	(Handfield and Bechtel, 2002; Lusch and Brown, 1996)
<b>Information Sharing</b>	Partner provides information that informs the firm's business decision-making processes, (e.g. price information, inventory, forecasts, KPIs, etc.)	(Chen et al., 2013; Mohr and Spekman, 1994; Nyaga et al., 2010; Prajogo and Olhager, 2012; Whipple et al., 2010)
<b>Dedicated Resources</b>	Partner provides relationship-specific investments to support the firm; can be related to site, physical or human resources	(Handfield and Bechtel, 2002; Nyaga et al., 2010; Rinehart et al., 2004; Whipple et al., 2010)
<b>Dependence</b>	Dependence of one party on the other, which causes a power imbalance in the relationship, negatively effecting organizational behavior.	(Corsten and Felde, 2005; Handfield and Bechtel, 2002)
<b>Conflicting Views</b>	Tensions in the relationship caused by incongruent economic priorities, goals, management styles, philosophies, or organizational cultures	(McKone-Sweet et al., 2005)

(Emerson 1962; Morgan and Hunt 1994). The *economic perspective* considers trust as a rational behavior exercised in the right circumstance to maximize utility, such as Williamson's (1993) concept of "*calculative trust*". Early work in game theory also probes the role of trust in generating more favorable outcomes: "*trust is often achieved simply by the continuity of the relation between parties and the recognition by each that what he might gain by cheating in a given instance is outweighed by the value of the tradition of trust that makes possible a long sequence of future agreement.*" (Schelling 1960, 134–135).

Rather than provide a comprehensive review of the trust literature, we defer to other recent work that synthesizes the inter-organizational trust literature (in chronological order):

- Seppanen, Blomqvist, and Sundqvist (2007) review publications pertaining to inter-organizational trust between 1990 and 2003. The review looks at multiple aspects of trust research including theoretical lens, operationalizations of trust, sub-dimensions, and research methodologies.
- Whipple, Lynch and Nyaga (2010) summarize the antecedents of successful relationships used in over a dozen influential publications in the field.
- Delbufalo (2012) reviews empirical research about inter-organizational trust, published between 1990 and 2010, and presents a systematic literature review as well as a meta-analysis of the association of trust with many types of outcomes.
- Whipple, Griffis, and Daughterty (2013) review conceptualizations of inter-organizational trust in various disciplines and focus on how trust is operationalized in the logistics and supply chain literature. They show that there have been numerous interpretations of trust and ways to operationalization it.

- Day, Fawcett, Fawcett and Magnan (2013) amass a list of trust definitions taken from some of the key publications on this topic.

Multiple streams of research have come to show that trust is a necessary prerequisite to supply chain integration and successful collaboration efforts. In Fawcett et al.'s (2008) study about supply chain collaboration, findings from 51 in-depth interviews emphasize the importance of trust: "*When asked to identify the most important prerequisites to alliance success, trust was identified as the single most important relationship-building factor.*" (p. 103). In support of this concept, Vanpoucke et al. (2014) build a model of buyer-supplier integration from qualitative data and propose that buyer-supplier trust is a critical trigger towards developing integration initiatives.

To the extent that trust induces collaborative relationships between buyers and suppliers, literature has established the link between trust and higher performance for both parties in a relationship. Several performance dimensions have been examined in the context of buyer-supplier trust. Research studies have operationalized performance using supply chain operational-level metrics such as on-time deliveries, reduction in cycle times, and order processing accuracy, among other metrics (Handfield and Bechtel 2002; Kalwani and Narayandas 1995; Nyaga, Whipple, and Lynch 2010; Whipple, Lynch, and Nyaga 2010). Research has also operationalized performance as the satisfaction of the other party with the relationship outcomes (Johnston et al. 2004; Nyaga, Whipple, and Lynch 2010).

*H1: Having a higher level of trust in a buyer-supplier relationship is positively associated with higher performance for the focal organization.*

## *Contracts*

Contracts play a role in inter-organizational relationships and are therefore factored into many management theories (Dyer and Singh 1998; Gulati 1995; Jeffries and Reed 2000). Legally binding agreements between buyers and suppliers represent a formalized governance mechanism. In agency theory (Jenson and Meckling 1976), different types of contracts can be utilized to mitigate opportunism. Depending on the characteristics of the principal-agent relationship and the nature of the delegated task, extant research has shown how behavior-based contracts or outcome-based contracts mitigate the problem of potential opportunism (Eisenhardt 1989a; Fayezi, O'Loughlin, and Zutshi 2012).

Several perspectives have been established regarding the association between formalized governance mechanisms (contracts) and relational governance mechanisms (trust). The two governance mechanisms have been considered to be substitutes by some researchers (Dyer and Singh 1998; Gulati 1995; Uzzi 1997), and complementary by others (Poppo and Zenger 2002; Ring and Van de Ven 1994). For example, Dwyer (1987) argues that trust replaces the need to cover all contingencies in contracts while Ring and Van de Ven (1994) call for an ongoing balance between informal and formal governance mechanisms.

Even if formal and informal governance are substitutes, it is clear that they are not perfect substitutes. A formalized governance mechanism can never fully manage a distrustful relationship (i.e. when the risk of opportunism runs rampant) particularly due to the widely accepted assumption of bounded rationality (Williamson 1981). On the other hand, even with a high level of trust between a buyer and supplier, the relationship is always "*conditioned by legal systems*" (Ring and Van de Ven 1994, 93).

The complementary view considers the iterative interactions between buyers and suppliers, where trust builds off of the consistent and repeated execution of formalized contract agreements. Poppo and Zenger (2002, 712) find evidence of a complementary relationship between contracts and trust with the logic that "*The presence of clearly articulated contractual terms, remedies, and processes of dispute resolution as well as relational norms of flexibility, solidarity, bilateralism, and continuance may inspire confidence to cooperate in interorganizational exchanges.*" Vanpoucke et al. (2014) develop a model of relational development which proposes that trust develops from parties meeting their contractual obligations. Autry and Golicic (2010) show how arms-length relationships are initiated with contractual agreements and build social capital value over time, leading to a relationship-performance spiral. Other research also establishes a similar positive feedback loop when formal governance gives paves way for relational governance (Ariño and de la Torre 1998). Ireland and Webb (2007) propose that contracts buffer economic vulnerability and that contractual relationships can generate some trust between firms. We subscribe to the perspective that contracts establish the groundwork for developing trusting relationships and continue to augment buyer-supplier trust.

Contracts play a particularly important role in governing healthcare supply chains, particularly given the low level of trust and adversarial relationships between supply chain partners (L. R. Burns et al. 2009; Dominy and O'Daffer 2011; McKone-Sweet, Hamilton, and Willis 2005; Schneller and Smeltzer 2006). In healthcare supply chains, contracts are an important vehicle for reducing opportunistic behavior and uncertainties regarding price changes, stock-outs or disruptions, provision of product-related services, and returns of outdated products (Robinson 2015).

*H2: Clearly defined contracts between buyers and suppliers is positively associated with trust.*

### *Dedicated Resource Investments*

Relationship-specific investments play a large role in a relationship's longevity and success. These idiosyncratic investments enable customized services or processes between the supply chain partners, incentivizing parties to maintain the relationship and avoid opportunism (Doney and Cannon 1997; Williamson 1981). Investing in dedicated resources is a practice that is generally observed to improve trust between the buyers and suppliers (Dyer and Singh 1998; Ganesan 1994; Nyaga, Whipple, and Lynch 2010; Smith and Barclay 1997). Dedicated resource investments can be tangible assets, people, or intangible knowledge (De Vita, Tekaya, and Wang 2011; Ganesan 1994). Human-specific resource investments are often executed in the form of "guest" or co-located employees, and such arrangements benefit both the guest and the host organizations (Dyer 1996b). This practice is prevalent in the auto industry, where both supplier and buyer engineers participate in the product and process designs of the other party, paving the way for a higher level of innovation and co-creation. In fact, the success of Japanese auto-manufacturers is often attributed to their buyer-supplier human-specific investments (Dyer 1996b; Dyer 1996a; Womack, Jones, and Roos 2007).

In the healthcare industry, dedicated resource investments play an important role in the buyer-supplier relationship between, particularly for high-valued medical devices and other physician preference items (L. R. Burns et al. 2009). Supplier representatives interact intensely with physicians to provide a high level of support regarding their products. Supplier sales representative go as far as extending technical support during clinical surgery procedures, by assisting the physician with the provisioning and calibration of the purchased medical devices. Physical resources, such as medical instruments, equipment, and supplier-provided hardware and software, are also provided by suppliers (Montgomery and Schneller 2007). This

level of support builds a high level of trust between physicians and supplier representatives at the individual level, which leads to inter-organizational trust (Zaheer, McEvily, and Perrone 1998). Even when faced with evidence of product equivalency and better prices, physicians frequently continue to recommend buying from the entrenched supplier due to these resource investments (L. R. Burns et al. 2009; Pauly and Burns 2008).

*H3a: Dedicated resource investments by the partner is positively associated with the perceived level of trust.*

*H3b: Dedicated resource investments by the partner is positively associated with the performance of the focal organization.*

#### *Information Sharing*

Information sharing pertains to timely two-way communication of relevant information between a buyer and supplier. This includes sharing of price or cost information, inventory, supply or demand forecasts, organizational goals, and key performance metrics. Information sharing not only supports operational activities and decisions, but also brings awareness of product or process innovations available through the relationship partner (McEvily and Marcus 2005). Extant literature has shown that information sharing is essential to trust building activities (Kwon and Suh 2005; Anthony S. Roath et al. 2005; Nyaga, Whipple, and Lynch 2010). Chen, Preston and Xia (2013) study buyer-supplier relationships in the healthcare context and observe that knowledge sharing has a positive impact on hospital-supplier integration and supply chain performance. Even though information sharing expectations may differ between the buyer and supplier (Whipple, Frankel, and Daugherty 2002), evidence suggests that information sharing is perceived to be a significant antecedent of trust for both parties (Kwon and Suh 2005; Mohr and Spekman 1994; Nyaga, Whipple, and Lynch 2010).



*H4: Information sharing is positively associated with trust.*

### **Distrust & Barriers to Trust**

Even with the recent interest in inter-organizational distrust, limited research has applied antecedents of distrust (i.e. barriers to trust) in the buyer-supplier relationship. Whipple et al. (2010) provide a list of antecedents of successful relationships used in recent studies (Table 1, p. 508). From the dozens of constructs listed in the table, very few had a clear negative connotation with respect to trust. Perhaps the only construct with a clear negative connotation is *opportunistic behavior* (Morgan and Hunt 1994). Other constructs such as conflict, uncertainty and dependence have a more ambiguous association with trust and distrust, as their effect on trust depends on how they are framed. For example, *conflict* in some studies was framed positively as an opportunity for innovation and joint problem-solving (e.g. Morgan and Hunt 1994). In other studies, conflict describes situations that deteriorate trust (e.g. Kauser and Shaw 2004). The two trust barriers that this study examines are dependence and conflicting views.

#### *Dependence*

Dependence in the trust literature has been framed in multiple ways. One conception puts dependence in a positive frame of reference when firms are mutually dependent on each other to achieve success (Knemeyer, Corsi, and Murphy 2003). This version of the construct, sometimes labeled as *interdependence*, emphasizes the reciprocity and balance in power between the parties (Anthony S. Roath et al. 2005; Monczka et al. 1998; e.g., Kauser and Shaw 2004).

In this research context dependence is framed as a barrier to trust, reflecting a power imbalance between the partners, consistent with social exchange theory (Emerson 1962). Resource dependence theory looks extensively at the issue of dependence in inter-organizational relationships, with one of its axioms being that

*"patterns of dependence produce inter-organizational as well as intra-organizational power, where such power has some effect on organizational behavior"* (Hillman, Withers, and Collins 2009, 1405).

The main factors influencing dependence are the importance of the resource to the focal firm, the extent of discretion over that product by the resource provider, and the prevalence of substitutes in the market (Handfield and Bechtel 2002). With a power imbalance, the more powerful partner can abuse his power and behave opportunistically. Consistent with Handfield and Bechtel's (2002) model of buyer-supplier trust, we hypothesize that a greater power imbalance driven by dependence reduces the level of trust between the buyer and the supplier. Furthermore, an organization that is more dependent on its partner is more willing to compromise in order to maintain the relationship (Anderson and Narus 1990). The same dynamic is expected to develop whether the supplier or the buyer is in the more powerful position (Anderson and Narus 1990). Finally, the power imbalance motivates the dependent partner in the relationship to enter into stronger contracts, to provide safeguards against opportunistic behavior (Williamson 1981).

*H5a: Dependence is negatively associated with trust.*

*H5b: Dependence is negatively associated with performance.*

*H5c: Dependence is positively associated with the contracts.*

### *Conflicting Views*

Conflicts inevitably arise in inter-organizational relationships, whether at the level of interacting individuals or at the organizational level. Some conflicts, labeled as functional conflicts, arise from business-as-usual circumstances and are perceived as beneficial for a healthy relationship (Anderson and Narus 1990; Morgan and Hunt 1994). In fact, the absence or avoidance of functional conflicts may indicate complacency and excessive trust, which is counterproductive (Day et al. 2013;

Villena, Revilla, and Choi 2011). This also occurs at the interpersonal level where individuals representing opposing sides in the buyer-supplier relationship avoid conflict to preserve their personal friendship (Jeffries and Reed 2000).

More serious conflicts, on the other hand, can have detrimental effects on trust. Such conflicts involve issues of divergent management styles, philosophies, or organizational cultures, and are much harder to resolve (Kauser and Shaw 2004). Discordant economic priorities or incongruent goals between organizations can lead to procedural tensions and a higher risk of opportunistic behavior (Cuevas, Julkunen, and Gabrielsson 2015). Lack of transparency about operating metrics pertaining to the relationship can signal ulterior motives and hinder trust. Such misunderstanding and conflicting views can impede trust to the point of relationship dissolution (Park and Ungson 1997).

*H6: Conflicting views are negatively associated with the perceived level of trust*

The full conceptual model based on the hypotheses is presented in Figure 4.

### **The Perspectives of Buyers and Suppliers**

There have been studies that consider the similarities and differences between buyer and supplier perceptions of the relationships (Anderson and Narus 1990; Nyaga, Whipple, and Lynch 2010; Whipple, Frankel, and Daugherty 2002). Some studies have used dyadic pairs of buyers and suppliers to address research questions (e.g. Carter 2000; Whipple, Frankel, and Daugherty 2002). In this study, we separately analyzed the two samples in order to examine the differences in general perceptions between the buyers and suppliers, and not necessarily how specific pairs of buyers and suppliers differ in perceptions.

Buyers and suppliers may experience different degrees of success and satisfaction coming from the relationship (e.g., Benton and Maloni 2005). This is

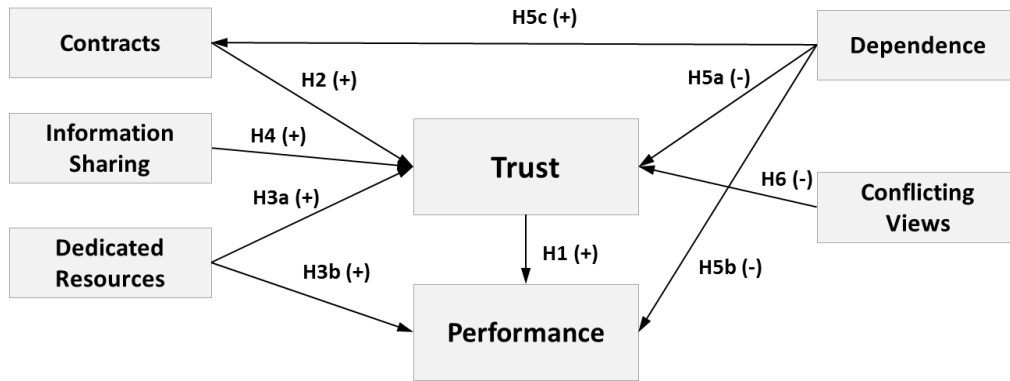


Figure 4. Conceptual Model

natural due to factors discussed earlier, such as dependence, and their level of investment in that relationship. Each party may prioritize different factors, and find some factors more relevant to trust. For example, Whipple et al. (2002) examine a dyadic sample and observe that information sharing priorities differed between buyers and suppliers, where buyers valued accuracy of information while suppliers valued timeliness of information.

More recently, Nyaga et al. (2010) examine a trust model on the independent buyer and supplier samples and find some differences in the general perceptions of trust between the two. One difference was that buyers placed more emphasis on trust's impact on performance outcomes while suppliers placed more emphasis on the inputs towards trust, such as information sharing.

## METHODOLOGY

A survey instrument was designed to measure healthcare buyer and supplier perceptions of trust, antecedents, and performance regarding their most important supply chain partner. The constructs applied in this study were measured using scales from literature where available. Table 4 provides a list of the constructs used along with the sources we referred to obtain measurement scales. We did not find

specific scales for the conflicting views construct and, therefore, developed a new scale based on the literature. All measurement items utilized a 7-point Likert scale ranging from "strongly disagree" to "strongly agree". In some cases, the items were modified from the original scale to be more relevant to the healthcare context, and as an outcome of the pre-test. For example, the items measuring dedicated investments were taken from Nyaga et al. (2010) but were modified to address clinical support and technology. Appendix B presents all the measurement items, with their factor loadings for both the buyer and supplier samples.

To validate our survey instrument and assess the reliability of our measures, a pilot survey was distributed to healthcare providers (i.e. the "buyers"), and 93 complete responses were obtained. The results of the pre-test showed high reliability of the instrument, and therefore only minor changes were applied before the main survey was rolled out. This step was particularly important for validating the scales for the barriers to trust since we found less guidance from the literature regarding constructing these scales, particularly for conflicting views. The main survey consisted of Likert scale items to measure the seven constructs relevant for this study, as well as a host of demographic questions. Two versions of the survey were distributed, measuring the same constructs but with minor changes in wording based on whether the respondent was a buyer or supplier (ex. "supplier keeps commitments" versus "customer keeps commitments"). The surveys were distributed to buyers and suppliers via email, with a cover letter that explained the purpose of the project. The mailing list was provided by the Association for Healthcare Resource and Materials Management (AHRMM) and the Association of National Account Executives (ANAE). We anticipated the survey to take between 15 to 20 minutes to complete.

#### *Buyer Sample*

The buyer survey was distributed to 9,411 potential respondents (i.e. healthcare systems and hospitals). We received 695 responses (7.4% response rate) in total. After removing responses that failed the screening criteria ("Are you in a role in which you interact with Supplier Organizations?") and removing responses with missing data, the usable sample was reduced to 458 responses. Table 5 presents summary statistics regarding the characteristics of the respondents, the organizations they represented, and information about their most important supplier. Compared to the population of hospitals in the United States, the collected sample is biased towards larger hospitals (in terms of bed size)<sup>2</sup>.

Table 5. Descriptive statistics about the buyer and supplier data samples

	Buyers Sample (N= 458)	Suppliers Sample (N=460)
Organization Size	25.0% - under 100 beds, 27.2% - over 400 beds.	28.0% - revenue under \$50 million, 34.5% - revenue over \$1 billion.
Organization type	68.3% of hospitals represented were not-for-profit. 35% of hospitals are part of a Health System / IDN.	54% of suppliers offered two or more product categories. 65.1% of respondents identified their main product category to be PPI, Medical/Surgical devices, or Capital Equipment.
Respondent's Industry Experience	86.8% have at least 10 years of experience in healthcare	36.8% have at least 10 years of experience in healthcare
Respondent's Current Position	48% of respondents have had their current role for at least 10 years. 53% of respondents are at the Vice President or Director level.	38.4% of respondents have had their current role for at least 10 years. 63% of respondents are at the CEO, Vice President or Director level.
Respondent's Work Background	31% have a clinical background. 15% previously worked for a supplier.	20.3% have a clinical background. 19.2% previously worked for a hospital / IDN.
Most important relationship	62.5% indicated that their most important relationship is with distributors, 33% with manufacturers.	46% indicated that their most important relationship is with hospitals/health systems, 29.5% with National Group Purchasing Organizations.
Length of Relationship	67% of responses have had a relationship with their best supplier for over 5 years.	86% of respondents have had a relationship with their best customer for over 10 years.

### *Supplier Sample*

The supplier survey was distributed to 5,220 potential respondents (i.e. medical device manufacturers and distributors), and 612 responses were received in total (11.7% response rate). After filtering out missing responses and unqualified respondents (i.e. those who answered *no* to "Are you in a role in which you interact with Healthcare Provider Organizations?") the usable sample was reduced to 460 responses. Over 60% of the respondents represented suppliers who focused on physician preference items, medical/surgical devices or capital equipment. These items generally make up the majority of supply spend for hospitals (Montgomery and Schneller 2007). A majority of the respondents were at a director level or higher.

## **ANALYSIS**

### **Measurement Model**

A confirmatory factor analysis was used to analyze the twenty-three survey items used to measure the seven constructs of interest, using MPlus version 7.2. The measurement models for the two samples displayed good fit statistics, based on generally accepted fit statistic standards (Kline 2010). The measurement model fit statistics for the buyer sample was: CFI = 0.961, NNFI of 0.953, RMSEA = 0.057 and SRMR = 0.039. The measurement model fit statistics for the supplier sample was: CFI = 0.950, NNFI of 0.940, RMSEA = 0.048 and SRMR = 0.043.

### *Reliability and Validity*

To assess reliability of the measurement scales, Cronbach's alpha and the composite reliability were calculated for each construct. All constructs displayed a Cronbach's alpha above 0.70, indicating good reliability (Nunnally and Bernstein

1994). Recent research in the methodological literature has questioned the usefulness of Cronbach's alpha as a measure of internal consistency (Bentler 2008; Sijtsma 2009), and, therefore, the composite reliability, which is another measure of internal consistency, is also measured. The composite reliability for all constructs in both samples, as listed in Tables 6.1 and 6.2, was observed to be above the general guidelines of above 0.70 (Hair et al. 2010).

Two types of construct validity are commonly examined in studies of this type. First, convergent validity establishes that the items that should be related to each construct are, in fact, related to each other and measure the same construct. The constructs in this study showed convergent validity with all factor loadings being significant at  $p < 0.001$ . The average variance extracted (AVE), was generally above the commonly applied threshold of 0.50 (O'Leary-Kelly and J. Vokurka 1998), except for two constructs in the supplier sample (dependence and conflicting views), but nonetheless, their AVE was very close to the suggested threshold.

Discriminant validity examines whether different constructs, which are expected to measure distinct concepts, are unrelated. To confirm discriminant validity at the item level, we observe that all items have a higher loading on the intended construct than any other construct. To confirm discriminant validity at the construct level (i.e. verifying that each construct is unique), we check that the AVE values are greater than the average shared variance (ASV) across all constructs, which is confirmed by the analysis. Finally, the square root of the AVE for each construct should be greater than inter-construct correlations related to that construct (Hair et al. 2010). One exception to this test of discriminant validity in our sample is with the dedicated resources construct, whose square root AVE was lower than its correlation with information sharing. This is not very surprising, considering that dedicated resources (whether human resources or IT resources) represent an important medium for



information sharing. We performed a secondary validation, where we tested a model which set as a constraint the correlation between Dedicated Resources and Information Sharing. The difference in the chi-square statistics of the constrained model and the unconstrained model was significantly worse (buyer model:  $\Delta\chi^2 = 238.7$ ,  $df= 1$ ,  $p\text{-value} < 0.001$ ; supplier model:  $\Delta\chi^2 = 212.5$ ,  $df=1$ ,  $p\text{-value} < 0.01$ ), indicating that our theorized factor model provided a better fit for the data.

Keeping in mind that the generally accepted followed guidelines do not necessarily imply hard cutoffs, we opt to use our a priori theoretical framework and

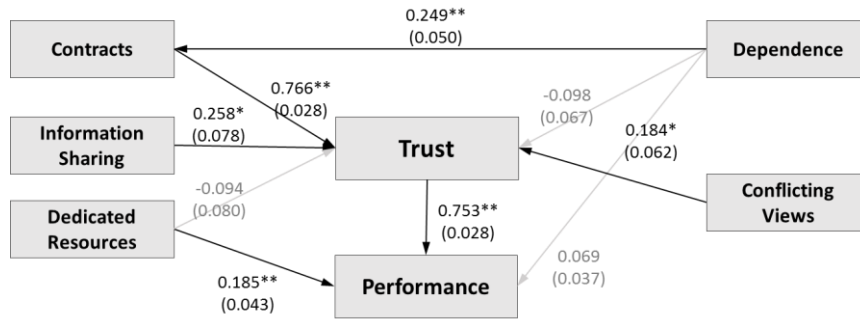
Table 6.1. Reliability and inter-construct correlations for the buyer sample

Buyer Sample	CR	AVE	1	2	3	4	5	6	7
1. Trust	0.924	0.803	0.896						
2. Performance	0.923	0.749	0.806	0.866					
3. Contracts	0.923	0.800	0.790	0.759	0.895				
4. Info Sharing	0.837	0.633	0.461	0.492	0.433	0.796			
5. Ded. Resources	0.819	0.603	0.362	0.455	0.384	0.790	0.776		
6. Dependence	0.864	0.681	0.228	0.262	0.257	0.071	0.176	0.825	
7. Conflicting Views	0.945	0.812	0.268	0.265	0.222	0.040	0.089	0.747	0.901

Table 6.2. Reliability and inter-construct correlations for the supplier sample.

Supplier Sample	CR	AVE	1	2	3	4	5	6	7
1. Trust	0.894	0.739	0.860						
2. Performance	0.871	0.631	0.584	0.794					
3. Contracts	0.849	0.656	0.734	0.520	0.810				
4. Info Sharing	0.845	0.645	0.486	0.415	0.446	0.803			
5. Ded. Resources	0.754	0.507	0.353	0.401	0.351	0.786	0.712		
6. Dependence	0.724	0.470	0.150	0.215	0.122	0.087	0.109	0.686	
7. Conflicting Views	0.774	0.463	0.228	0.232	0.314	0.175	0.245	0.388	0.681

CR = Composite reliability, AVE = Average Variance Extracted, matrix's diagonal is the square root of the AVE.



Model Fit Statistics: CFI=0.951, NNFI=0.942, RMSEA=0.063, SRMR=0.104

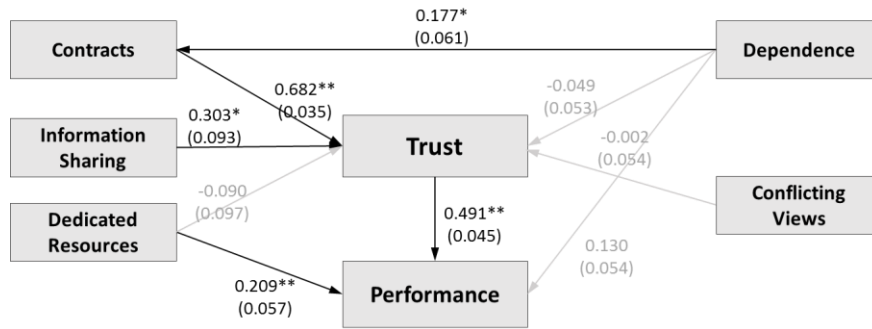
Note: \*p-value < 0.01; \*\*p-value < 0.001

Figure 5. Buyer (healthcare providers) model results

move forward with our factor structure, (Fawcett et al. 2014). Tables 6.1 and 6.2 summarize the reliability and validity measures for the buyer and supplier samples, respectively.

*Common Method and Non-Response Bias*

Because all measurements within each observation were taken from a single respondent, our data becomes exposed to the risk of common method bias. One qualitative approach to gauge the risk of common method bias is to examine the correlation matrix between the latent variables (Craighead et al. 2011). Insignificant correlations in the results provide some indication of the low risk of common method bias. A statistical approach used to check for common method bias is the Harman Single Factor Test (Podsakoff et al. 2003). This test loads all measurement items onto a single latent construct to see if either a single-factor model adequately fits the data or if one factor accounts for the majority of covariance in the measures. For both the buyer and supplier samples, several factors were identified and the first factor did not account for the majority of the variance (the first factor accounted for 35% and 24% of the variance in the provider and supplier samples, respectively). This suggests that common method bias is not a major threat in the collected data.



Model Fit Statistics: CFI=0.933, NNFI=0.921, RMSEA=0.055, SRMR=0.097

Note: \*p-value < 0.01 \*\*p-value < 0.001

Figure 6. Supplier (distributors, medical device manufacturers) model results

Although the threat of common method bias can never be resolved unless there are multiple respondents per observation, the qualitative and statistical checks performed provide some assurance that the risk of common method bias is not high in this study.

Non-response bias was also assessed by comparing the responses from the first and last wave of respondents, which were four weeks apart. We compared responses across all twenty-three survey items and found no significant differences between responses of the first wave and the last wave, based on a two-tailed T-Test (p-values for all the tests were greater than 0.01). Furthermore, we compared demographic variables (size of the organization, and the number of years the respondent has worked for the organization) and found no significant differences between the early and late respondents.

### Structural Equation Model

A structural equation model was estimated using MPlus software (Version 7.2). We tested our theoretical model on our two samples. Based on the global fit indices, both models demonstrated a good fit given the observed data, exceeding recommended thresholds (Kline 2010). The results of the two models are provided in

Figure 5 and Figure 6, showing the global fit statistics, the path coefficients and their respective standard errors (in parentheses).

### **Hypotheses Support**

Not all of the hypotheses that were proposed were supported, but even the lack of support provide interesting insights. First, trust was shown to have a positive and significant impact on Performance (H1). Contracts, Dedicated Resources, and Information Sharing were all hypothesized to positively impact trust. These hypotheses were supported for Contracts (H2) and Information Sharing (H4), but not Dedicated Resources (H3a). Dedicated Resources was shown to have a positive and significant impact on Performance as hypothesized (H3b). Results also indicated that Dependence has a significant positive impact on Contracts (H5c), but no direct impact on Trust (H5a) nor Performance (H5b). Conflicting Views shows a positive and significant impact on trust in the buyer sample (H6) which is opposite of what was hypothesized, but no significant relationship in the supplier sample. Finally, the combination of supported hypotheses (H1, H2, and H5c) and unsupported hypotheses (H5a and H5b) suggests that the association between dependence and performance is fully mediated by contracts and trust. This mediation is statistically validated in a later subsection based on accepted methodological guidelines (e.g. McKinnon 2008; Rungtusanatham, Miller, and Boyer 2014).

Overall, the samples of buyers and suppliers were highly consistent, except for the hypothesis that tested the relationship between Conflicting Views and Trust (H6). Additionally, the associated between Trust and Performance showed the same effect in both samples but differed in magnitude. Buyers perceived that Trust had a greater impact on Performance compared to the perception of suppliers. Observations of the differences between the samples are statistically validated through the invariance analysis discussed below and summarized in Table 8.

Table 7. Mediation analysis

Structural Path	Buyer			Supplier		
	Coeff.	S.E.	p-value	Coeff.	S.E.	p-value
Dependence → Performance	0.067	0.037	0.073	0.114	0.053	0.031
Dependence → Trust → Performance	-0.044	0.055	0.422	0.037	0.031	0.237
<b>Dep. → Contract → Trust → Perf.</b>	<b>0.155</b>	<b>0.031</b>	<b>&lt; 0.01</b>	<b>0.054</b>	<b>0.021</b>	<b>&lt; 0.01</b>

### Mediation Analysis

A mediation analysis was conducted to examine the mediating relationship between Dependence, Contracts, Trust, and Performance. First, we verify the role of Contracts as a mediator between Dependence and Trust, following recommendations by Rungtusanatham, Miller, and Boyer (2014) for testing mediation. We conducted a Sobel Test (McKinnon 2008; Sobel 1982), which is a commonly used method to test for a mediation effect, and find that the indirect effect of Dependence on Trust (via Contracts) is significantly different than zero (Sobel test= 5.9, s.e. = 0.028,  $p < 0.001$ ). Furthermore, the direct path from Dependence to Trust is not significant, suggesting full mediation. Second, all the direct and indirect paths between Dependence and Performance are examined and evidence suggests that the effect of Dependence on Performance is fully mediated by Contracts and Trust. Table 7 presents the direct and indirect paths between Dependence and Performance, showing that the path with the highest magnitude is the one that passes through both Contracts and Trust.

### Measurement and Structural Invariance

Our survey structure enables us to examine the congruency between buyer and supplier perceptions since we use the same survey items and factor structures across the two groups and have similar sample sizes. Measurement invariance quantitatively examines whether structures of latent constructs are consistent under

different conditions or sub-samples in multiple steps: configural invariance, metric invariance and scalar invariance (Meade and Lautenschlager 2004). Configural invariance is considered to be the first and most basic form of measurement invariance, which indicates whether the number of factors and item loading structure is consistent across two groups (Kline 2010). To test this, the measurement model is simultaneously fitted to the two independent samples, and the goodness-of-fit statistics are observed. In our sample, the configural invariance model fit the data well (Table 8), thus the constructs and loading structure are consistent across groups.

The second form of invariance, metric invariance, assesses whether the factor loadings themselves are equivalent across the groups. To test this, we constrain the factor loadings to be equal across the two groups, and assess the difference in chi-square ( $\Delta\chi^2$ ) compared to the configural invariance model. However, since  $\Delta\chi^2$  is sensitive to sample size, it has become questionable whether this measure is useful in studies of large sample sizes (Cheung and Rensvold 2002; Kline 2010). As an alternative, researchers have suggested comparing fit indices, particularly the CFI (Cheung and Rensvold 2002; Meade, Johnson, and Braddy 2008). Cheung and Rensvold (2002) suggest that a change in CFI less than 0.01 indicates that the null

Table 8. Invariance models fit statistics

Model	$\chi^2$	d.f.	CFI	NNFI	RMSEA	$\Delta\chi^2$
<b>Measurement Invariance</b>						
Configural Invariance (baseline)	1250.88	592	0.953	0.994	0.049	-
Metric Invariance	1308.59	611	0.950	0.943	0.050	57.71
Scalar Invariance	1610.72	630	0.930	0.922	0.058	302.1
<b>Structural Invariance</b>						
Baseline Model	1796.42	646	0.918	0.911	0.062	-
Full Structural Invariance	1832.91	656	0.916	0.910	0.063	36.49
Partial Structural Invariance*	1802.358	654	0.918	0.912	0.062	5.94

\*This model relaxes the invariance constraints on two paths: Conflicting Views → Trust, and Trust → Performance.

hypothesis of the invariance model should not be rejected. In our sample, the CFI of the metric invariance model is reduced by 0.003 relative to the configural model, indicating that the factor loadings are invariant across the buyer and supplier samples. A more restrictive form of invariance, scalar invariance, poses constraints on the intercepts. Imposing constraints on the intercepts results in fit statistics that are substantially lower than the metric invariance model (Table 8) and, therefore, we reject the null hypothesis that the buyer and supplier samples demonstrate scalar invariance.

Structural invariance compares the consistency of the structural path model between the two groups (buyers and suppliers). The chi-squared of the full structural invariance model (where path coefficients are constrained to be equal across the two groups) is compared against a baseline model, where all path coefficients are allowed to differ between groups. The results (in Table 8) show that differences exist between the two models ( $\Delta\chi^2 = 36.49$ ,  $df = 10$ ,  $p < 0.001$ ). We identified the constrained paths that cause the greatest amount of misfit by examining the modification indices, and relaxed the constraints on these paths, arriving at a partial structural invariance model. This model allows the path between conflicting views and trust, as well as trust and performance to vary across groups. Comparing this model with the baseline, we find no significant differences ( $\Delta\chi^2 = 5.94$ ,  $df = 8$ ,  $p = 0.654$ ), implying that all other paths are consistent across the two groups.

## **DISCUSSION**

This section discusses the theoretical and managerial implications related to the main findings of this study. First, the general comparison and points of deviation between the buyer and supplier perceptions will be discussed. Second, we highlight the implications of the mediated relationship between dependence and trust, and

relate it to very recent work in power and dependence between buyers and suppliers (Hingley, Angell, and Campelo 2015). Finally, limitations and future research opportunities that come out of this work are discussed.

### **Comparing Buyer and Supplier Perceptions**

There is a high level of congruence between the perceptions of buyers and suppliers regarding the barriers and enablers of trust based on this study, with two notable differences. A notable point of divergence between the buyer and the suppliers is the perceived impact of relationship trust and the performance that comes as an outcome of the relationship. Based on the invariance analysis, buyers perceived a significantly higher association between trust and performance, compared to suppliers. Suppliers may perceive themselves in a dominant position in this industry, where relationships are very "sticky" and driven largely by physicians rather than materials managers (L. R. Burns et al. 2009; Lerner et al. 2008). As a consequence, suppliers may find lesser value from the partnerships with the buyers since they already gain much of the value through their position of power. On the other hand, a relatively underpowered buyer gains a bigger performance advantage from a trusting relationship. This is consistent with recent literature regarding the effect of power on trust and performance (Chicksand 2015; Cuevas, Julkunen, and Gabrielsson 2015), making it likely that relative power between buyer and supplier moderates the relationship between trust and performance. This finding is also similar to Nyaga et al.'s (2010) finding that commitment and trust reflect on performance more strongly with the buyers than with the suppliers.

The other point of divergence between the buyer and supplier models is how Conflict was perceived. The supplier model revealed no significant association between conflict and trust while the buyer model revealed a positive and significant association with trust. The latter finding contradicts what we hypothesized, which



was that Conflict is negatively associated with Trust. We measured Conflict as the perceived incongruence in economic priorities and sales/marketing strategies between the parties and the lack of full transparency, all of which may sow the seeds of opportunistic behavior (Kang and Jindal 2015; Lamming et al. 2001). However, Morgan and Hunt's (1994) seminal work on buyer-supplier trust shows that conflicts can positively influence trust. In their model, they find that conflict is positively associated with trust and is not significantly associated with opportunism. Some level of conflict and tension is inevitable between two parties in an exchange relationship, and parties accept the fact that there will be incongruent economic incentives driving each party. A healthy level of tension may even be necessary to encourage ongoing communication, which fosters long-term trust (Anderson and Narus 1990; Dwyer, Schurr, and Oh 1987). The divergence of perceptions in our analysis regarding conflict and trust certainly raises more questions about what a "healthy" level of functional conflict should look like and whether there are other variables that mediate this association, such as contracts or communication. Finally, it is important to keep in mind that the survey had asked respondents to provide information about their most important buyer/supplier. Thus, the importance of this buyer/supplier may overshadow any negative perceptions of trust from functional conflicts.

### **Dependence-Contracts-Trust Mediation**

An interesting finding that comes from this study is the mediation between dependence, contracts, and trust. This causal chain from dependence to contracting to trust and, finally, to performance was originally hypothesized by Handfield and Bechtel (2002) based on previous research arguing that contracts establish voluntary restraints on the use of power (Noordewier, John, and Nevin 1990). However, Handfield and Bechtel do not find the evidence to support their causal chain. Several reasons may help explain how this study is able to support this mediation

hypothesis. First, this study had higher statistical power due to a much larger sample size of over 450 observations for each of the buyer and supplier samples, compared to Handfield and Bechtel's sample of 97 usable responses. Second, the sample in this study is focused on a single industry, which has been traditionally known to have adversarial relationships between the hospital buyers and medical device suppliers (L. R. Burns et al. 2009; McKone-Sweet, Hamilton, and Willis 2005). As a consequence, the true effect size may be greater in this context, making it easier to detect.

This dynamic between dependence and performance is a *fully*-mediated relationship since dependence does not directly influence trust nor performance in the presence of the path through contracts. Multiple tests for mediation were conducted (as presented in the results section) to validate this observation. This finding carries significant implication to the healthcare industry and relationship management in general, by presenting contracting as an effective mechanism to address concerns of dependence on the other party, and making it viable for organizations to develop trusting relationship regardless of their divergence in size or industry clout. This idea is supported by recent work revealing that buyer-supplier trust can develop despite a high level of dependence and power asymmetry, when other mechanisms mediate the dependence-trust relationship (Cuevas, Julkunen, and Gabrielsson 2015). Cuevas et al. (2015) propose that goal congruence can be this mediator, and our contribution shows that contracting can be another such mediator.

### **Information Sharing and Dedicated Resources**

Information sharing was positively associated with trust for both the buyer and supplier samples, consistent with our hypotheses. Information sharing is a core ingredient for trust and this is no different in our study. The more pressing issue

regarding information sharing, especially in the health sector, is not whether an organization should share information with its trading partner, but rather whether the organization has the capability and infrastructure to collect and share information that is adequate, timely, and accurate. Hospitals and suppliers need to jointly consider the gains from information sharing in order to resolve the gap in information sharing. New “unique device identification” (UDI) standards for product barcoding and registering, as mandated by the Food and Drug Administration, may provide some justification for both hospitals and suppliers to invest in the adequate information capturing and sharing infrastructure (The Brookings Institute 2015; Wilson 2012). Providers can benefit from the information provided by suppliers about product usage, availability, price transparency, and alternatives. Suppliers value information from health providers relating to product performance, demand forecasting, and utilization.

Dedicated resource investments did not significantly impact trust, but positively impacted performance for both buyers and suppliers. While our hypothesis about dedicated resources having a positive impact on trust was not supported, the findings are consistent with other work (Handfield and Bechtel 2002; Nyaga, Whipple, and Lynch 2010; Whipple, Lynch, and Nyaga 2010). It appears that respondents acknowledge the value of the resources provided by the other party, in terms of improving the performance that results from the relationship, but it does not improve trust. It is likely that dedicated resources are a required component of the relationship, and are therefore factored into the cost of the transaction rather than considered as goodwill. Dedicated resources provide interesting implications to the dark-side of buyer-supplier relationships (Day et al. 2013). In fact, recent discussions in the medical device industry have been about replacing supplier embedded human resources (sales representatives) with newly trained hospital

employees that substitute for the supplier sales representatives (J. Lee 2014).

However, removing supplier dedicated resources does not negate the need for the hospital to gain knowledge about new products and their application; information that only the supplier may possess.

### **Post-Hoc Analysis**

Our non-findings with regards to the association between dedicated resource investments and trust motivated a posthoc analysis. As mentioned earlier, supply managers in the health sector often associate supplier resources (particularly human resources) with opportunism, upselling, and winning the physician's favor, at the expense of the hospital (L. R. Burns et al. 2009; Robinson 2015). This view of dedicated resources runs contrary to the "mainstream" views in other industries that consider dedicated investments as enablers or trust (Dyer and Singh 1998; Nyaga, Whipple, and Lynch 2010; Rokkan, Heide, and Wathne 2003). We opted to further explore the impact of dedicated resources on trust, given the increased attention to the potentially hazardous effects of supplier dedicated resources in hospitals (Kracov et al. 2013; J. Lee 2014). With the idea that complex surgical supplies better justify the need for dedicated resources relative to other product categories, we separated the buyer sample into two categories: a category whose most important supplier provided complex surgical supplies (general surgery, cardiology, orthopedics, spine, or other surgical specialty; N=213) and the rest of the buyers who reported about suppliers that provided non-surgical supplies (N=244).

We retested the same model focusing on how the perceptions between dedicated resources differed between the two groups of buyers. The results showed that buyers of non-surgical supplies perceived dedicated resources to be *negatively* associated to trust (coefficient=-0.219, s.e.=0.109, p=0.044). Buyers of surgical supplies showed perceptions consistent with the aggregate buyer sample, in that dedicated resources

did not significantly impact trust (coefficient=-0.028, s.e.=0.068, p=0.680). All other relationships in the model were consistent with our aggregate model. This finding reflects the concerns in healthcare about supplier opportunism when it comes to bundling services with products, particularly with products that do not hold the complexity that necessitates dedicated resources (Robinson 2015; M. Thill 2015).

### **Limitations and Future Research**

A promising area of future research pointed to by our findings is to further investigate the role of dedicated resources (or asset-specific investment) on buyer-supplier trust and performance. Several previous studies that have attempted to study this concept (e.g., Handfield and Bechtel 2002; Nyaga, Whipple, and Lynch 2010) have hypothesized a positive relationship between dedicated resource investments and trust but find no support for this hypothesis based on their sample (e.g., Handfield and Bechtel 2002). It is certainly interesting to parse the types of dedicated resource investments into human resources and physical or informational resources. Furthermore, identifying whether such resources are directly or indirectly accounted for in pricing may also clarify these concepts. At least in our study, there is acknowledgement that supplier representatives are necessary to provide value for the buyers (since dedicated resources were positively associated with performance), but much skepticism remains regarding the true motives and potential hidden agenda of these suppliers, to the point that some healthcare systems have started outsourcing or disintermediating the role of the supplier representative (J. Lee 2014; Pauly and Burns 2008). A fruitful research direction that can push the boundaries of our knowledge about the dark-side of buyer-supplier trust can examine the conditions where dedicated resources are perceived to be beneficial to trust (Dyer and Singh 1998), trust-neutral, or detrimental to trust (Day et al. 2013).

Finally, the role of the physician in the buyer-supplier relationship as a “surrogate buyer” draws significant implications that may not be well captured in our dyadic trust model (Bhakoo, Prakash Singh, and Amrik Sohal 2012). Courtship efforts by both hospital purchasing managers and supplier representatives make a case for conceptualizing buyer-supplier relationships in the triadic context (L. R. Burns et al. 2009). This context can certainly benefit from--and be of benefit to--recent developments in service triads research (e.g., Wynstra, Spring, and Schoenherr 2015).

### **CONCLUDING REMARKS**

The large accumulation of research about inter-organizational trust and continued interest in the topic underscores the importance of this research area (Delbufalo 2012). There is little debate left that trust provides mutual gain for supply chain partners. However, more research is needed to examine the progression and attainment of trust, which recent research has begun to explore (Vanpoucke, Vereecke, and Boyer 2014). Furthermore, an excess of any trust enabler, such as dedicated resource investments or long contracts, may tip the balance towards entrenchment and "sticky" relationships, causing complacency and relationship stagnation (Day et al. 2013). Findings in this study begin to consider such implications, particularly with the frequent negative portrayal of dedicated human resources in healthcare. There is an acknowledgment that there is value in the services that supplier representatives offer, but also a high-level suspicion around supplier representatives, at least as perceived by hospital purchasing managers and executives (J. Lee 2014; Robinson 2015). Perhaps a mix of multiple trust enablers (contracts, information transparency, and dedicated resource investments) is what is required to create a balanced trusting relationship.

Healthcare supply chains demonstrate a considerable lack of trust among trading partners (Dominy and O’Daffer 2011), providing a fitting context to study some of the trust barriers as well as how commonly recognized enablers are perceived in this adversarial environment. We examined both buyer (i.e. the hospitals) and supplier (manufacturers or distributors) perspectives, finding that they are highly congruent. Furthermore, perceptions of trust and its antecedents also generally agreed with findings in multi-industry samples of buyers and suppliers (Handfield and Bechtel 2002; Nyaga, Whipple, and Lynch 2010), with a few notable differences. In this environment, characterized by a high level of distrust, contracting appears to be an effective mechanism to hedge the risk of opportunism, clearing a way for collaborative relationships. Formalized contracts in the healthcare sector play a pivotal role in defining the buyer-supplier relationship, especially when this relationship is tempered by others forces such as intermediation (distributors, GPOs, consolidated service centers etc.) and government regulations. As healthcare systems engage in contracting in an environment characterized by global sourcing, pressures towards reducing supplier-base and customized demand, the contracting language must be diligent in its ability to reduce dependency and sustain successful relationships.

## CHAPTER 3

### THE ROLE OF PROFESSIONAL BUYERS IN A SUPPLY CHAIN TRIAD

#### **ABSTRACT**

This study examines how alignment between players of an agency triad in a supply management context influences decisions and performance. We apply the literature on professionalism and supply chain triads to the health sector to better understand the procurement process, which involves the physician, hospital, and medical device manufacturer. Based on a cross-sectional sample of hospital data, we estimate random effects models to investigate the association between physician-hospital integration arrangements and hospital supply performance. Our results provide empirical evidence that physician-hospital alignment is associated with lower hospital supply expenses, supporting theoretical propositions about agency triads. The findings contribute to research surrounding supply chain triads, the role of professionals in health care procurement and has implications for healthcare management research.



## **INTRODUCTION**

Research on supply chain triads has increased significantly in the past decade. Some researchers have proposed that the triad is the smallest unit of analysis to consider when studying supply networks (Choi and Wu 2009). In a recent special issue by the *Journal of Operations Management*, Wynstra, Spring, and Schoenherr (2015) map out the theoretical progression and proliferation of triads in the supply chain literature. Of particular interest to this research is the branch of supply chain triads that considers two internal actors--usually the purchasing department and a professional—and a supplier as an external actor. The involvement of professionals as “surrogate buyers” (Solomon 1986) in the procurement process introduces significant complications to the buyer-supplier dyad, effectively transposing it into an agency triad (Tate et al. 2010).

Professionalization has become prevalent in society, with the global trend towards knowledge-based economies. Sociologists have long studied how professions represent a departure from other occupations with their high level of power, autonomy, knowledge monopolization, and exclusionary jurisdictions (Abbott 1988; Freidson 1983; Larson 1979). Even when employed within bureaucratic organizations, professionals such as lawyers, accountants, physicians, or engineers have a strong influence in the decision-making and value creation processes. In supply chain management, this translates to conflicts between supply managers and the professional users. Supply managers often find themselves at odds with the professionals, particularly in matters of supply selection (Lewis 2012; Tate et al. 2010; Wind and Robertson 1982). In such a context, professionals assume the role of surrogate buyers who make decisions based on their expertise, on behalf of the buyer or consumer (i.e. the organization). Therefore, in purchasing matters with surrogate buyer involvement, two principals –the professional and the supply

manager—interface with the agent supplier. Divergent incentives (or simply a lack of communication) between the two principals can lead to sourcing issues and exposes the principals to opportunism by the agent (Tate et al. 2010). Thus, alignment between the supply manager and the professional is essential in navigating supply chain agency triads.

Our research question asks how two different types of alignment between the two principals of the agency triad impacts procurement performance. We build upon the work of Tate et al. (2010) by empirically validating some of their theoretical propositions, and applying the theory to other professional services outside marketing. Our work also answers the call for future research in a recent study by Nyaga et al. (2015), which begins to examine impacts of physician-hospital alignment on hospital supply chain performance. We address several limitations in that study and further develop their theoretical basis. The physician-hospital-supplier triad has long been a topic of discussion in the healthcare management literature (Burns et al. 2009; Lerner et al. 2008; Montgomery and Schneller 2007; Pauly and Burns 2008), and we believe it is important that the supply chain literature participates in this discussion, both to inform healthcare practice and to expand upon supply chain theory (Abdulsalam et al., 2015).

Drawing from sociology and management theory on professionalism in bureaucratic contexts (Freidson 1983; A. Sharma 1997), we examine two mechanisms that push physicians towards aligning with the bureaucratic organization they reside in: bureaucratic pressures and professional hierarchy pressures. Using a random effects regression model, we operationalize our hypotheses in the healthcare context. The analysis is based on a U.S. sample of hospitals and considers bureaucratic pressures in the form of physician employment; and professional hierarchy pressures as physician affiliations with various forms of physician-hospital

arrangements. Our analysis indicates that both physician employment and physician affiliations with tightly-integrated physician-hospital arrangements lead to a reduction in supply expenses. The results demonstrate that these two alignment mechanisms, which have very different implications and structures for both the professionals and the organization (i.e., hospital), are feasible methods to move professionals towards standardization of practices when it comes to physician supply preferences.

A methodological contribution of this study is in demonstrating the viability of a random effects model in analyzing the impact that alliances and systems have on the hospitals (Bazzoli et al. 2004; Burns and Pauly 2002). Many studies use a dummy variable to account for a hospital's affiliation with a system (e.g., Chen, Preston, and Xia 2013; Wang et al. 2005), whereas this study uses a random effects model to consider the variance in supply expenses associated with systemization. Through the random effects model, we identify and test factors that may explain system-level variance, such as the level of decision-making centralization across system hospitals. Such a method and context can be leveraged in future research to examine how mergers, acquisitions, and alliances effect supply performance.

Finally, this research adds some clarity to the inconsistent research findings in the healthcare management literature regarding the impact of physician-hospital arrangements on hospital costs (Bazzoli et al. 2004). Physician-hospital arrangements impact cost in multiple ways: increasing some costs, such as coordination and employment costs while decreasing others such as monitoring and other agency costs. This study shows that physician-hospital arrangements provide value to at least one specific source of operating costs, supply expenses.

The next section provides some theoretical background on agency triads in supply chains, explored further through a brief review of the literature about

professionalism and surrogate buyers. This theoretical framework is then overlaid onto the healthcare context, as we develop our hypotheses regarding the effect of physician-hospital alignment on supply performance. This is followed by a description of the research methods and the analysis. Finally, we discuss the results and their implications for theory and practice, before concluding with some thoughts about future research.

## **LITERATURE REVIEW**

### **Professionals as Surrogate Buyers**

An extensive literature about professions exists in sociology and management, discussing the characteristics that define professions, what differentiates them from other occupations, and how professional norms and behaviors impact the stakeholders around them (Abbott 1988; Freidson 1983). Professions are occupations that “*apply in their work a body of knowledge and techniques acquired through training and experience, have a service orientation and distinctive ethics and have a great deal of autonomy and prestige in the modern economy.*” (A. Sharma 1997, 763). One school of thought emphasizes social system preservation and stewardship, where professionals uphold an ethical obligation towards society and their clients, and by doing so they preserve their prestige as honored servants of public need (Davis, Schoorman, and Donaldson 1997; Freidson 1983; Parsons 1968). A second conception frames professionals as conforming to the classical economic concept of *homo economicus*--the rational, self-interested man (Larson 1979; A. Sharma 1997).

The stewardship approach to professionalism argues for *self-control* and *community control* as the dominant restraints on potential opportunism of professionals (professional hierarchy pressures), while the agency conception argues

that *bureaucratic control* and *client control* (bureaucratic hierarchy pressures) are the major restraints against opportunistic inclinations (A. Sharma 1997). In addition to inhibiting potential opportunism, these restraints have unavoidable side-effects on professionals that impact their behaviors and norms. Of the four restraints mentioned above, the one that places the highest tension on professional behaviors and norms is bureaucratic control (i.e. when professionals are engaged with large bureaucratic organizations) often leading conflicts (Blau and Scott 1962; Green 1975; Hall 1967; Sorensen and Sorensen 1974). Yet, the most prototypical professionals (accountants, lawyers, physicians, professors, etc.) are commonly employed by bureaucratic organizations, making this issue of high practical relevance, intriguing sociology and management researchers for many decades (Hall 1967; Parsons 1968; A. Sharma 1997; Wallace 1995). Tension arises from the stark differences in bureaucratism and professionalism vis-à-vis source of authority, direction of loyalty, and discretion in task execution. Conflicts that arise from these tensions include the professional's rejection of standards, resistance to supervision, and compromised loyalty towards the bureaucracy (Freidson 1988; A. Sharma 1997; Sorensen and Sorensen 1974). This erosion of professional power and increased assimilation of professionals in bureaucratic organizations was coined by Marie Haug (1988; 1972) as the "deprofessionalization" hypothesis.

Eliot Freidson (1994; 1985) noticed that when professionals within bureaucracies faced with the changing the landscape for professions caused by commercial and bureaucratic forces, they coordinate among themselves and adapt in ways to retain their autonomy and power within the bureaucracy. Freidson's restratification thesis proposes that in order to alleviate the bureaucratic pressures and the threat of deprofessionalization, professionals that reside in bureaucracies form internal hierarchies as a way to protect their autonomy and power in the bureaucratic

workplace. From these internal hierarchies, “professional elites” rise up to interface and engage with the bureaucracy and govern the rest of their professional colleagues, referred to as the “rank and file” professionals. Thus, for rank-and-file professionals, bureaucratic pressures are substituted for professional hierarchy pressures that the elites apply. Professional hierarchy pressure presents a more favorable alternative to bureaucratic pressures for professionals since it comes from more a legitimate source —their respected professional peers. And while professional pressures define guidelines and standards of work, professionals retain a sense of “collective” autonomy and power even as they reside within highly structured bureaucratic organizations (Freidson 1994; Waring 2014).

Of particular interest to this research is the professional-bureaucratic friction in the supply chain function. More specifically, a professional’s duty as a *surrogate buyer* for an organization (or the organization’s client) may clash with an organization’s bureaucratic structure, which favors standardization over individual professional judgment. Michael Solomon (1986) identifies the *surrogate consumer*— or buyer— as an agent of the consumer to “guide, direct, and/or transact marketplace activities” on his behalf (Solomon 1986, 208). Surrogate buyers are generally professionals (i.e. financial portfolio managers, interior designers, physicians, engineers, etc.) who demonstrate different degrees of influence over choice, ranging from descriptive (e.g. travel agents) to prescriptive (e.g. physicians) (Aggarwal, Cha, and Wilemon 1998).

The service that a surrogate buyer provides is frequently reflected in the direct interactions between the surrogate buyer and suppliers, even when the formal transaction occurs between the buyer and supplier. In that respect the marketing literature about buying centers has recognized the level of influences of surrogate buyers, referring to them as the “linking pin” between organizations (Wind and

Robertson 1982). Recognizing the influence that surrogate buyers have on supply selection, suppliers often attempt to take advantage of the interaction with the surrogate buyer to improve chances that consumers will adopt their products (Aggarwal, Cha, and Wilemon 1998). For example, surrogate-supplier interactions are prevalent in the health sector, where medical device manufacturers form strong relationships with physicians, undermining the hospital's (i.e. the buyer's) influence over price negotiations and selection (Burns et al. 2009). The result is a complex triadic dynamic between the buyer, supplier, and surrogate buyer.

### **Agency Triads**

In the past decade, supply chain research has been undergoing a significant paradigm shift from understanding dyadic relationships between buyers and suppliers, towards understanding the network of relationships around a focal firm (e.g., Choi and Wu 2009). Sociological network theories have been utilized as frameworks to guide developments in supply chain triads and network research (e.g., Burt 1992; Emerson 1962; Tichy, Tushman, and Fombrun 1979). Richard Emerson (1962) discussed triads, explain how different balancing operations can occur when player C is introduced to a dyad of A and B. Even though such theories were first developed to describe interpersonal interactions, they prove to be highly applicable to inter-organizational dynamics. The value that comes from these half-century old theories comes from their clever crafting: "*... these formulations have been so worded in the hope that they will apply across a wide range of social life.*" (Emerson 1962, 33).

A wide variety of triadic structures have been examined, such as the buyer-supplier-supplier triad (Choi et al. 2002; Wu, Choi, and Rungtusanatham 2010; Wu and Choi 2005), and multi-tiered supplier-buyer-customer triads (Bastl, Johnson, and Choi 2013; Mena, Humphries, and Choi 2013). Recent studies also consider the

triadic context with two entities within a single organization (i.e. the purchasing agent and the user) interacting with each other and the external supplier, as three players with divergent interests (Wynstra, Spring, and Schoenherr 2015). This dynamic becomes particularly relevant in procurement contexts that involve professionals who embody the role of a surrogate buyer. Recognizing that marketing services are a form of professional services, Tate et al. (2010) apply the concept of surrogate buyers to the service triad between the buying organization, the marketing professional, and the supplier to develop theory about *agency triads*. Agency triads represent the case of an agent (generally the external supplier) being engaged by two principals from the same organization. The principals, in this case, are co-initiators of the transaction with the agent and have some “ownership” stake in the transaction. The principals in the procurement context are the supply manager and the professional. The propositions that are developed out of Tate et al.’s (2010) case studies emphasize the importance of alignment between the two principals (i.e. the buyer and the surrogate buyer), or else the agent will act opportunistically or behave only to the favor of one of the two principals.

However, the recent research about the professional service triad has been largely limited to conceptual and/or qualitative work (Wynstra, Spring, and Schoenherr 2015). Empirical research can potentially provide a significant contribution as procurement issues continue to increase in importance in organizational strategy. Conflicts between the professional surrogate buyer and the bureaucratic purchasing organization are persistent and prevalent in many contexts, suggesting a continuing need to address relationships between alignment and optimized sourcing strategies (Bhakoo, Prakash Singh, and Amrik Sohal 2012; Burns et al. 2009).



## **The Physician-Hospital-Supplier Triad**

To study the role of the professional surrogate buyers in agency triads, we look to the healthcare purchasing context involves the hospital, medical device manufacturer, and physician (Burns et al. 2009). Physicians are widely recognized as both professionals (Freidson 1988; A. Sharma 1997) and as surrogate buyers (Aggarwal, Cha, and Wilemon 1998; Bhakoo, Prakash Singh, and Amrik Sohal 2012). The overall influence of physician supply selection decisions is substantial, considering that 60% of a typical hospital's supply spend is on the aptly named *physician preference items (PPI)* category (Lerner et al. 2008; Montgomery and Schneller 2007). Finally, confining the study to a single industry controls for industry-specific norms and nuances. This is particularly important since, as mentioned earlier, the role of surrogate buyers in different industries varies significantly with respect to activities performed and their level of influence over the buyer (Solomon 1986).

The physician-hospital-supplier triad provides a rich context for research because both physical products, as well as support services, are involved in the exchange between hospitals, physicians, and suppliers (Burns et al. 2009). Multiple governance mechanisms –both relational and contractual– exist between physicians, hospitals and suppliers. First, the hospital and supplier have an exchange relationship, and hospital-supplier integration is often pursued in order to achieve better purchasing performance (Chen, Preston, and Xia 2013). Second, multiple types of relationships can exist between the physician and the hospital, including employment, contract-basis, voluntary-basis, admitting privileges etc. (Burns and Muller 2008; Casalino et al. 2008).

As surrogate buyers who choose the treatment and clinical products on behalf of the patient and the serving hospital, physicians have a significant amount of

discretion in supply selection. Three factors in particular lead to the physicians having a high level of discretion over supply selection: (1) their professional expertise, (2) the combination of limited price transparency, limited comparative product effectiveness research, and the lack standardization regarding medical products nomenclature (Lerner et al. 2008; The Brookings Institute 2015) and, (3) the high level of service customization required to cater to diverse patient needs (Landry and Beaulieu 2013). Even though physicians influence a large portion of hospital supply spend, they pay surprisingly little attention to the costs associated with the medical supplies they select. Okike et al.'s (2014) study demonstrates that less than a quarter of the orthopedic surgeons surveyed had a good estimate (within 20%) of the actual cost of the medical devices they selected for their patients. This is certainly influenced by the physicians' stewardship and oath towards patients, but little consideration is taken for hospital interests.

Finally, physicians generally develop strong relationships with suppliers their representatives, who support physicians in post-sale product-related services and education (Schneller and Smeltzer 2006; Thill 2015). Recognizing the important role of physicians in supply selection, suppliers very often form close relationships with physicians and invest heavily in these relationships by providing training, dedicated resources, value-added services, and other incentives (Montgomery and Schneller 2007). Particularly for sophisticated (and high-valued) medical or surgical devices, supplier representatives play a significant role in assisting the physician in the use of the device (Lee 2013a). The extent to which suppliers work to influence physicians through a variety of incentive schemes has resulted in regulatory interventions, such as the Physician Payments Sunshine Act, to monitor the physician-supplier dyad (Kracov et al. 2013). The Sunshine Act requires manufacturers of drugs, medical devices and biologicals that participate in U.S. federal healthcare programs to report

certain payments and items of value given to physicians and teaching hospitals (Iezzoni et al. 2012).

The relationships between the hospital, physician and the supplier are summarized in Figure 7. The relationships described in the figure are largely in reference to “privileged physicians,” physicians who have operating privileges at one or more hospital (and perhaps contractual agreements), but are not employees of any hospital.

### HYPOTHESIS DEVELOPMENT

Two hypotheses are offered, based on the proposition that a higher degree of alignment between the buyer and the surrogate buyer will act in favor of the buyer who attempts to override the surrogate buyer’s bridge position (Tate et al. 2010). Sharma (1997) expresses a similar idea from another perspective, stating that the professional is less likely to behave opportunistically when there is a high degree of alignment and coproduction with the principal. Hence, when there is a high degree of

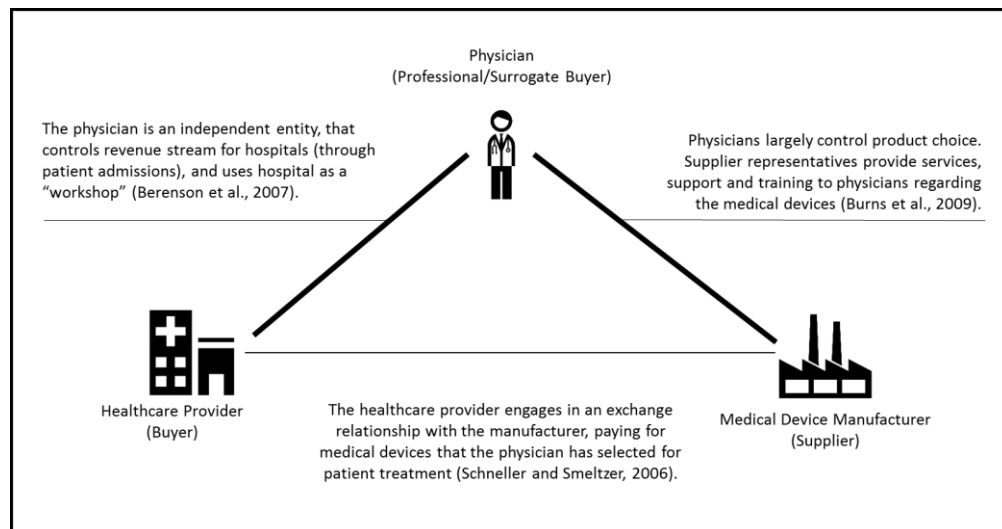


Figure 7. The buyer-professional-supplier triad in healthcare purchasing

alignment between the physician and hospital, both the physician and the supplier are less likely to act opportunistically towards the hospital.

Recent regulation, such as the Affordable Care Act of 2010, has pushed for more attention towards physician-hospital integration to better align incentives for achieving high quality in patient care (Burns and Pauly 2012). Burns and Muller (2008) review a wide continuum of strategies for physician-hospital integration. Broadly speaking, we hypothesize about two alignment pressures to which professionals may be exposed to bureaucratic pressures and professional hierarchy pressures. Bureaucratic pressures (related to bureaucratic and client control) emanate from the institutional environment in which a professional may be duty-bound (Green 1975; M. R. Haug 1988). Professionals operating in bureaucracies may also face conformance pressures from the professional elites who coordinate and their professional colleagues through internal professional hierarchies that interface with the bureaucracy (i.e. community control).

### **Bureaucratic Pressures**

Alignment between two parties may be a result of various forms of contracts or other relationship artifacts (e.g., trust, mutual gain). Certainly, agency theory speaks extensively about incentive alignment and various forms of contracts (Eisenhardt 1989). The most commonly used form of contract used for agents is the employment contract. Physician employment in the hospitals has been a long-debated topic in healthcare management literature (Bazzoli et al. 2004; Berenson, Ginsburg, and May 2007; Dynan et al. 1998). Hospitals may choose to employ physicians for numerous reasons such as to extend service lines, increase negotiating leverage with health plans, or minimize specialist search costs (Casalino et al. 2008). Nonetheless, there is a high level of variance across hospitals in the percentage of employed physicians, and the majority of physicians operate as voluntary medical staff (i.e. privileged or

voluntary physicians). Such physicians utilize hospitals as workshops to carry out their professional services, directly buying services from the hospital but not competing with them (Berenson, Ginsburg, and May 2007; Casalino et al. 2008). Voluntary physicians display the lowest level of commitment to hospital organizations (Burns et al. 2001; Zuckerman et al. 1998).

While research regarding the effects of physician employment on hospital performance has produced mixed findings ( Bazzoli et al. 2004; Berenson, Ginsburg, and May 2007; Chukmaitov et al. 2014), there is consistency in demonstrating that salaried physicians have the highest level of commitment to the hospital when compared with non-salaried physicians (Burns et al. 2001; Zuckerman et al. 1998). Commitment is defined as "*the strength of an individual's identification with and involvement in the organization along three psychological dimensions: the desire to remain in the organization ('continuance commitment'), willingness to exert considerable effort on its behalf, and belief in and acceptance of its goals and values.*" (Burns et al. 2001, 12). Embedded within this definition of commitment is the incentive for physicians to align their actions with the well-being of the hospital, which includes supply selection in a coordinated manner that conforms to a hospital's strategic sourcing and standardization efforts. Wallace (1995) confirms the employment-commitment relationship with professionals in another context. His study shows that lawyers are more committed to a nonprofessional organization when they are employed by it, rather than contracted professionals or professionals working in professional organizations. There is a concern, however, that the employment of professionals may lead to their adherence to organizational norms at the expenses of exercising sound professional judgment (e.g. deprofessionalization).

Therefore, we propose that physician employment as a method of achieving alignment between the hospital and the physician will result in better outcomes for

the hospital in negotiating with suppliers, and that will reflect on the supply costs of the hospital.

*H1: Hospitals with a higher percentage of employed physicians incur lower supply expenses.*

### **Professional Hierarchy Pressures**

Besides employment, many other forms of physician-hospital integration arrangements exist. Hospitals often form joint venture arrangements with physician groups in order to achieve integration with the physicians, utilizing one of many potential joint venture models, such as physician-hospital organizations (PHOs), management service organizations (MSOs), and independent practice associations (IPAs) (Bazzoli et al. 2000; Dynan et al. 1998). These arrangements may be seen as a manifestation of Freidson's (1994) restratification thesis. Hospitals interface with the professional elites that lead these professional hierarchy structures while the rest of the practitioners adhere to the control of these elites as an alternative to adhering to the hospital's bureaucratic control. The professional elites establish boundaries and govern the rank-and-file practitioners while maintaining working relationship with non-professional groups at the hospital including procurement, contracting, and performance management (Waring 2014).

Burns and Muller (2008) review various forms of physician-hospital integration across economic and clinical dimensions. Arrangements are generally classified as either tight physician-hospital arrangements or loose physician-hospital arrangements (Chukmaitov et al. 2014; Dynan et al. 1998). Such a classification is based on the level of physician involvement in governance, capital planning, economic involvement and clinical integration. Furthermore, the research suggests that such contractual models of physician-hospital integration may be just as

effective in achieving organizational objectives compared to ownership models (Dyner et al. 1998). From the perspective of the professional, such arrangements provide support through an association of like-minded colleagues around the professional-- a core feature of professionalization (Sorensen and Sorensen 1974). Physician-hospital arrangements provide an integration mechanism that, consistent with the restratification thesis, retains a collective autonomy among professionals while allowing for standardization that is facilitated by the professional elites (Freidson 1994; James C. Robinson 1997; J. C. Robinson and Casalino 1996). Such structures reinforce self-control and community control, which restrain potential professional opportunism: *"scrutiny by professional peers neutralizes the agent's advantage of unique access to an esoteric body of knowledge and exposes the behavior of agents for comparison with the work and ethical standards of their respective community of professionals"* (Sharma 1997, 780). Therefore, with such arrangements, the hospital can align its interests with the physicians through the professional elites who cater to the hospital's interests by influencing the rest of the practitioners (i.e. the "rank and file" professionals) towards norms that result in mutual gains (Waring 2014).

Some studies have demonstrated that physician-hospital arrangements positively impact cost containment initiatives and improve quality for the hospital (Burns and Muller 2008; James C. Robinson 1997). However, other studies have suggested that the cost of coordinating physician integration offsets any improvements in hospital costs and quality, and may even adversely impact some performance metrics (Burns and Pauly 2012; Chukmaitov et al. 2014; Mark et al. 1998). With respect to supply expenses, we hypothesize that the more physicians engaged in tightly-integrated physician-hospital arrangements, the lower are supply expenses. This comes from the fact that physicians are more likely to conform to standards that

have been negotiated by the professional elites, and are less likely to engage in opportunistic behavior with the suppliers (Freidson 1985; A. Sharma 1997; Waring 2014).

*H2: Hospitals with a higher percentage of physicians engaged in tightly-integrated physician-hospital arrangements have lower supply expenses.*

## **RESEARCH METHODS**

### **Sample**

The unit of analysis for testing the hypotheses is the hospital, which engages in numerous relationships with suppliers and physicians. To that end, secondary cross-sectional data on U.S. hospitals (from the fiscal year 2013) was collected. hospitals. The primary source of data is the American Hospital Association's (AHA) Annual Survey Database. Supplementary data was collected from the Center for Medicare & Medicaid Services (CMS). According to the American Hospital Association, there were 5,627 hospitals in the U.S. in 2014. In our data, 3,879 hospitals reported their annual supply expense for fiscal year 2013. Psychiatric, rehabilitation, and long-term care hospitals were removed from the sample since they were distinctly different from most other hospitals in terms of their operations and utilization of supplies. We also disregarded hospitals with less than 100 admissions during fiscal year 2013. This left us with a sample of 3,321 hospitals. After excluding observations with missing data on the variables needed for our analysis (i.e. list-wise deletion) we were left with a usable sample of 2,070 observations. The limiting factor in our data was the case-mix index, which is a measure of patient case intensity at the hospitals, made publically available by the Center for Medicare and Medicaid. Even though the availability of this measure disqualified many observations, it could not ignore this measure since it provides a good aggregate measure of the types of cases that the



Table 9. Observation filtering criteria

<b>Filtering Criteria</b>	<b>Sample Size</b>
Universe of U.S. hospitals	5,627
Supply expense information available	3,879
Not psychiatric, rehabilitation, or long-term care hospitals	3,381
Admissions of 100 or more patients per year	3,321
Physician employment information available	2,967
Case-mix index information available	2,070

hospital gets, and is often used as a control variable in analyzes of hospitals. Table 9 provides a summary of the observation inclusion criteria.

### **Variables**

#### *Dependent Variable*

The dependent variable of this study is the annual supply expense of hospitals. This measure is available from the AHA database. The definition of supply expense as presented by the AHA database is presented in Appendix C, as are the definitions are sources for all other variables used in this paper.

While more granularity regarding the different categories of supply expenditures would improve the precision of our hypothesis tests, this measure is adequate (and conservative) since physicians have a large impact on the hospital’s overall supply expenditures. Medical supply costs generally account for over 60% of total supply costs (Young, Nyaga, and Zepeda 2015). Other research has demonstrated that physician preference items alone account for well over 50% of supply expenditures at hospitals, giving physicians a strong hand in shaping a hospital’s supply expenses (Lee 2013b; Montgomery and Schneller 2007; E. S. Schneller and Smeltzer 2006). Finally, it is worth noting that physician preference items account for a large proportion of the variance supply expenses. While most commodity products are purchased by hospitals through standardized group purchasing contracts, sourcing

physician preference items occurs through direct relationships between the hospital and suppliers (Burns and Lee 2008). A result of this is a high level of variance in pricing, partly driven by a lack of price transparency and prevalence of non-disclosure agreements in the industry (Lerner et al. 2008; Pauly and Burns 2008). As an example, a survey of 100 hospitals showed that the price paid for an artificial hip ranged from \$2,000 to \$9,000 (Abelson 2006).

Some studies have used relative measures as dependent variables such as supply costs as a percentage of total operating expenditures (Nyaga, Young, and Zepeda 2015), or operating costs per bed (L. Sharma et al. 2016). We opted to use the supply expense and control for other factors (hospital size, total expenses, labor expenses etc.) rather than use a ratio and risk estimating confounding effects. For example, it is plausible that physician employment (one of the independent variables in this study) correlates with higher labor costs at the hospital. High labor expenses relative to total expenses means that supply expense will appear smaller relative to total expenses, even if employment has no impact on supply expenses. We follow guidance from Bergh and Ketchen (2009), by including that denominator (total expenses) as a control variable instead. A natural log transformation to the supply expense measure is applied to satisfy the normality condition required for conducting regression analysis and mitigating the effect of outliers on the analysis. This transformation is common in empirical research for measures of costs, revenues and size.

Since supply expense is the main focus of this study, we sought to independently validate our secondary data. This was to ensure that respondents of the AHA Annual Survey fully understood the components of the supply expense and reported accurate values. To do so, we contacted the supply chain leaders (e.g. "Vice President of Supply Chain" or equivalent) of three large health systems and

Table 10. Supply expense related metrics

	<b>mean</b>	<b>sd</b>	<b>median</b>	<b>min</b>	<b>max</b>
Supply Expense (Mil \$)	34.96	66.7	13.21	0.05	1466.75
Total Expenses (Mil \$)	190.27	309.09	80.55	3	4435.29
Supply per admission (CMI)	2,809.04	3428.32	2295.27	100.75	118238
Supply Expense / Total Expense	0.1613	0.08	0.15	0	0.63
ln(Supply Expense)	16.26	1.63	16.4	10.9	21.11

Notes: n = 3,321, except for supply per case-mix adjusted admissions (n = 2,304) since this measure required information about hospital admissions and case-mix index, which was not provides for in all observations.

requested from them the 2013 supply expenses for the hospitals they manage. For these three systems, AHA Annual Survey reported supply expense data for 115 hospitals. Our informants provided data for 92 of these hospitals.<sup>3</sup> The correlation between the secondary AHA data and our primary data was 0.9846, providing a strong indication that the data provided by the AHA Annual Survey was highly reliable. Table 10 provides descriptive statistics for different supply cost metrics and Figure 8 illustrates their distributions.

#### *Independent Variables*

Our first measure of physician-hospital integration is the percentage of physicians that are employed, relative to the total number of physicians with operating privileges at the hospital. Besides employment, physicians engage in affiliations with hospitals through physician-organization arrangements (POA) with the hospital. We operationalize this construct using two variables as done in Chukmaitov et al.'s (2014) study. Dynan et al. (1998) categorize eight forms of POAs into two categories: tightly-integrated POAs (group practices without walls, integrated salary model, equity model, and foundation model) and loosely-integrated POAs (independent practice associations, open physician-hospital organization, closed

<sup>3</sup> Changes hospital ownership, between 2013 and the time we requested this data from our informants (late 2015) prevented our informants from accessing data for all 115 hospitals.

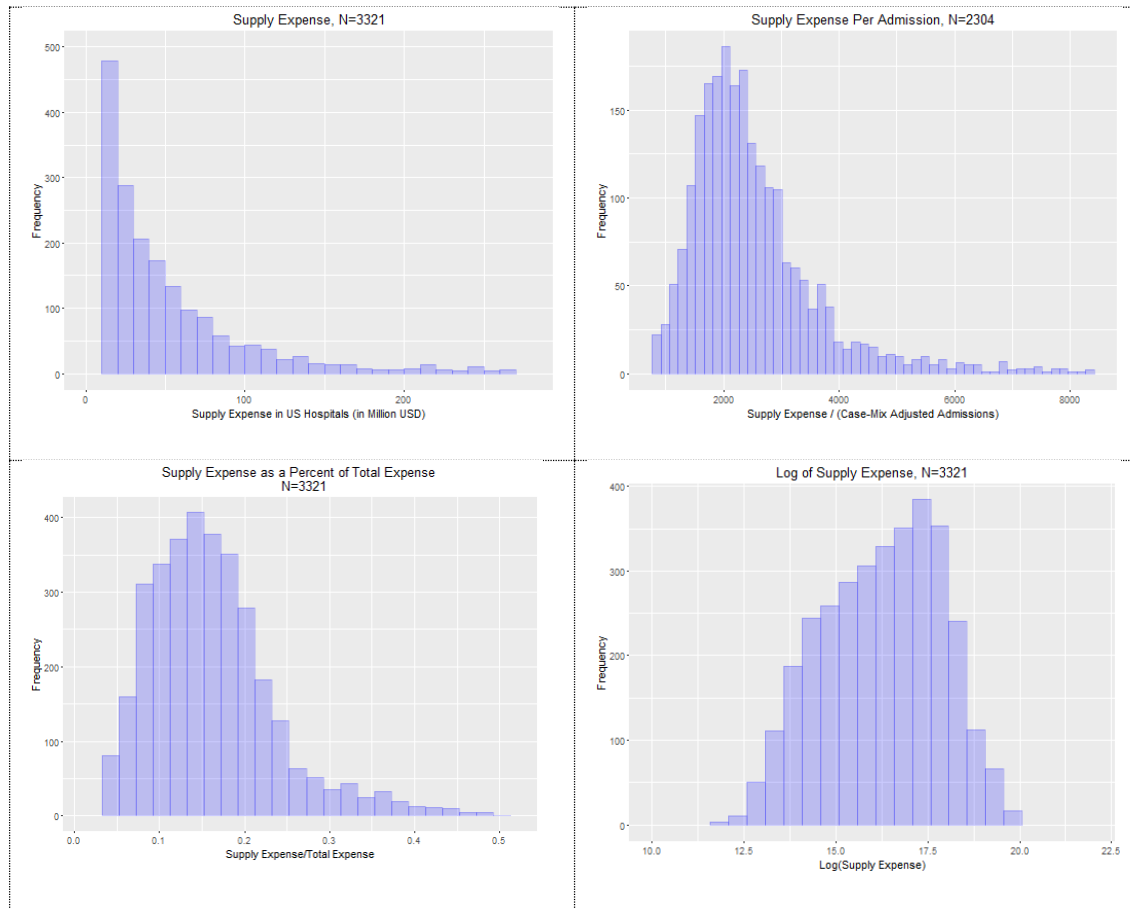


Figure 8. Distributions of supply metrics

physician-hospital organizations, and management service organizations). A description of each POA is presented in Appendix D.

#### *Hospital-level Control Variables*

We controlled for a number of different variables in this study. They are described briefly here, and Appendix C provides more complete descriptions and sources for each variable.

Inpatient days was used as a proxy for hospital size. Other empirical studies that have looked at hospitals in the supply chain and operations management discipline have used similar measures for size including number of beds, patient admissions, or number of employees (Chen, Preston, and Xia 2013; Nyaga, Young, and Zepeda 2015; L. Sharma et al. 2016). While all of these measures are highly correlated, we

believe that inpatient days provide the best measure because it accounts for admissions as well as for the length of stay of each patient.

We control for the non-supply related hospital expenses. We subtracted the supply expense from the total expense and used that to control for other all other hospital expenses. This control variable also accounts for any differences in costs of operations based on a hospital's location. Therefore, there was less concern about controlling for regional or market competition. Expenses also served as a proxy for hospital size, and highly correlated with inpatient days. As a consequence, inpatient days was dropped to avoid multicollinearity issues in the regression analysis

We controlled for the clinical intensity of the hospital by including the case mix index (CMI). The CMI is an indicator of service intensity at the hospital based on the average complexity of the patient cases that are admitted to the hospital. This index is developed by the Center for Medicare and Medicaid Services, and commonly used in academic research to control for the patient mix in hospitals. Hospitals with a higher CMI are expected to require more resources (i.e. more expensive resources and supplies) to treat patients.

Dummy variables were used to control for urban versus rural hospitals, based on classifications by the U.S. Census Bureau. We also control for academic hospitals versus non-academic hospitals. Finally, dummy variables are used to control for the ownership status at hospitals, differentiating between non-profit, investor-owned, and government hospitals.

#### *System-level Control Variables*

We consider it important to recognize that the majority of hospitals in the United States are engaged in other hospitals in alliances of different sizes and structures, commonly referred to as health systems or integrated delivery networks. These alliances can influence a hospital's strategy, decision-making, and operations to

varying degrees depending on the level integration and centrality of the alliance. Previous research that examines hospitals has most commonly used a dummy variable to indicate whether a hospital is independent or part of a system (Chen, Preston, and Xia 2013; Mark et al. 1998; Wang et al. 2005). However, the diversity of the types of system alliances--in terms of centralized decision-making, shared services, geographic dispersion, services portfolios, etc.—suggests that different systems serve different needs and produce different outcomes (A. Chukmaitov et al. 2009; Dubbs et al. 2004).

The main drivers that motivate alliance behavior in healthcare are economic efficiencies, market power, and increased scope of operations (Bazzoli et al. 2004; Bazzoli et al. 2002; Begun, Zimmerman, and Dooley 2003). Dranove and Shanely (1995) also identify the major motivation for integration in healthcare is to centralize decision-making to gain economies of scale and scope advantages. More specifically economic efficiencies are achieved through quantity buying, avoiding duplicate services, and better access to capital (Markham and Lomas 1995). Certainly supply chain expenses are an important target when the objective is to achieve operating efficiencies.

In order to measure the effects of hospital alliances, we first recognize the clustering effect of health systems and use a random effects model to parse out the variance in supply expense from the “system-level” effect. We control for the level of centralization in the system with a variable from the AHA Database that classifies health systems. This classification is widely used in the healthcare management literature (Bazzoli et al. 1999; Dubbs et al. 2004). Appendix E provides a description of each of type of system. For the purpose of this study, we created a dummy

Table 11.1. Hospital-level descriptive statistics

		Mean	Stdev	1	2	3	4	5	6	7	8	9	10
1	Supply Expenses (mil)	46.84	77.75	1									
2	Physician Employment	0.20	0.27	0.12	1								
3	Tight-POA Physicians	91.23	255.7	0.45	0.21	1							
4	Loose-POA Physicians	166.7	574.0	0.19	0.06	0.19	1						
5	Inpatient days ('000)	50.25	60.71	0.86	0.10	0.41	0.20	1					
6	Total Expenses (mil)	246.7	347.9	0.91	0.19	0.56	0.19	0.89	1				
7	Case-mix Index	1.54	0.31	0.46	0.03	0.26	0.10	0.49	0.48	1			
8	Urban location	0.71	0.46	0.27	-0.08	0.16	0.14	0.36	0.30	0.43	1		
9	Teaching status	0.10	0.30	0.60	0.16	0.43	0.16	0.65	0.65	0.38	0.20	1	
10	For-profit hospital	0.15	0.36	-0.02	0.02	-0.02	-0.09	-0.01	-0.01	-0.15	-0.17	0.05	1
11	Government hospital	0.15	0.36	-0.14	-0.18	-0.13	-0.08	-0.15	-0.17	0.10	0.04	-0.12	-0.18

Notes: n = 2,070 hospital observations; Variables 8-11 are dummy variables; Physician employment is the percentage of employed physicians out of total privileged physicians at the hospital;

Table 11.2. Health system level descriptive statistics

	Mean	Stdev	Median	Max	Min	1	2	3
1. Number of hospitals in system	9.30	79.49	4	200	1	1		
2. Patient admissions total (thousands)	75.67	146.7	41.07	1,720.1	0.17	0.88	1	
3. Supply Expense / Total Expense (Average across system's hospitals)	18.2%	6.2%	17.6%	4.7%	46.8%	-0.07	-0.03	1
4. Centralized system (1=centralized, 0=decentralized)	0.65	0.47	1	1	0	-0.23	-0.14	-0.02

Notes: n = 303 health systems, based on the hospital data of 2,070 hospitals, 693 hospitals were not affiliated with a health system

variable to reflect whether a system is highly- to moderately-centralized versus decentralized or independent. We also controlled for the size of the health systems that hospitals belonged to, in terms of number of patient admissions across all hospitals that belong to the system.

Tables 11.1 and 11.2, provide descriptive statistics for the hospital-level and system-level variables included in our analysis, respectively.

### Analysis

To account for the nested nature of hospitals in health systems, we use a multilevel regression modeling approach (also known as hierarchical linear modeling)

to account for the effect that health systems may have on individual hospital supply performance, following common practices used for this approach as described below (Hox, Moerbeek, and Van de Schoot 2010).

#### *Unconditional Means Model*

We ran an unconditional means model to determine the proportion of variance explained at the hospital level and system level (Bliese and Hanges 2004; Hox, Moerbeek, and Van de Schoot 2010). This model is useful to test the assumption of independence between the hospital observations.

$$\ln(\text{SupplyExpense}_{ij}) = \gamma_0 + \mu_{0j} + \varepsilon_{ij} \quad \text{Eq. 1}$$

In this model,  $\gamma_0$  represents the grand mean (i.e. the intercept), while  $\mu_{0j}$  represents the group mean difference in system  $j$  (i.e. Level-2 residual), and  $\varepsilon_{ij}$  represents the within-group difference in hospital  $i$  within system  $j$  (i.e. the level-1 residual). Both  $\mu_{0j}$  and  $\varepsilon_{ij}$  are assumed to be normally distributed with variances of  $\sigma^2_{\mu_0}$  and  $\sigma^2_e$ , respectively. The unconditional means model provides estimates for the between-group variance and within-group variance. From these estimates, the intraclass correlation coefficient (ICC) can be calculated as follows:

$$ICC = \frac{\sigma^2_{\mu_0}}{\sigma^2_{\mu_0} + \sigma^2_e} \quad \text{Eq. 2}$$

From our data, the intraclass correlation coefficient derived after estimating the unconditional means model was 0.281 ( $\sigma^2_{\mu_0}=0.30$ , and  $\sigma^2_e=0.75$ ). This indicates that about 28.1% percent of the variance in the dependent variable is explained by system-level differences. In other words, the *expected* correlation of total annual supply expenses for hospitals in the same health system is 28.1%. This outcome confirms that a multi-level modeling approach is needed to account for non-



independence of systemized hospitals and since both variance components are significantly different from zero (Singer and Willett 2003).

#### *Random Intercept Model*

A random effects model estimates hospital-level and system-level effects on the dependent variable. With a random intercept model, both hospital-level and system-level predictors can be added to the model to predict the supply expenses of hospitals. The structure of the random intercept model is as follows:

$$\begin{aligned} \ln(\text{SupplyExpense}_{ij}) &= \beta_{0j} + \beta_{1j}(\text{PhysicianEmployment}_{ij}) + \beta_{2j}(\text{LoosePOA}_{ij}) + \\ &\quad \beta_{2j}(\text{TightPOA}_{ij}) + \beta_{nj}(\text{HospitalControls}_{ij}) + \varepsilon_{ij} \\ \beta_{0j} &= \gamma_{00} + \gamma_{01}(\text{Centralization}_j) + \gamma_{0m}(\text{SystemControls}_j) + \mu_{0j} \end{aligned} \quad \text{Eq. 3}$$

## **RESULTS**

Table 12 provides the results from the random effects regression models that were estimated. Since our dependent variable is in the natural log scale, a one-unit increase in an independent variable is associated with a ( $\beta_x * 100$ ) percent increase in the dependent variable. The regression coefficients are also standardized, meaning that the units are in standard deviations.

A hierarchical regression approach was used to assess the incremental increase in explanatory power from the base model to the model that includes our study variables (by examining the Likelihood Ratio). Model 1 is the base model which includes only the control variables. Model 2 provides support for Hypothesis 1, regarding the negative relationship between physician employment and supply expenses, after taking into account other control variables. Hypothesis 2, is also supported based on Model 3. The results suggest that the greater the number of physicians that engage with the hospital through tightly-integrated physician arrangements, the lower the hospital's supply chain expenses after controlling for

Table 12. Random effects model estimation

	<b>Model 1</b>	<b>Model 2</b>	<b>Model 3</b>	<b>Model 4</b>
<i>Hospital-Level Variables</i>				
Physician Employment		-0.018** (0.006)		-0.021** (0.007)
POA – Tightly Integrated			-0.030** (0.008)	-0.026** (0.008)
POA – Loosely Integrated			0.010 (0.008)	0.010 (0.008)
Hospital Expenses (ln) (Total Exp – Supply Exp)	0.816** (0.010)	0.820** (0.010)	0.821** (0.010)	0.823** (0.011)
Case-Mix Index	0.239** (0.009)	0.234** (0.009)	0.241** (0.009)	0.240** (0.009)
Government hospital	-0.000 (0.036)	-0.008 (0.036)	-0.000 (0.036)	-0.006 (0.036)
For-profit hospital	-0.059** (0.023)	-0.063** (0.022)	-0.058* (0.023)	-0.062** (0.022)
Urban	-0.059** (0.017)	-0.052** (0.017)	-0.057** (0.007)	-0.05** (0.017)
Academic	-0.041** (0.008)	-0.039** (0.007)	-0.034** (0.007)	-0.033** (0.007)
<i>System-Level Variables</i>				
System Centralization	-0.023* (0.011)	-0.025* (0.011)	-0.022 (0.011)	-0.037* (0.012)
Total System Admissions	-0.038* (0.030)	-0.038* (0.030)	-0.037* (0.030)	-0.037 (0.030)
AIC	806.92	797.39	797.92	791.28
BIC	868.86	864.97	871.12	870.11
Deviance (-2LogL)	784.92	773.4	771.92	763.28
Likelihood Ratio (DF)	-	11.52** (1)	13.00** (2)	21.64** (3)

Notes: N=2,070 observations nested in 845 groups; \*\* p<0.01, \*p<0.05

POA = Physician-hospital Arrangements

other factors. Loosely-integrated physician arrangements showed no impact on supply expenses of a hospital. The level of centralization across hospitals within a system was negative and significant, suggesting that more centralized systems perform better in terms of controlling supply expenses.

The hospital's total expenses and case-mix index were significant predictors of a hospital's supply expenses. For-profit hospitals are associated with lower supply expenses relative to non-profit hospitals, and hospitals in urban locations were associated with lower supply expenses. A hospital's teaching status was found to be a significant predictor of supply expenses, where academic hospitals had fewer supply expenses, after controlling for all other factors.

### **Accounting for Endogeneity**

The potential risk of endogeneity is a serious issue to tackle directly, particularly so in this context due to the cross-sectional nature of the sample (Antonakis et al. 2010; Guide Jr. and Ketokivi 2015). Endogeneity, in this paper, is approached both theoretically and empirically. In the literature review and hypotheses section, a case is made for why physician-hospital integration impacts supply expenses. Supply expenses experience a lot higher fluctuation (driven by variations in annual admissions) relative to physician employment or affiliations. It is highly unlikely that hospitals change their physician hiring practices based on supply expenses.

Besides the risk of reverse causality, there may be confounding variables omitted from our analysis that influence both the supply expenses and the decision to employ physicians which we do not control for. To mitigate such risk, a two-stage least square (2SLS) regression model is estimated (Kennedy 2008). The percentage of voluntary physicians at the hospitals is used as the instrument variable, due to its high correlation with our focal independent variable (physician employment) and low correlation with the dependent variable. All other variables in the 2SLS model matched those in Model 4 of Table 12. The results of the model appeared to be highly consistent with the non-instrumented model (Table 13). To formally test this observation, the Durbin-Wu-Hausman test was used to compare the regression estimates of the two models. The test was not significant ( $\chi^2 = 17.60$ ,  $df = 13$ ,  $p >$

Table 13. Supplementary analysis

	<b>2SLS</b>	<b>System Hospitals</b> (n = 1,372)
<i>Hospital-Level Variables</i>		
Physician Employment	-0.09** (0.015)	-0.028** (.008)
POA – Tightly Integrated	-0.011 (0.009)	-0.041** (0.010)
POA – Loosely Integrated	0.016* (0.008)	0.013 (0.010)
Hospital Expenses (ln)	0.833** (0.010)	0.821** (0.012)
Case-Mix Index	0.237** (0.010)	0.239** (0.011)
Government hospital	-0.030 (0.037)	0.006 (0.044)
For-profit hospital	-0.076** (0.018)	-0.036 (0.037)
Urban	-0.025 (0.008)	-0.060 (0.021)
Academic	-0.031** (0.011)	-0.025** (0.009)
<i>System-Level Variables</i>		
System Centralization	-0.029** (0.011)	-0.016 (0.016)
Total System Admissions	-0.039* (0.031)	-0.032 (0.033)

Notes: \*\* p<0.01, \*p<0.05; in the 2SLS model, the Instrument used was percentage of voluntary physicians relative to total privileged physicians

0.1), meaning that we fail to reject the null hypothesis that our model and the instrumented model are different from each other. This increases our confidence that endogeneity between physician employment and supply expenses is not a major concern.

### **Omitting Single-Hospital Health Systems**

A substantial number of hospitals in our sample were single-hospital health systems (n=685), which generally consist of numerous healthcare facilities anchored around one hospital. Empirically, there are no issues with including single-unit groups in a random or fixed effects model. However, such hospitals may have

systematic differences relative to other hospitals that are not controlled for, which may impact the results. To weigh the effect of such hospitals on our analysis, our main model (Model 4) was analyzed using a subsample that omitted all independent hospitals. The results are displayed in the second column of Table 13. The results are highly consistent with the model that includes the full data, with respect to our focal variables.

## **DISCUSSION**

### **Theoretical Implications**

The main focus of this study is to extend a branch of supply chain triads literature that has recently emerged, examining the two units within the buying organization and supplier (Wynstra, Spring, and Schoenherr 2015). While much of the literature on triads has been developed using social network theory as a theoretical approach, we extend the study of this specific form of triad using sociology theory on professions with marketing perspectives on surrogate buyers and linking pins. More specifically, we examine the internal alignment between the two principals of an agency triad and how that impacts the relationship outcomes between one of the principals (the hospital's supply management) and the agent. First we investigate employment as a mechanism to increase the commitment of the professional to the organization and find that it reflected positively on supply expenses. This validates and extends recent studies that observe of the role of physicians in supply chain management (Young, Nyaga, and Zepeda 2015).

In recent years, there has been increased attention towards hospital costs and efficiency. An important consideration in this conversation is the role of physicians in supply management (Schneller 2015). As the surrogate buyers that act on behalf of the hospital and patients, physicians form a key bridging position between the

hospital and suppliers, particularly the suppliers of drugs and medical devices. Hospital supply managers often find themselves contending with supplier representatives for the physicians' attention and alignment (Burns et al. 2009). The physicians themselves carry their own agenda, acting in a manner to preserve their professional power and autonomy.

Employment of professionals in bureaucratic organizations has been extensively researched in the sociology literature (Green 1975; Sorensen and Sorensen 1974). The Professionalism-bureaucratism conflict is often discussed in such research due to the stark contrast that bureaucratic pressures exert on the professions. Unlike most other professions where employment is highly prevalent nowadays, in medicine, the percentage of physicians employed by hospitals is relatively low, average at about 20% based on our data. To work within bureaucratic organizations while retaining some level of autonomy, professionals develop and conform to coordination structures lead by the "professional elites" that interface with the bureaucracy in exchange for maintaining a level of autonomy and power (Freidson 1994). This substitutes the more threatening bureaucratic pressure with more accepted professional pressure towards conformance.

Physician-hospital arrangements which represent an instance of this phenomenon have had a presence in medicine and been gaining increasing interest in recent years (Freidson 1985; Waring 2014). These arrangements carry interesting implications to supply chain management in the agency triad context since they have the potential to drive supply chain conformance in professional practices without severely compromising the autonomy or power of the practitioners. With physicians acting as the surrogate buyers, a disregard to standardization effort by supply managers is cited as a major obstacle for hospital supply managers as they strive for more efficient sourcing (Lee 2013c; Montgomery and Schneller 2007). Using previously

developed conventions that classify arrangements are “tightly-integrated” and “loosely-integrated”, we find hospitals with more physicians that are part of tightly-integrated physician-hospital arrangements demonstrated lower supply expenses, after controlling for size, expenses case-mix, and other factors. It is interesting to note that marketing literature about buying centers identifies a concept parallel to the professional elites, referring to them as “linking pins”, who invoke legitimate power to influence purchasing decisions (Venkatesh, Kohli, and Zaltman 1995; Wind and Robertson 1982). One study concludes that: *“the key role that heads of a professional group (e.g., chief radiologists) play in the purchase decision. A primary marketing effort should be directed at this member of this type of organization, who, through his or her intra- and inter-organizational relationships, has a major impact on the adoption of innovative technology and practices.”* (Wind and Robertson 1982, 182).

This work also adds to the healthcare management literature which has been relatively inconsistent in its findings on the effects of physician-hospital arrangements. A review of the literature on physician-hospital arrangements concludes that *“it is not clear from these results if hospitals financially benefit from their physician-hospital integration activities”* (Bazzoli et al. 2004, 318). The studies reviewed generally considered overall hospital costs, without differentiating between the different types of costs. We examine one specific component of hospital costs—supply expenses—which is strongly linked to physician behavior and preferences (Burns et al. 2009; Schneller and Smeltzer 2006). It may well be the case that the additional costs such as physician salaries or coordination costs of physician-hospital arrangements negate the cost reductions in supply expenses. It is also possible that the increasing attention to healthcare supply chain costs in recent years and the pressures to increase operating efficiency caused aligned physicians, particularly the

influential professional elites, to be more diligent to supply chain concerns than they were in the past (Landry and Beaulieu 2013). Initiatives such as the government's Open Payments Program (Kracov et al. 2013), which mandates transparency in physician-supplier relationships, provide credence towards this idea.

### **Practical Implications**

To the best of our knowledge, this study is the first to examine a hospital supply expenses at a national level. Researchers have previously estimated that supply chain expenses account for about one-third of total hospital expenses (Chen, Preston, and Xia 2013; Kowalski 2009; Nachtmann and Pohl 2009). Based on the data we analyzed, expenses as a percent of total expenses was about 17%. This is significantly lower than values cited by previous years, which have ranged between 25 and 40 percent. One possible reason might be in the timing of the data collection. Our study analyzes 2013 data while other studies have cited data from 2008 or earlier. It is plausible that with more attention towards hospital operations and supply chains, managers have reigned in supply expenditures over the past decade. A second reason might be due to variations in the sampling between previous studies and ours. Most previous studies that have provided estimates were based on survey data (e.g., Nachtmann and Pohl 2009), whereas this study resorted to secondary data report by the Hospitals to the AHA. The validation efforts we have taken to ensure that the supply expenses numbers reported by the hospitals in our secondary data were accurate provide assurance that data in the AHA survey was accurate. A few types of hospitals such as cardiology, orthopedic, and surgical hospitals did demonstrate supply expenses between 30 and 35% on average. General medical and surgical hospitals (which account for 80% of total hospitals) had a supply expense of about 16%.



The application of the random effects model is a departure from previous methods used to isolate the effects of systems on hospital decision-making and performance outcomes. The unconditional means model and the intraclass correlation coefficient suggest a system-level effect on supply expenses across hospitals of the same system. We assessed the effect of a system's centralization on the supply expenses of hospitals belonging to that system and find that more centralized systems (i.e. systems with hospitals that are within close proximity of each other, centralized decision making, shared services, etc.) demonstrated lower supply expenses when controlling for other hospital factors. The size of the system, in terms of total patient admissions across all of the system's hospitals, did not appear to influence supply chain efficiency at hospitals.

The performance impacts of hospitals affiliated with health systems compared to free-standing hospitals have been debated in the healthcare management literature (Bazzoli et al. 2004; Burns and Pauly 2012; Burns and Pauly 2002). We hope that demonstrating the use of the random effects model to study system-level influences on hospital performance triggers more research about the effect of alliances and networks on supply chain performance.

### **Limitations and Future Research**

Several limitations exist in this study. First, we acknowledge that our study was conducted at the firm level (i.e. the hospital), whereas hospital-physician-supplier triad dynamics occur at the transaction level. Particularly, it is in the transactions for high-valued physician preference items where the effects of physician integration are expected to be most strongly observable on supply expenses. Instead of this unit of analysis, we examine the hospital's annual supply expenses, which is essentially the aggregate of all supply transactions that physicians may have influenced, including other non-clinical supply costs. However, knowing that physician preference items

constitute over 50% of a hospital's supply expenses suggests that the variance in total annual hospital supply expenses is, in fact, being driven –at least partially-- by physician choice. Therefore, we consider our estimates to be conservative and expect to find stronger effects when examining the variance of only supply expenses that were associated with physician preferences. Future research can study the variance in costs of specific clinical departments (or even down to specific medical devices) across different hospitals.

A second natural extension to this study is to elaborate further on the role of medical device manufacturers in this procurement triad. Our study focuses on the physician and hospital, and only theoretically explains the role of the suppliers. We did not empirically measure supplier alignment with the physicians nor with the hospitals. Physician-supplier alignment has gained a significant amount of attention in the recent years, with concerns about opportunism and misaligned incentives that may adversely impact the hospital and, more importantly, the patient (Kracov et al. 2013; Wilson et al. 2008). The Centers for Medicare & Medicaid Services (CMS) has been charged with implementing the Sunshine Act and has called it the Open Payments Program. As part of this program, manufacturers are now required to submit annual data on payment and other transfers of value that they make to physicians or teaching hospitals. Perhaps, researchers can use this information (which is publically available at [www.cms.gov/openpayments](http://www.cms.gov/openpayments)) to paint a more complete picture about the agency triad, and answer research questions stemming from the physician-supplier perspective.

From an empirical standpoint, we have attempted to demonstrate the robustness of our results but recognize that no estimation method is free of issues. For example, we mitigate the risk endogeneity by employing a 2SLS estimation method but are aware that sometimes instrumental variables bring in problems of their own into the

estimation (Murray 2006). We have also controlled for the factors that are commonly included in empirical research that use hospital financial measures (A. S. Chukmaitov et al. 2014; Nyaga, Young, and Zepeda 2015; L. Sharma et al. 2016). Future research can attempt to use a similar methodology to address questions about how hospitals alliances impact hospital performance and what factors best dictate the level of supply chain integration that can be achieved through different alliance structures.

## **CONCLUSION**

Overall, our study provides important insights for both theory and practice regarding achieving alignment between a buyer and surrogate buyer that are part of an agency triads. The complexity of procurement increases with the involvement of professionals as surrogate buyers in the process (Aggarwal, Cha, and Wilemon 1998; Wind and Robertson 1982). Our results suggest that professionals can be driven towards more mindful supply decisions through bureaucratic pressures, such as employment. More interestingly, we show that pressures on practitioners from professional hierarchies within bureaucratic organizations also bear similar results, suggesting that professional elites govern practitioners towards standardized practices (Freidson 1994; Wind and Robertson 1982). Future research should consider the coordination costs associated with each mechanism of alignment. Empirically, our study demonstrates the value of a random effects regression model when studying hospital performance, examine the effects of the health systems which hospitals are nested in.

Healthcare provides a fitting context to extend theory on agency triads and professional surrogate buyers. There is strong anecdotal evidence towards the increased awareness in the health sector regarding this agency triad. Hospitals are

more aware than ever regarding the need for physician alignment for better supply chain outcomes (Kutscher 2014; Lee 2013a; E. Schneller 2015). Physicians are being urged to pay closer attention to the implications of supply selection, especially with the recent push towards bundled payments and Accountable Care Organizations (Burns and Pauly 2012; Okike et al. 2014). Even the largest medical device manufacturers “*have faced increased price pressure from hospitals looking to cut costs by negotiating better discounts on implanted devices*” (Walker 2016). Certainly issues of hospital-physician alignment have implications beyond supply chains, but the research in this specific context will be very valuable to in extending theory to other triadic contexts beyond supply chains and healthcare.

## REFERENCES

- Abbott, A. 1988. *The System of Professions: An Essay on the Division of Expert Labor*. University of Chicago Press.
- Abdulsalam, Y., Gopalakrishnan, M., Maltz, A., and Schneller, E. S. 2015. "Health Care Matters: Supply Chains In and Of the Health Sector." *Journal of Business Logistics* 36 (4): 335–39.
- Abelson, R. 2006. "Pricing Power at Risk for Orthopedics Makers." *The New York Times*, June 29, sec. Business. <http://www.nytimes.com/2006/06/29/business/29place.html>.
- Agency for Healthcare Research and Quality. 2012. "Trending Results by Hospital Characteristics." Text. December. <http://www.ahrq.gov/professionals/quality-patient-safety/patientsafetyculture/hospital/2012/hosp12appc.html>.
- Aggarwal, P., Cha, T., and Wilemon, D. 1998. "Barriers to the Adoption of Really-new Products and the Role of Surrogate Buyers." *Journal of Consumer Marketing* 15 (4): 358–71.
- Aksin, Z., and Masini, A. 2008. "Effective Strategies for Internal Outsourcing and Offshoring of Business Services: An Empirical Investigation." *Journal of Operations Management* 26 (2): 239–56.
- Alexander, J. A., Halpern, M. T., and Lee, S. Y. 1996. "The Short-Term Effects of Merger on Hospital Operations." *Health Services Research* 30 (6): 827–47.
- Anderson, J. C., and Narus, J. A. 1990. "A Model Of Distributor Firm And Manufacturer Firm Working P." *Journal of Marketing* 54 (1): 42.
- Anthony S. Roath, Daugherty, P. J., Stefan E. Genchev, Haozhe Chen, Aaron D. Arndt, and R. Glenn Richey. 2005. "Supply Chain Collaboration: What's Happening?" *The International Journal of Logistics Management* 16 (2): 237–56.
- Antonakis, J., Bendahan, S., Jacquart, P., and Lalive, R. 2010. "On Making Causal Claims: A Review and Recommendations." *The Leadership Quarterly* 21 (6): 1086–1120.
- Ariño, A., and de la Torre, J. 1998. "Learning from Failure: Towards an Evolutionary Model of Collaborative Ventures." *Organization Science* 9 (3): 306–25.
- Autry, C. W., and Golicic, S. L. 2010. "Evaluating Buyer–supplier Relationship–performance Spirals: A Longitudinal Study." *Journal of Operations Management* 28 (2): 87–100.
- Bales, W., and Fearson, H. 1993. *CEOs'/presidents' Perceptions and Expectations of the Purchasing Function /*. Center for Advanced Purchasing Studies. Tempe, Arizona.

- Barratt, M., Choi, T. Y., and Li, M. 2011. "Qualitative Case Studies in Operations Management: Trends, Research Outcomes, and Future Research Implications." *Journal of Operations Management* 29 (4): 329–42.
- Bass, B. M., Avolio, B. J., Jung, D. I., and Berson, Y. 2003. "Predicting Unit Performance by Assessing Transformational and Transactional Leadership." *Journal of Applied Psychology* 88 (2): 207–18.
- Bastl, M., Johnson, M., and Choi, T. Y. 2013. "Who's Seeking Whom? Coalition Behavior of a Weaker Player in Buyer–Supplier Relationships." *Journal of Supply Chain Management* 49 (1): 8–28.
- Bazzoli, G. J., Dynan, L., Burns, L. R., and Lindrooth, R. 2000. "Is Provider Capitation Working? Effects on Physician-Hospital Integration and Costs of Care." *Medical Care* 38 (3): 311–24.
- Bazzoli, G. J., Dynan, L., Burns, L., and Yap, C. 2004. "Two Decades of Organizational Change in Health Care: What Have We Learned?" *Medical Care Research and Review* 61 (3): 247–331.
- Bazzoli, G. J., Losasso, A., Arnould, R., and Shalowitz, M. 2002. "Hospital Reorganization and Restructuring Achieved through Merger." *Health Care Management Review* 27 (1): 7–20.
- Bazzoli, G. J., Shortell, S. M., Dubbs, N., Chan, C., and Kralovec, P. 1999. "A Taxonomy of Health Networks and Systems: Bringing Order out of Chaos." *Health Services Research* 33 (6): 1683–1717.
- Beckman, S., and Sinha, K. K. 2005. "Conducting Academic Research with an Industry Focus: Production and Operations Management in the High Tech Industry." *Production and Operations Management* 14 (2): 115–24.
- Begun, J., Zimmerman, B., and Dooley, K. 2003. "Health Care Organizations as Complex Adaptive Systems." In *Advances in Health Care Organization Theory*, 253–88.
- Beier, F. J. 1995. "The Management of the Supply Chain for Hospital Pharmacies: A Focus on Inventory Management Practices." *Journal of Business Logistics* 16 (2): 153.
- Bentler, P. M. 2008. "Alpha, Dimension-Free, and Model-Based Internal Consistency Reliability." *Psychometrika* 74 (1): 137–43.
- Benton, W. C., and Maloni, M. 2005. "The Influence of Power Driven Buyer/seller Relationships on Supply Chain Satisfaction." *Journal of Operations Management* 23 (1): 1–22.
- Berenson, R. A., Ginsburg, P. B., and May, J. H. 2007. "Hospital-Physicians Relations: Cooperation, Competition, Or Separation?" *Health Affairs* 26 (1): w31–43.

- Bergh, D. D., and Ketchen, D. J. 2009. *Research Methodology in Strategy and Management*. Emerald Group Publishing.
- Bhakoo, V., Prakash Singh, and Amrik Sohal. 2012. "Collaborative Management of Inventory in Australian Hospital Supply Chains: Practices and Issues." *Supply Chain Management: An International Journal* 17 (2): 217–30.
- Blau, P. M., and Scott, W. R. 1962. *Formal Organizations: A Comparative Approach*. Stanford University Press.
- Bliese, P. D., and Hanges, P. J. 2004. "Being Both Too Liberal and Too Conservative: The Perils of Treating Grouped Data as Though They Were Independent." *Organizational Research Methods* 7 (4): 400–417.
- Brooks, A. 2015. "DIY Distribution: Is It for You?" *GHX Supply Chain Healthcare Summit*, May.
- Burns, L. R., Alexander, J. A., Shortell, S. M., Zuckerman, H. S., Budetti, P. P., Gillies, R. R., and Waters, T. M. 2001. "Physician Commitment to Organized Delivery Systems." *Medical Care* 39 (7 Suppl 1): I9–29.
- Burns, L. R., Housman, M. G., Booth, R. E., and Koenig, A. 2009. "Implant Vendors and Hospitals: Competing Influences over Product Choice by Orthopedic Surgeons." *Health Care Management Review* 34 (1): 2–18.
- Burns, L. R., and Lee, J. A. 2008. "Hospital Purchasing Alliances: Utilization, Services, and Performance." *Health Care Management Review* 33 (3): 203–15.
- Burns, L. R., and Muller, R. W. 2008. "Hospital-Physician Collaboration: Landscape of Economic Integration and Impact on Clinical Integration." *The Milbank Quarterly* 86 (3): 375–434.
- Burns, L. R., and Pauly, M. V. 2002. "Integrated Delivery Networks: A Detour on the Road to Integrated Health Care?" *Health Affairs* 21 (4): 128–43.
- Burns, L. R., and Pauly, M. V. 2012. "Accountable Care Organizations May Have Difficulty Avoiding The Failures Of Integrated Delivery Networks Of The 1990s." *Health Affairs* 31 (11): 2407–16.
- Burns, L. R., and Yovovich, R. 2014. *Hospital Supply Chain Executives' Perspectives on Group Purchasing: Results from a 2014 National Survey*. Wharton: The Association for Healthcare Resource and Materials Management.
- Burt, R. S. 1992. *Structural Holes: The Social Structure of Competition*. Cambridge, Mass: Harvard University Press.
- Carter, C. R. 2000. "Ethical Issues in International Buyer–supplier Relationships: A Dyadic Examination." *Journal of Operations Management* 18 (2): 191–208.

- Casalino, L. P., November, E. A., Berenson, R. A., and Pham, H. H. 2008. "Hospital-Physician Relations: Two Tracks And The Decline Of The Voluntary Medical Staff Model." *Health Affairs* 27 (5): 1305–14.
- Chandler, A. D. 1994. *Scale and Scope: The Dynamics of Industrial Capitalism*. Cambridge, Mass: The Belknap Press.
- Chen, D. Q., Preston, D. S., and Xia, W. 2013. "Enhancing Hospital Supply Chain Performance: A Relational View and Empirical Test." *Journal of Operations Management* 31 (6): 391–408.
- Cheung, G. W., and Rensvold, R. B. 2002. "Evaluating Goodness-of-Fit Indexes for Testing Measurement Invariance." *Structural Equation Modeling: A Multidisciplinary Journal* 9 (2): 233–55.
- Chicksand, D. 2015. "Partnerships: The Role That Power Plays in Shaping Collaborative Buyer–supplier Exchanges." *Industrial Marketing Management* 48 (July): 121–39.
- Choi, T. Y., Dooley, K. J., and Rungtusanatham, M. 2001. "Supply Networks and Complex Adaptive Systems: Control versus Emergence." *Journal of Operations Management* 19 (3): 351–66.
- Choi, T. Y., and Krause, D. R. 2006. "The Supply Base and Its Complexity: Implications for Transaction Costs, Risks, Responsiveness, and Innovation." *Journal of Operations Management* 24 (5): 637–52.
- Choi, T. Y., and Wu, Z. 2009. "Taking the Leap from Dyads to Triads: Buyer–supplier Relationships in Supply Networks." *Journal of Purchasing and Supply Management* 15 (4): 263–66.
- Choi, T. Y., Wu, Z., Ellram, L., and Koka, B. R. 2002. "Supplier-Supplier Relationships and Their Implications for Buyer-Supplier Relationships." *IEEE Transactions on Engineering Management* 49 (2): 119–30.
- Chukmaitov, A., Bazzoli, G. J., Harless, D. W., Hurley, R. E., Devers, K. J., and Zhao, M. 2009. "Variations in Inpatient Mortality among Hospitals in Different System Types, 1995 to 2000." *Medical Care* 47 (4): 466–73.
- Chukmaitov, A. S., Harless, D. W., Bazzoli, G. J., Carretta, H. J., and Siangphoe, U. 2014. "Delivery System Characteristics and Their Association with Quality and Costs of Care: Implications for Accountable Care Organizations." *Health Care Management Review*, February, 1.
- Consulting CSC. 1996. *Efficient Healthcare Consumer Response: Improving the Efficiency of the Healthcare Supply Chain*. American Hospital Association/American Society for Healthcare Materials Management.



- Conway, K. 2011. "Applying Supply Chain Best Practices from Other Industries to Healthcare: A GHX White Paper for Healthcare Executives." *Global Health Exchange*.
- Craighead, C. W., Ketchen, D. J., Dunn, K. S., and Hult, G. G. 2011. "Addressing Common Method Variance: Guidelines for Survey Research on Information Technology, Operations, and Supply Chain Management." *IEEE Transactions on Engineering Management* 58 (3): 578–88.
- Cuevas, J. M., Julkunen, S., and Gabrielsson, M. 2015. "Power Symmetry and the Development of Trust in Interdependent Relationships: The Mediating Role of Goal Congruence." *Industrial Marketing Management* 48 (July): 149–59.
- Darling, M., and Wise, S. 2010. "Not Your Father's Supply Chain. Following Best Practices to Manage Inventory Can Help You Save Big." *Materials Management in Health Care* 19 (4): 30–33.
- Davis, J. H., Schoorman, F. D., and Donaldson, L. 1997. "Toward a Stewardship Theory of Management." *The Academy of Management Review* 22 (1): 20–47.
- Davis, K., Stermikas, K., Squires, D., and Scheon, C. 2014. *Mirror, Mirror on the Wall, 2014 Update: How the U.S. Health Care System Compares Internationally*. The Commonwealth Fund. <http://www.commonwealthfund.org/publications/fund-reports/2014/jun/mirror-mirror>.
- Day, M., Fawcett, S. E., Fawcett, A. M., and Magnan, G. M. 2013. "Trust and Relational Embeddedness: Exploring a Paradox of Trust Pattern Development in Key Supplier Relationships." *Industrial Marketing Management* 42 (2): 152–65.
- Delbufalo, E. 2012. "Outcomes of Inter-organizational Trust in Supply Chain Relationships: A Systematic Literature Review and a Meta-analysis of the Empirical Evidence." Edited by Richard Wilding. *Supply Chain Management: An International Journal* 17 (4): 377–402.
- Deloitte. 2013. *2013 Global Shared Services - Survey Results*.
- De Vita, G., Tekaya, A., and Wang, C. L. 2011. "The Many Faces of Asset Specificity: A Critical Review of Key Theoretical Perspectives." *International Journal of Management Reviews* 13 (4): 329–48.
- Dodder, R., and Dare, R. 2000. "Complex Adaptive Systems and Complexity Theory: Inter-Related Knowledge Domains." *ESD. 83: Research Seminar in Engineering Systems. MIT. 83*. <http://web.mit.edu/esd>.
- Dominy, M., and O'Daffer, E. 2011. *Supply Chain Consultants and Outsourcing Providers for Healthcare Delivery Organizations*. G00213110. Stamford, CT: Gartner Research.

- Doney, P. M., and Cannon, J. P. 1997. "An Examination of the Nature of Trust in Buyer-Seller Relationships." *Journal of Marketing* 61 (2): 35–51.
- Doucette, W. R. 1997. "Influences on Member Commitment to Group Purchasing Organizations." *Journal of Business Research* 40 (3): 183–89.
- Dranove, D. 1998. "Economies of Scale in Non-Revenue Producing Cost Centers: Implications for Hospital Mergers." *Journal of Health Economics* 17 (1): 69–83.
- Dranove, D., and Shanley, M. 1995. "Cost Reductions or Reputation Enhancement as Motives for Mergers: The Logic of Multihospital Systems." *Strategic Management Journal (1986-1998)* 16 (1): 55.
- Dubbs, N. L., Bazzoli, G. J., Shortell, S. M., and Kralovec, P. D. 2004. "Reexamining Organizational Configurations: An Update, Validation, and Expansion of the Taxonomy of Health Networks and Systems." *Health Services Research* 39 (1): 207–20.
- Dwyer, F. R., Schurr, P. H., and Oh, S. 1987. "Developing Buyer-Seller Relationships." *Journal of Marketing* 51 (2): 11.
- Dyer, J. H. 1996a. "Specialized Supplier Networks as a Source of Competitive Advantage: Evidence from the Auto Industry." *Strategic Management Journal* 17 (4): 271–91.
- Dyer, J. H. 1996b. "Does Governance Matter? Keiretsu Alliances and Asset Specificity as Sources of Japanese Competitive Advantage." *Organization Science* 7 (6): 649–66.
- Dyer, J. H., and Singh, H. 1998. "The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage." *Academy of Management. The Academy of Management Review* 23 (4): 660–79.
- Dynan, L., Bazzoli, G. J., Burns, L. R., and Kuramoto, R. K. 1998. "Assessing the Extent of Integration Achieved through Physician-Hospital Arrangements / Practitioner Response." *Journal of Healthcare Management* 43 (3): 242–61; discussion 261–62.
- Eisenhardt, K. M. 1989a. "Agency Theory: An Assessment and Review." *The Academy of Management Review* 14 (1): 57–74.
- Eisenhardt, K. M. 1989b. "Building Theories from Case Study Research." *The Academy of Management Review* 14 (4): 532–50.
- Ellram, L. M. 1996. "The Use of the Case Study Method in Logistics Research." *Journal of Business Logistics* 17 (2): 93–138.
- Emerson, R. M. 1962. "Power-Dependence Relations." *American Sociological Review* 27 (1): 31–41.

- Fawcett, S. E., and Magnan, G. M. 2002. "The Rhetoric and Reality of Supply Chain Integration." *International Journal of Physical Distribution & Logistics Management* 32 (5): 339–61.
- Fawcett, S. E., Waller, M. A., Miller, J. W., Schwieterman, M. A., Hazen, B. T., and Overstreet, R. E. 2014. "A Trail Guide to Publishing Success: Tips on Writing Influential Conceptual, Qualitative, and Survey Research." *Journal of Business Logistics* 35 (1): 1–16.
- Fayezi, S., O'Loughlin, A., and Zutshi, A. 2012. "Agency Theory and Supply Chain Management: A Structured Literature Review." *Supply Chain Management* 17 (5): 556–70.
- Flynn, B. B., Huo, B., and Zhao, X. 2010. "The Impact of Supply Chain Integration on Performance: A Contingency and Configuration Approach." *Journal of Operations Management* 28 (1): 58–71.
- Frankel, R., Goldsby, T. J., and Whipple, J. M. 2002. "Grocery Industry Collaboration in the Wake of ECR." *The International Journal of Logistics Management* 13 (1): 57–72.
- Freidson, E. 1983. "The Theory of Professions." In *The Sociology of the Professions: Lawyers, Doctors and Others*, edited by R. Dingwall and P. Lewis. London: Macmillian.
- Freidson, E. 1985. "The Reorganization of the Medical Profession." *Medical Care Research and Review* 42 (1): 11–35.
- Freidson, E. 1988. *Profession of Medicine: A Study of the Sociology of Applied Knowledge*. Reprint edition. Chicago: University of Chicago Press.
- Freidson, E. 1994. *Professionalism Reborn: Theory, Prophecy, and Policy*. 1 edition. Chicago: University of Chicago Press.
- Ganesan, S. 1994. "Determinants of Long-Term Orientation in Buyer-Seller Relationships." *Journal of Marketing* 58 (2): 1–19.
- Goldstein, J. 2000. "Emergence: A Construct Amid a Thicket of Conceptual Snares." *Emergence* 2 (1): 5–22.
- Green, S. 1975. "Professional/Bureaucratic Conflict: The Case of the Medical Profession in the National Health Service\*." *The Sociological Review* 23 (1): 121–41.
- Griffin, A., and Adams, S. 1981. "Shared services—A Recipe for Cost-Cutting in Hospitals." *Long Range Planning* 14 (6): 76–79.
- Guide Jr., V. D. R., and Ketokivi, M. 2015. "Notes from the Editors: Redefining Some Methodological Criteria for the Journal." *Journal of Operations Management* 37 (July): v – viii.

- Gulati, R. 1995. "Does Familiarity Breed Trust? The Implications of Repeated Ties for Contractual Choice in Alliances." *The Academy of Management Journal* 38 (1): 85–112.
- Hair, J. F., Black, W. C., Babin, B. J., and Anderson, R. C. 2010. *Multivariate Data Analysis*. 7th ed. Upper Saddle River, NJ: Prentice Hall.
- Hall, R. 1967. "Some Organizational Considerations in the Professional-Organizational Relationship." *Administrative Science Quarterly* 12 (3): 461–78.
- Handfield, R. B., and Bechtel, C. 2002. "The Role of Trust and Relationship Structure in Improving Supply Chain Responsiveness." *Industrial Marketing Management* 31 (4): 367–82.
- Haug, M. R. 1972. "Deprofessionalization: An Alternate Hypothesis for the Future\*." *The Sociological Review* 20 (S1): 195–211.
- Haug, M. R. 1988. "A Re-Examination of the Hypothesis of Physician Deprofessionalization." *The Milbank Quarterly* 66 Suppl 2: 48–56.
- Health Industry Distributors Association. 2012. *Evaluating Self-Distribution: A Guide for Healthcare Executives*. Health Industry Distributors Association.
- Hillman, A. J., Withers, M. C., and Collins, B. J. 2009. "Resource Dependence Theory: A Review." *Journal of Management* 35 (6): 1404–27.
- Hingley, M., Angell, R., and Campelo, A. 2015. "Introduction to the Special Issue on Power in Business, Customer, and Market Relationships." *Industrial Marketing Management* 48 (July): 101–2.
- Hox, J., Moerbeek, M., and Van de Schoot, R. 2010. *Multilevel Analysis: Techniques and Applications, Second Edition*. 2 edition. New York: Routledge.
- Hult, G. T. M., Ketchen, D. J., and Chabowski, B. R. 2007. "Leadership, the Buying Center, and Supply Chain Performance: A Study of Linked Users, Buyers, and Suppliers." *Industrial Marketing Management* 36 (3): 393–403.
- Iezzoni, L. I., Rao, S. R., DesRoches, C. M., Vogeli, C., and Campbell, E. G. 2012. "Survey Shows That At Least Some Physicians Are Not Always Open Or Honest With Patients." *Health Affairs* 31 (2): 383–91.
- Ireland, R. D., and Webb, J. W. 2007. "A Multi-Theoretic Perspective on Trust and Power in Strategic Supply Chains." *Journal of Operations Management, Special Issue Evolution of the Field of Operations Management SI/ Special Issue Organisation Theory and Supply Chain Management*, 25 (2): 482–97.
- Jeffries, F. L., and Reed, R. 2000. "Trust and Adaptation in Relational Contracting." *The Academy of Management Review* 25 (4): 873–82.

- Jenson, M., and Meckling, W. 1976. "Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure." *Journal of Financial Economics* 3: 305–60.
- Johnston, D. A., McCutcheon, D. M., Stuart, F. I., and Kerwood, H. 2004. "Effects of Supplier Trust on Performance of Cooperative Supplier Relationships." *Journal of Operations Management* 22 (1): 23–38.
- Kalwani, M. U., and Narayandas, N. 1995. "Long-Term Manufacturer-Supplier Relationships: Do They Pay off for Supplier Firms?" *Journal of Marketing* 59 (1): 1.
- Kang, B., and Jindal, R. P. 2015. "Opportunism in Buyer–seller Relationships: Some Unexplored Antecedents." *Journal of Business Research* 68 (3): 735–42.
- Kannampallil, T. G., Schauer, G. F., Cohen, T., and Patel, V. L. 2011. "Considering Complexity in Healthcare Systems." *Journal of Biomedical Informatics* 44 (6): 943–47.
- Katok, E., and Pavlov, V. 2013. "Fairness in Supply Chain Contracts: A Laboratory Study." *Journal of Operations Management* 31 (3): 129–37.
- Kauffman, S., and Levin, S. 1987. "Towards a General Theory of Adaptive Walks on Rugged Landscapes." *Journal of Theoretical Biology* 128 (1): 11–45.
- Kauffman, S., and Macready, W. 1995. "Technological Evolution and Adaptive Organizations: Ideas from Biology May Find Applications in Economics." *Complexity* 1 (2): 26–43.
- Kauffman, S., and Weinberger, E. 1989. "The NK Model of Rugged Fitness Landscapes and Its Application to Maturation of the Immune Response." *Journal of Theoretical Biology* 141 (2): 211–45.
- Kauser, S., and Shaw, V. 2004. "The Influence of Behavioural and Organisational Characteristics on the Success of International Strategic Alliances." *International Marketing Review* 21 (1): 17–52.
- Kennedy, P. 2008. *A Guide to Econometrics*. 6 edition. Malden, MA: Wiley-Blackwell.
- Kim, Y., Chen, Y.-S., and Linderman, K. 2015. "Supply Network Disruption and Resilience: A Network Structural Perspective." *Journal of Operations Management* 33–34 (January): 43–59.
- Kline, R. B. 2010. *Principles and Practice of Structural Equation Modeling, Third Edition*. 3rd edition. New York: The Guilford Press.
- Knemeyer, A. M., Corsi, T. M., and Murphy, P. R. 2003. "Logistics Outsourcing Relationships: Customer Perspectives." *Journal of Business Logistics* 24 (1): 77–110.

- Kowalski, J. C. 2009. "Needed: A Strategic Approach to Supply Chain Management." *Journal of the Healthcare Financial Management Association* 63 (6): 90–98.
- Kracov, D., Handwerker, J., Rosemary, M., and Gustafson, T. 2013. *Final Rule Issued For Physician Payment Sunshine Provisions of the Affordable Care Act*. Arnold & Porter LLP.
- Kutscher, B. 2014. "Hospitals Struggle to Balance Current Costs with Future Benefits of Employing Docs." *Modern Healthcare*, February 22.  
<http://www.modernhealthcare.com/article/20140222/MAGAZINE/302229986>.
- Kwon, I.-W. G., and Suh, T. 2005. "Trust, Commitment and Relationships in Supply Chain Management: A Path Analysis." *Supply Chain Management: An International Journal* 10 (1): 26–33.
- Lamming, R. C., Caldwell, N. D., Harrison, D. A., and Phillips, W. 2001. "Transparency in Supply Relationships: Concept and Practice." *Journal of Supply Chain Management* 37 (3): 4–10.
- Landry, S., and Beaulieu, M. 2013. "The Challenges of Hospital Supply Chain Management, from Central Stores to Nursing Units." In *Handbook of Healthcare Operations Management*, edited by Brian T. Denton, 465–82. International Series in Operations Research & Management Science 184. Springer New York.  
[http://link.springer.com/chapter/10.1007/978-1-4614-5885-2\\_18](http://link.springer.com/chapter/10.1007/978-1-4614-5885-2_18).
- Larson, M. S. 1979. *The Rise of Professionalism: A Sociological Analysis*. Berkeley: Univ of California Pr.
- Lee, C. W., Kwon, I. G., and Severance, D. 2007. "Relationship between Supply Chain Performance and Degree of Linkage among Supplier, Internal Integration, and Customer." *Supply Chain Management: An International Journal* 12 (6): 444–52.
- Lee, J. 2013a. "Losing Preferential Treatment: Supply-Chain Cost Cutting Leads to Fewer Medical Device Options." *Modern Healthcare*. February.  
<http://www.modernhealthcare.com/article/20130215/MAGAZINE/302169953>.
- Lee, J. 2013b. "Supply-Chain Cost Cutting Leads to Fewer Medical Device Options." *Modern Healthcare*, February.  
<http://www.modernhealthcare.com/article/20130215/MAGAZINE/302169953>.
- Lee, J. 2013c. "Breaking the Chain: Hospitals Set Supply Cost-Cutting Targets, Push Physicians to Change Behavior." *Modern Healthcare*, August.  
<http://www.modernhealthcare.com/article/20130817/MAGAZINE/308179905>.
- Lee, J. 2014. "Devicemaker Sales Reps Being Replaced in the OR." *Modern Healthcare*, August.  
<http://www.modernhealthcare.com/article/20140816/MAGAZINE/308169980>.

- Lerner, J. C., Fox, D. M., Nelson, T., and Reiss, J. B. 2008. "The Consequence Of Secret Prices: The Politics Of Physician Preference Items." *Health Affairs* 27 (6): 1560–65.
- Leuschner, R., Rogers, D. S., and Charvet, F. F. 2013. "A Meta-Analysis of Supply Chain Integration and Firm Performance." *Journal of Supply Chain Management* 49 (2): 34–57.
- Levinthal, D. A. 1997. "Adaptation on Rugged Landscapes." *Management Science* 43 (7): 934–50.
- Levinthal, D. A., and Warglien, M. 1999. "Landscape Design: Designing for Local Action in Complex Worlds." *Organization Science* 10 (3): 342–57.
- Lewis, M. A. 2012. "Knowledge Intensive/profession AI Service Triads: Preliminary Reflections and Research Options." In . Amsterdam.
- Mackelprang, A. W., Robinson, J. L., Bernardes, E., and Webb, G. S. 2014. "The Relationship between Strategic Supply Chain Integration and Performance: A Meta-Analytic Evaluation and Implications for Supply Chain Management Research." *Journal of Business Logistics* 35 (1): 71–96.
- Markham, B., and Lomas, J. 1995. "Review of the Multi-Hospital Arrangements Literature: Benefits, Disadvantages and Lessons for Implementation." *Healthcare Management Forum / Canadian College of Health Service Executives = Forum Gestion Des Soins De Santé / Collège Canadien Des Directeurs De Services De Santé* 8 (3): 24–35.
- Mark, T. L., Evans, W. N., Schur, C. L., and Guterman, S. 1998. "Hospital-Physician Arrangements and Hospital Financial Performance." *Medical Care* 36 (1): 67–78.
- Mason, S. A. 1979. "The Multihospital Movement Defined." *Public Health Reports (1974-)* 94 (5): 446–53.
- Matos, S., and Hall, J. 2007. "Integrating Sustainable Development in the Supply Chain: The Case of Life Cycle Assessment in Oil and Gas and Agricultural Biotechnology." *Journal of Operations Management* 25 (6): 1083–1102.
- McDaniel, R. R., Lanham, H., and Anderson, R. 2009. "Implications of Complex Adaptive Systems Theory for the Design of Research on Health Care Organizations." *Health Care Management Review April/June 2009* 34 (2): 191–99.
- McEvily, B., and Marcus, A. 2005. "Embedded Ties and the Acquisition of Competitive Capabilities." *Strategic Management Journal* 26 (11): 1033–55.
- McKinnon, D. P. 2008. *Introduction to Statistical Mediation Analysis*. 1 Pap/Cdr edition. New York: Routledge.
- McKone-Sweet, K. E., Hamilton, P., and Willis, S. B. 2005. "The Ailing Healthcare Supply Chain: A Prescription for Change." *The Journal of Supply Chain Management* 41 (1): 4–17.

- Meade, A. W., Johnson, E. C., and Braddy, P. W. 2008. "Power and Sensitivity of Alternative Fit Indices in Tests of Measurement Invariance." *Journal of Applied Psychology* 93 (3): 568–92.
- Meade, A. W., and Lautenschlager, G. J. 2004. "A Comparison of Item Response Theory and Confirmatory Factor Analytic Methodologies for Establishing Measurement Equivalence/Invariance." *Organizational Research Methods* 7 (4): 361–88.
- Mena, C., Humphries, A., and Choi, T. Y. 2013. "Toward a Theory of Multi-Tier Supply Chain Management." *Journal of Supply Chain Management* 49 (2): 58–77.
- Miles, M. B., and Huberman, A. M. 1994. *Qualitative Data Analysis: An Expanded Sourcebook*. SAGE.
- Mohr, J., and Spekman, R. 1994. "Characteristics of Partnership Success: Partnership Attributes, Communication Behavior, and Conflict Resolution Techniques." *Strategic Management Journal* 15 (2): 135–52.
- Monczka, R. M., Petersen, K. J., Handfield, R. B., and Ragatz, G. L. 1998. "Success Factors in Strategic Supplier Alliances: The Buying Company Perspective." *Decision Sciences* 29 (3): 553–77.
- Montgomery, K., and Schneller, E. S. 2007. "Hospitals' Strategies for Orchestrating Selection of Physician Preference Items." *The Milbank Quarterly* 85 (2): 307–35.
- Morgan, R. M., and Hunt, S. D. 1994. "The Commitment-Trust Theory of Relationship Marketing." *Journal of Marketing* 58 (3): 20–38.
- Mossialos, E., Wenzl, M., Osborn, R., and Anderson, C. 2015. *2014 International Profiles Of Health Care Systems*. 1802. The Commonwealth Fund.
- Murray, M. P. 2006. "Avoiding Invalid Instruments and Coping with Weak Instruments." *Journal of Economic Perspectives*, 111–32.
- Nachtmann, H., and Pohl, E. 2009. *The State of Healthcare Logistics: Cost and Quality Improvement Opportunities*. Center for Innovation in Health care Logistics, Arkansas.
- Narayanan, V. G., and Brem, L. 2009. "Supply Chain Partners: Virginia Mason and Owens & Minor (A)." *Boston: Harvard Business Publishing*, April.
- Noordewier, T. G., John, G., and Nevin, J. R. 1990. "Performance Outcomes of Purchasing Arrangements in Industrial Buyer-Vendor Relationships." *Journal of Marketing* 54 (4): 80–93.
- Nunnally, J. C., and Bernstein, I. H. 1994. *Psychometric Theory*. 3rd edition. New York: McGraw-Hill.



- Nyaga, G. N., Whipple, J. M., and Lynch, D. F. 2010. "Examining Supply Chain Relationships: Do Buyer and Supplier Perspectives on Collaborative Relationships Differ?" *Journal of Operations Management* 28 (2): 101–14.
- Nyaga, G. N., Young, G. J., and Zepeda, E. D. 2015. "An Analysis of the Effects of Intra- and Interorganizational Arrangements on Hospital Supply Chain Efficiency." *Journal of Business Logistics* 36 (4): 340–54.
- O'Daffer, E., and Mooraj, H. 2011. *To CSC or Not to CSC, That Is the Question for Healthcare Providers*. Gartner Research. <https://www.gartner.com/doc/1554216/csc-csc-question-healthcare-providers>.
- Okike, K., O'Toole, R. V., Pollak, A. N., Bishop, J. A., McAndrew, C. M., Mehta, S., Cross, W. W., Garrigues, G. E., Harris, M. B., and Lebrun, C. T. 2014. "Survey Finds Few Orthopedic Surgeons Know The Costs Of The Devices They Implant." *Health Affairs* 33 (1): 103–9.
- O'Leary-Kelly, S. W., and J. Vokurka, R. 1998. "The Empirical Assessment of Construct Validity." *Journal of Operations Management* 16 (4): 387–405.
- Park, S. H., and Ungson, G. R. 1997. "The Effect of National Culture, Organizational Complementarity, and Economic Motivation on Joint Venture Dissolution." *The Academy of Management Journal* 40 (2): 279–307.
- Parsons, T. 1968. "Professions." In *International Encyclopedia of the Social Sciences*, XII:536–47. New York: Macmillian.
- Pauly, M. V., and Burns, L. R. 2008. "Price Transparency For Medical Devices." *Health Affairs* 27 (6): 1544–53.
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., and Podsakoff, N. P. 2003. "Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies." *Journal of Applied Psychology* 88 (5): 879–903.
- Poppo, L., and Zenger, T. 2002. "Do Formal Contracts and Relational Governance Function as Substitutes or Complements?" *Strategic Management Journal* 23 (8): 707–25.
- Ring, P. S., and Van de Ven, A. H. 1994. "Developmental Processes of Cooperative Interorganizational Relationships." *The Academy of Management Review* 19 (1): 90.
- Rivard-Royer, H., Landry, S., and Beaulieu, M. 2002. "Hybrid Stockless: A Case Study." *International Journal of Operations & Production Management* 22 (4): 412–24.
- Roark, D. 2005. "Managing the Healthcare Supply Chain." *Nursing Management* 36 (2): 36–40.
- Robinson, J. C. 1997. "Physician-Hospital Integration and the Economic Theory of the Firm." *Medical Care Research and Review* 54 (1): 3–24.

- Robinson, J. C. 2015. "Biomedical Innovation In The Era Of Health Care Spending Constraints." *Health Affairs* 34 (2): 203–9.
- Robinson, J. C., and Casalino, L. P. 1996. "Vertical Integration and Organizational Networks in Health Care." *Health Affairs (Project Hope)* 15 (1): 7–22.
- Rokkan, A. I., Heide, J. B., and Wathne, K. H. 2003. "Specific Investments in Marketing Relationships: Expropriation and Bonding Effects." *Journal of Marketing Research* 40 (2): 210–24.
- Rungtusanatham, M., Miller, J. W., and Boyer, K. K. 2014. "Theorizing, Testing, and Concluding for Mediation in SCM Research: Tutorial and Procedural Recommendations." *Journal of Operations Management* 32 (3): 99–113.
- Schelling, T. C. 1960. *The Strategy of Conflict*. Cambridge: Harvard University Press.
- Schneller, E. 2015. "The Post-Reform Environment for Supply Chain Management." *Healthcare Purchasing News* 39 (9): 58–59.
- Schneller, E. S., and Smeltzer, L. R. 2006. *Strategic Management of the Health Care Supply Chain*. 1st ed. Jossey-Bass.
- Seppänen, R., Blomqvist, K., and Sundqvist, S. 2007. "Measuring Inter-Organizational Trust—a Critical Review of the Empirical Research in 1990–2003." *Industrial Marketing Management* 36 (2): 249–65.
- Sharma, A. 1997. "Professional as Agent: Knowledge Asymmetry in Agency Exchange." *The Academy of Management Review* 22 (3): 758–98.
- Sharma, L., Chandrasekaran, A., Boyer, K. K., and McDermott, C. M. 2016. "The Impact of Health Information Technology Bundles on Hospital Performance: An Econometric Study." *Journal of Operations Management* 41 (January): 25–41.
- Sigmund, K. 1993. *Games of Life Explorations in Ecology, Evolution, and Behaviour*. Etats-Unis: Oxford University Press New-York.
- Sijtsma, K. 2009. "On the Use, the Misuse, and the Very Limited Usefulness of Cronbach's Alpha." *Psychometrika* 74 (1): 107–20.
- Simon, H. A. 1962. "The Architecture of Complexity." *Proceedings of the American Philosophical Society* 106 (6): 467–82.
- Singer, J. D., and Willett, J. B. 2003. *Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence*. Oxford University Press, USA.

- Smith, J. B., and Barclay, D. W. 1997. "The Effects of Organizational Differences and Trust on the Effectiveness of Selling Partner Relationships." *Journal of Marketing* 61 (1): 3.
- Sobel, M. 1982. "Asymptotic Confidence Intervals for Indirect Effects in Structural Equation Models." *Sociological Methodology* 1982. <http://ci.nii.ac.jp/naid/30005197124/>.
- Solomon, M. R. 1986. "The Missing Link: Surrogate Consumers in the Marketing Chain." *Journal of Marketing* 50 (4): 208–18.
- Sorensen, J. E., and Sorensen, T. L. 1974. "The Conflict of Professionals in Bureaucratic Organizations." *Administrative Science Quarterly* 19 (1): 98–106.
- Tate, W. L., Ellram, L. M., Bals, L., Hartmann, E., and van der Valk, W. 2010. "An Agency Theory Perspective on the Purchase of Marketing Services." *Industrial Marketing Management*, Corporate image and reputation in B2B markets, 39 (5): 806–19.
- The Brookings Institute. 2015. *Strengthening Patient Care: Building an Effective National Medical Device Surveillance System*. Washington, DC: The Brookings Institute.
- Thill, M. 2012. "The Self-Distribution Shuffle." *The Journal of Healthcare Contracting*, August.
- Thill, M. 2015. "Implant Strategies for Today." *Journal of Healthcare Contracting* 12 (2): 22–36.
- Thill, M. D. 1989. "Group Purchasing Organizations: A Presence Guaranteed?" *Hospital Materiel Management Quarterly* 10 (4): 77–82.
- Tichy, N. M., Tushman, M. L., and Fombrun, C. 1979. "Social Network Analysis for Organizations." *Academy of Management Review*, 507–19.
- Uzzi, B. 1997. "Social Structure and Competition in Interfirm Networks: The Paradox of Embeddedness." *Administrative Science Quarterly* 42 (1): 35–67.
- Vanpoucke, E., Vereecke, A., and Boyer, K. K. 2014. "Triggers and Patterns of Integration Initiatives in Successful Buyer–supplier Relationships." *Journal of Operations Management* 32 (1-2): 15–33.
- Venkatesh, R., Kohli, A. K., and Zaltman, G. 1995. "Influence Strategies in Buying Centers." *Journal of Marketing* 59 (4): 71–82.
- Villena, V. H., Revilla, E., and Choi, T. Y. 2011. "The Dark Side of Buyer–supplier Relationships: A Social Capital Perspective." *Journal of Operations Management* 29 (6): 561–76.
- Voss, C., Tsikriktsis, N., and Frohlich, M. 2002. "Case Research in Operations Management." *International Journal of Operations & Production Management* 22 (2): 195–219.

- Walker, J. 2016. "Medical Technology Firms Branch Out." *Wall Street Journal*, February 1, sec. Business. <http://www.wsj.com/articles/medical-technology-firms-branch-out-1454364767>.
- Wallace, J. E. 1995. "Organizational and Professional Commitment in Professional and Nonprofessional Organizations." *Administrative Science Quarterly* 40 (2): 228–55.
- Wang, B. B., Wan, T. T., Burke, D. E., Bazzoli, G. J., and Lin, B. Y. 2005. "Factors Influencing Health Information System Adoption in American Hospitals." *Health Care Management Review* 30 (1): 44–51.
- Waring, J. 2014. "Restrification, Hybridity and Professional Elites: Questions of Power, Identity and Relational Contingency at the Points of 'Professional–Organisational Intersection.'" *Sociology Compass* 8 (6): 688–704.
- Whipple, J. M., Frankel, R., and Daugherty, P. J. 2002. "Information Support for Alliances: Performance Implications." *Journal of Business Logistics* 23 (2): 67–82.
- Whipple, J. M., Griffis, S. E., and Daugherty, P. J. 2013. "Conceptualizations of Trust: Can We Trust Them?" *Journal of Business Logistics* 34 (2): 117–30.
- Whipple, J. M., Lynch, D. F., and Nyaga, G. N. 2010. "A Buyer's Perspective on Collaborative versus Transactional Relationships." *Industrial Marketing Management, Sense-Making and Management in Business Networks*, 39 (3): 507–18.
- Williamson, O. E. 1981. "The Economics of Organization: The Transaction Cost Approach." *American Journal of Sociology* 87 (3): 548–77.
- Williamson, O. E., and Craswell, R. 1993. "Calculativeness, Trust, and Economic Organization." *Journal of Law and Economics* 36 (1): 453, 487.
- Wilson, N. A. 2012. "The Value of Unique Device Identification across Healthcare [White Paper]." *Health Sector Supply Chain Research Consortium*.
- Wilson, N. A., Schneller, E. S., Montgomery, K., and Bozic, K. J. 2008. "Hip And Knee Implants: Current Trends And Policy Considerations." *Health Affairs* 27 (6): 1587–98.
- Wind, Y., and Robertson, T. S. 1982. "The Linking Pin Role in Organizational Buying Centers." *Journal of Business Research* 10 (2): 169–84.
- Womack, J. P., Jones, D. T., and Roos, D. 2007. *The Machine That Changed the World: The Story of Lean Production-- Toyota's Secret Weapon in the Global Car Wars That Is Now Revolutionizing World Industry*. Reprint edition. Toronto: Free Press.

- Wu, Z., and Choi, T. Y. 2005. "Supplier–supplier Relationships in the Buyer–supplier Triad: Building Theories from Eight Case Studies." *Journal of Operations Management* 24 (1): 27–52.
- Wu, Z., Choi, T. Y., and Rungtusanatham, M. J. 2010. "Supplier–supplier Relationships in Buyer–supplier–supplier Triads: Implications for Supplier Performance." *Journal of Operations Management* 28 (2): 115–23.
- Wynstra, F., Spring, M., and Schoenherr, T. 2015. "Service Triads: A Research Agenda for Buyer–supplier–customer Triads in Business Services." *Journal of Operations Management, Service Triads: A Research Agenda for Buyer-Supplier-Customer Triads in Business Services*, 35 (May): 1–20.
- Young, G. J., Nyaga, G. N., and Zepeda, D. 2015. "Hospital Employment of Physicians and Supply Chain Performance: An Empirical Investigation." *Health Care Management Review*, July.
- Zaheer, A., McEvily, B., and Perrone, V. 1998. "Does Trust Matter? Exploring the Effects of Interorganizational and Interpersonal Trust on Performance." *Organization Science* 9 (2): 141–59.
- Zuckerman, H. S., Hilberman, D. W., Andersen, R. M., and Burns, L. R. 1998. "Physicians and Organizations: Strange Bedfellows or a Marriage Made in Heaven?" *Frontiers of Health Services Management* 14 (3): 3–34.

APPENDIX A  
REPRESENTATIVE PROOF QUOTES ABOUT CSCS

## 1. Characteristics of CSCs

### 1.1. Customer Selectivity

Alpha

"We never go to find new customers, if they come to us we sit with them and think carefully about [adding them as a member]."

"Hospitals need to completely agree with our strategy and our philosophy [to be accepted as a customer]."

"The biggest difference [from national distributors] is that we are very selective of our customers."

"We focus on expanding the number of services we offer and increasing sales of existing services [as opposed to increasing customer base]."

Beta

"Our current strategy is to serve [Parent healthcare system's] hospitals well."

"... no near-future plans to provide service to other healthcare systems."

Gamma

"... Growing through innovation more than through acquiring new customers."

"We go through a rigorous screening process to ensure that customers have a comprehensive view."

"We are very picky when it comes to choosing customers."

### 1.2. Contract Compliance

Alpha

"Suppliers are eager to sign up with us... because we guarantee them that market share."

"The major difference between us and a GPO is that we were able to get a high level of compliance with purchasing agreements [over 90%] from the hospitals."

Beta

"Contracting directly with a system like us provides the supplier higher commitment and less risk in volume production... shorter payment cycles."

Gamma

"Suppliers value the compliance that [Gamma] can provide, which national GPOs can't."

"We can cut a check to the supplier and take the position of the goods directly from the supplier."

### 1.3. Hospital-CSC Reporting Structure

Alpha

"... [In the old model] materials managers would frequently clash with Alpha, it turned into an issue of internal negotiations."

Beta

"[The prior reporting structure at Beta] resulted in friction between the organization's shared goals and the incentives of the individual hospitals."

Gamma

"[The new reporting structure at Gamma] reduced the noise."

"It is less likely that someone you can fire will shout at you and hang up."

"... we realized early on that compromising some autonomy at the lower levels had more benefits for our model to drive down costs and increase service levels."

## 2. Managing Supply Chain Complexity

### 2.1. Supply Base Reduction - Reducing the Components

Alpha

"Standardization efforts focus on the middle 80% of spend, through about 150 suppliers."

"We don't carry 35 bedpans like a national distributor would, we only carry one."

Beta

"... capitated model to satisfy the largest number of physicians with the least number of suppliers."  
"Value analysis teams work to reduce product choices for commodities down to one or two."  
"Several millions in savings from standardizing supply contracts in cardiology and cath labs."  
Gamma  
"We always seek to achieve better prices for our products through standardization or negotiations with suppliers."  
"We were able to standardize spine implants, going from 13 vendors to 1."  
"... a smaller number of clinically engaged suppliers."

## 2.2. Disintermediation - Reducing Interrelatedness

Alpha

"[Prior to Alpha's disintermediation] The vendor-physician relationship was too powerful and hospitals had no leverage."  
"... greatly reduced the supply-side salesmen at hospitals salesmen or physicians need to follow a formal process through [Alpha] to request new products."  
"We have an agreement with [national distributor], and our goal is to shrink our business with them to zero."  
"We provide much better payment terms than a hospital's purchasing department would, making suppliers happy."

Beta

"The business with [distributor] has been steadily shrinking"  
"GPO spend is relatively stable year-to-year, but also steadily decreasing"

Gamma

[Discussing disintermediation of suppliers and internalizing the role of the sales rep]:  
"Physicians were heavily involved and contributed to the selection of the sales reps to be hired."  
"... required disintermediation to solve many of these issues"  
"GPO and distributors were then slowly being phased out... [they were] not happy about it."

## 3. Supply Chain Innovation

"At one point we were all wearing multiple hats"  
"... try to bring in ideas and learnings from other industries."  
"There is a strong entrepreneurial spirit."  
"[Referring to cost cutting strategies] We had to get creative."  
"We seek new opportunities both by listening to our customers and our own employees."  
"I would be disappointed if a year went by and there wasn't a major innovation introduced by [Gamma]"  
"We see [Gamma] growing through innovation more than through acquiring new customers."  
"We had to imagine a new model."

## 4. Transformational Leadership

"Project management and change management were critical in rolling out the model."  
"[The CSC operating model] requires a lot of courage and a strong opinion on the matter to move to such a model..."  
"Many healthcare system executives that tour [Alpha] do not currently have the background in supply chain and logistics on their team, and get scared."  
"The biggest worry was having the talent (people) to succeed in such a large task."



## APPENDIX B

### TRUST MODEL CONSTRUCTS AND SURVEY ITEMS

Survey Items	Mean (SD)		Stdized Loadings	
	Buyer	Supplier	Buyer	Supplier
<b>Trust (<math>\alpha = 0.919</math>; <math>0.884</math>)</b>				
Partner keeps commitments	5.72 (1.07)	5.61 (1.20)	0.878	0.818
Partner works for the best interests of the relationship	5.55 (1.12)	5.27 (1.25)	0.920	0.934
Partner wants your organization to succeed	5.70 (1.13)	5.14 (1.33)	0.855	0.787
<b>Performance (<math>\alpha = 0.920</math>; <math>0.867</math>)</b>				
Strategic advantage	5.08 (1.14)	5.25 (1.15)	0.831	0.830
Meeting organization's mission	5.29 (1.16)	5.19 (1.17)	0.894	0.873
Financial viability	5.40 (1.11)	5.28 (1.16)	0.834	0.756
Service effectiveness	5.46 (1.07)	5.40 (1.20)	0.853	0.666
<b>Contracting (<math>\alpha = 0.920</math>; <math>0.846</math>)</b>				
Contract language that mitigates problems	5.31 (1.21)	4.88 (1.31)	0.830	0.681
Fair contract negotiations	5.58 (1.11)	5.31 (1.26)	0.942	0.914
Clear contractual specifications	5.55 (1.12)	5.33 (1.24)	0.907	0.814
<b>Information Sharing (<math>\alpha = 0.840</math>; <math>0.835</math>)</b>				
Partner provides product performance data	4.59 (1.52)	4.28 (1.81)	0.806	0.829
Partner provides product utilization data	4.88 (1.48)	4.58 (1.74)	0.693	0.816
Partner provides clinical evidence-basis for product choice	4.49 (1.66)	4.47 (1.85)	0.874	0.763
<b>Dedicated Resources (<math>\alpha = 0.810</math>; <math>0.747</math>)</b>				
Partner provides personnel for product management	4.91 (1.45)	4.80 (1.57)	0.698	0.725
Partner provides personnel for clinical support	4.74 (1.62)	4.90 (1.56)	0.866	0.770
Partner provides equipment for product support	4.30 (1.72)	3.44 (1.90)	0.755	0.634
<b>Dependency (<math>\alpha = 0.849</math>; <math>0.722</math>)</b>				
Reliance on product services	4.52 (1.40)	4.25 (1.56)	0.795	0.726
Partner product is unique with few competitors	4.43 (1.66)	4.09 (1.70)	0.764	0.555
Product requires organizational service/support	4.33 (1.47)	4.16 (1.56)	0.910	0.755
<b>Conflicting Views (<math>\alpha = 0.946</math>; <math>0.769</math>)</b>				
Partner not sharing key performance indicators	4.53 (1.71)	4.63 (1.43)	0.841	0.629
Lack of price transparency	4.93 (1.80)	4.09 (1.51)	0.889	0.630
Incongruent economic priorities	4.79 (1.73)	4.68 (1.39)	0.950	0.761
Incongruent views of sales and marketing spending	4.56 (1.66)	4.18 (1.41)	0.921	0.692

APPENDIX C

CHAPTER 3 VARIABLE DEFINITIONS AND SOURCES

	<b>Variable</b>	<b>Description</b>	<b>Source</b>
1	Supply Expenses (mil)	"The net cost of all tangible items that are expensed including freight, standard distribution cost, and sales and use tax minus rebates. This would exclude labor, labor-related expenses, and services as well as some tangible items that are frequently provided as part of labor costs." (AHA Survey 24)	AHA Database
2	Physician Employment	The percentage of employment physicians at the hospital, relative to the total physicians with operating privileged.	AHA Database
3	Tight-POA Physicians	The number of physicians in tight arrangements. Refer to Appendix D for more details about each arrangement in this category.	AHA Database
4	Loose-POA Physicians	The number of physicians in loose arrangements. Refer to Appendix D for more details about each arrangement in this category.	AHA Database
5	Inpatient days ('000)	Aggregate days of care rendered to patients during the fiscal year(in thousands). Day of discharge is only counted if the patient is admitted on the same day.	AHA Database
6	Hospital Expenses (non-supply related)	Total Hospital Expenses minus supply expenses (in millions)	AHA Database
7	Case-mix Index	"A hospital's CMI represents the average diagnosis-related group (DRG) relative weight for that hospital. It is calculated by summing the DRG weights for all Medicare discharges and dividing by the number of discharges." ( <a href="https://www.cms.gov/">https://www.cms.gov/</a> )	Center for Medicare and Medicaid Services
8	Urban location	Categorical variable, indicating whether the hospital is in an urban location (1) or rural location (0), based on the CBSA (core base statistical area) code	AHA Database, U.S. Census Bureau
9	Teaching status	Hospital is a member of Council of Teaching Hospital of the Association of American Medical Colleges (COH)	AHA Database, Association of American Medical Colleges
11	Hospital operating status	Categorical variable indicating the hospital's operating status: <ul style="list-style-type: none"> <li>• <i>Nongovernment, not for profit.</i> Controlled by not-for-profit organizations, including religious organizations, community hospitals, cooperative hospitals, hospitals operated by fraternal societies, and so forth.</li> <li>• <i>Investor owned, for profit.</i> Controlled on a for-profit basis by an individual, partnership, or a profit-making corporation.</li> <li>• <i>Government, federal.</i> Controlled by an agency or department of the federal government.</li> </ul>	AHA Database
12	System Centralization	A system-level categorical variable that indicated whether the system is considered to be centralized or decentralized. Refer to Appendix C for more information regarding the taxonomy	AHA Database
13	Total System Admissions	The aggregate number of patients admissions across all hospitals of a system	AHA Database

APPENDIX D

TYPES OF PHYSICIAN-HOSPITAL ARRANGEMENTS

<b>POA Type</b>	<b>Description</b>
Loosely-integrated POAs*	
Independent practice association (IPA)	<i>A legal entity that holds managed care contracts. The IPA then contracts with physicians, usually in solo practice, to provide care either on a fee-for-services or capitated basis. The purpose of an IPA is to assist solo physicians in obtaining managed care contracts.</i>
Open physician-hospital organization (PHO)	<i>A joint venture between the hospital and all members of the medical staff who wish to participate. The PHO can act as a unified agent in managed care contracting, own a managed care plan, own and operate ambulatory care centers or ancillary services projects, or provide administrative services to physician members.</i>
Closed physician-hospital organization (PHO)	<i>A PHO that restricts physician membership to those practitioners who meet criteria for cost effectiveness and/or high quality.</i>
Management services organization (MSO)	<i>A corporation, owned by the hospital or a physician/hospital joint venture, that provides management services to one or more medical group practices. The MSO purchases the tangible assets of the practices and leases them back as part of a full-service management agreement, under which the MSO employs all non-physician staff and provides all supplies/administrative systems for a fee.</i>
Tightly-integrated POAs*	
Group practice without walls	<i>Hospital sponsors the formation of, or provides capital to physicians to establish, a "quasi" group to share administrative expenses while remaining independent practitioners.</i>
Integrated salary model	<i>Physicians are salaried by the hospital or another entity of a health system to provide medical services for primary care and specialty care.</i>
Equity model	<i>Allows established practitioners to become shareholders in a professional corporation in exchange for tangible and intangible assets of their existing practices.</i>
Foundation	<i>A corporation, organized either as a hospital affiliate or subsidiary, which purchases both the tangible and intangible assets of one or more medical group practices. Physicians remain in a separate corporate entity but sign a professional services agreement with the foundation</i>

Source: AHA 2013 Annual Survey Database

APPENDIX E  
AHA HEALTH SYSTEM TAXONOMY

The following excerpt and table are taken from the supplementary material of the AHA 2013 Annual Survey Database:

*Research using existing theory and AHA Annual Survey data identified a reliable set of five distinct groups of health systems that share common strategic/structural features. This identification system was developed jointly by the American Hospital Association's Health Research and Educational Trust and Health Forum, and the University of California-Berkeley. For further information on the development of the taxonomy please see: Bazzoli, GJ; Shortell, SM; Dubbs, N; Chan, C; and Kralovec, P; "A Taxonomy of Health Networks and Systems: Bringing Order Out of Chaos" Health Services Research, February; 1999.*

*A health system is assigned to one of five categories based on how much they differentiate and centralize their hospital services, physician arrangements, and provider-based insurance products. Differentiation refers to the number of different products or services that the organization offers. Centralization refers to whether decision-making and service delivery emanates from the system level more so than individual hospitals.*

<b>Label</b>	<b>Description</b>
Centralized Health System	A delivery system in which the system centrally organizes individual hospital service delivery, physician arrangements, and insurance product development. The number of different products/services that are offered across the system is moderate.
Centralized Physician/ Insurance Health System	A delivery system with highly centralized physician arrangements and insurance product development. Within this group, hospital services are relatively decentralized with individual hospitals having discretion over the array of services they offer. The number of different products/services that are offered across the system is moderate.
Moderately Centralized Health System	A delivery system that is distinguished by the presence of both centralized and decentralized activity for hospital services, physician arrangements, and insurance product development. For example, a system within this group may have centralized care of expensive, high technology services, such as open heart surgery, but allows individual hospitals to provide an array of other health services based on local needs. The number of different products/services that are offered across the system is moderate.
Decentralized Health System	A delivery system with a high degree of decentralization of hospital services, physician arrangements, and insurance product development. Within this group, systems may lack an overarching structure for coordination. Service and product differentiation is high, which may explain why centralization is hard to achieve. In this group, the system may simply serve a role in sharing information and providing administrative support to highly developed local delivery systems centered around hospitals.
Independent Hospital System	A delivery system with limited differentiation; hospital services, physician arrangements, and insurance product development. These systems are largely horizontal affiliations of autonomous hospitals.