Exploring Healthcare Supply Chain Structure Using Financial Ratios

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In this research we analyze the link between the healthcare supply chain structure and financial performance measures. Using publicly available financial data and analyzing financial ratios, we find that companies that operate in different stages of the healthcare supply chain do exhibit different characteristics. We describe the structure of the healthcare supply chain using the observed patterns. We also compare the performance of the supply chain leaders, as ranked by Gartner, with the performance of their competitors in their respective supply chain stages. We show that not all leaders outperform the sector average.

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I. INTRODUCTION

Healthcare providers are facing extraordinary cost pressures today largely because of the need to focus on efficiency and declining reimbursements for services (Kaufman, 2011). As a result, healthcare providers are seeking opportunities to reduce costs without diminishing quality of patient care. Their performance is heavily dependent on a complex network of companies working together in designing, producing, delivering, and managing a large array of healthcare related products and services. The industry is increasingly looking into the applications of supply chain management concepts, tools, and techniques to eliminate waste and achieve efficiency in healthcare networks. The emergence of the notion of healthcare supply chain management is evident in the trade press as well as in academic research.

The Gartner's annual ranking of supply chain leaders in healthcare, "The Gartner Healthcare Supply Chain Top 25", is one of such developments in the industry which started in 2009. O'Daffer et al. (2015) state that the goal remains the same since its inception in 2009 which is "The Healthcare Top 25 recognizes those life sciences and healthcare companies that have demonstrated leadership in developing and leveraging supply chain capabilities". Authors state that supply chain leadership requires a number of traits that includes a track record of consistent improvement in supply chain, demonstrated supply chain performance and a strong vision of the future. The motivation behind this ranking is that other companies can learn from the leaders and develop the supply chain capabilities necessary to succeed in the complex healthcare landscape. Gartner ranking methodology utilizes both quantitative /

financial measures as well as qualitative / expert opinions. Gartner has also been publishing the rankings for a number of other areas such as industrial, chemical and life sciences; the ranking methodology is similar across the areas but small differences do exist.

Supply Chain Management (SCM) in Healthcare is getting increasing attention in the academic literature lately (Dobrzykowski et al., 2014). Kwon et al. (2011) point out that the development stage in healthcare supply chain is far behind commercial supply chain in utilizing various supply chain tools. Hence the authors stress the need for scholarly discussions to re-conceptualize SCM in healthcare. As we discuss in the literature review, healthcare supply chain has to deal with patient flow (service) as well as flow of physical products, and thus differs from the traditional industrial supply chain. The complexity of the healthcare supply chain increases further because of the involvement of payers, fiscal intermediaries and regulatory agencies, who influence the materials and service flow in the supply chain.

This research was motivated by two key observations. First, supply chain finance concepts and ratios are increasingly used in supply chain performance assessments of companies and their rankings. Second, the academic as well trade press suggest that healthcare supply chain differs from other domains in a number of ways and the area is not well understood. The objective of this research is to characterize the healthcare supply chain structure using publicly available financial data. Specifically, our objective is to shed light on the supply chain performance structure of the companies operating in different stages of the healthcare supply chain. Also, we want to compare the performance of the supply chain leaders announced by Gartner, with the performance of their competitors in their respective supply chain stages. This will help us describe how the healthcare supply chain leaders are excelling in the respective supply chain stages.

The remaining part of this paper is organized as follows. In Section 2, we present a review of the academic literature pertaining to healthcare supply chain models and performance measurement systems. Section 3 describes Gartner's ranking methodology and the ranking for 2015, our research framework and research questions. In Section 4, we present our data collection, data analysis and observations. Finally, in Section 5 we conclude with a summary of our findings, contributions and discuss future research directions.

II. LITERATURE REVIEW

Our literature review is focused on research articles that help us characterize the link between the structure of healthcare supply chain and financial performance measurements. The literature review is primarily organized into two parts. The first part deals with the evolving body of research pertaining to the description of healthcare supply chain. This is followed by the review of articles pertaining to supply chain performance measurement systems reported in the product and service supply chains.
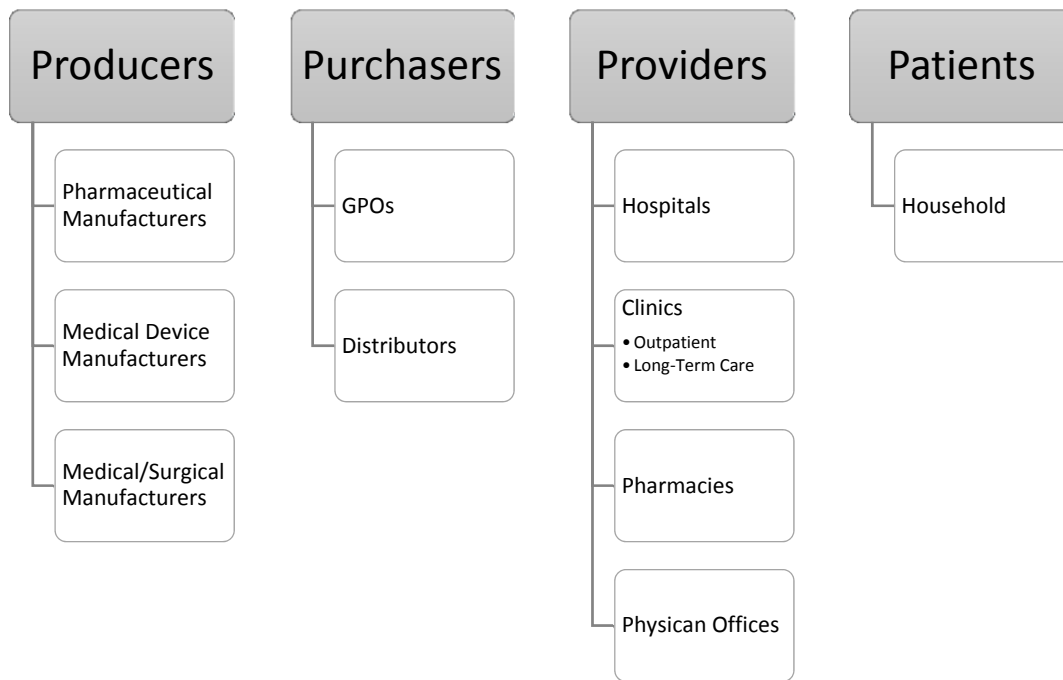
2.1. Healthcare Supply Chain Management

Similar to industrial supply chains, the healthcare value chain consists of multiple independent entities, such as hospitals, pharmacies, pharmaceutical companies, and insurance companies whose business models and objectives differ. Burns (2002) describes the healthcare value chain where the key members are divided into the following five categories:

- Payers for the service - government, employers and employees, individuals or coalitions;

- Fiscal intermediaries - insurers, healthcare maintenance organizations, pharmacy, beneficiaries or managers;
- Providers - hospitals, physicians, international distribution, pharmacists;
- Buyers - wholesalers, orders by postmen, distributors, groups of organizations;
- Producers - manufacturers of drugs, medical devices and surgical instruments.

Burns (2002) also conceptualizes the healthcare supply chain with four main components: producers, purchasers, providers, and patients as shown in Figure 1. In a nutshell, supply chain management in the healthcare context is about upstream and downstream relationships among producers, purchasers and service providers to deliver quality patient care in a cost-effective manner. The physical products that flow through the healthcare supply chain range from disposable bandages to state-of-the-art medical devices. The healthcare supply chain starts with the producers such as manufacturers of pharmaceuticals, medical devices, and medical/surgical supplies who produce items and send to a distribution center or purchasers. Purchasers consist of Group Purchasing Organizations (GPOs) and wholesale distributors who act as intermediaries between the producers and the providers. Depending on the type of product, hospitals can either purchase supplies directly from the manufacturer or the distributor, or the transaction can be conducted through a GPO. Providers deliver healthcare services to patients with the goods produced by producers complementing their service and their expertise.

FIGURE 1. COMPONENTS OF THE HEALTHCARE SUPPLY CHAIN.

The physical product-based characterization does not adequately describe the healthcare supply chain. Healthcare supply chain involves both physical and service product flow. Lee et al. (2011) state that supply chain management in hospitals includes an internal chain (e.g., patient care unit, hospital storage) and an external chain (e.g., manufacturers and distributors). A hospital receives products and services from suppliers, and then stores and distributes to each care unit based on the hospital's operation processes. SCM in hospitals includes flow of both materials and services for healthcare delivery. de Vries and Huijsman (2011) analyze whether any parallels can be found between the industrial sector and healthcare services with respect to the developments that have taken place in the area of supply chain management. They state that supply chain management practices in the healthcare sector not only relate to physical goods like drugs, pharmaceuticals, medical devices and health aids but also to the flow of patients. Therefore, the healthcare supply chain has to deal with patient flows (service) as well as physical products. SCM in healthcare context is thus concerned with designing and managing supply chains, controlling assets, and managing uncertainties in order to meet the needs of patients in a cost-effective manner.

Ellram, Tate and Billington (2004) compare the practices of SCM in the manufacturing industry and the service industry to which healthcare belongs. The authors indicate that much of the supply chain management literature examines activities and decisions used to move a physical product from suppliers to manufacturers and to customers and there has been limited attention given to service supply chains. They argue that one could expect improvement in organizational performance only when fundamental characteristics of manufacturing SCM is adequately modified and made suitable for the healthcare SC operations.

Samuel et al. (2010) state that a great deal of literature is available on supply chain management in finished goods inventory situations; however, little research exists on managing service capacity when finished goods inventories are absent.

Another distinct feature that increases the complexity of healthcare supply chain is the involvement of payers and fiscal intermediaries that include regulatory agencies such as FDA and healthcare payers such as medicare and insurance companies. Regulatory agencies determine if a medical product is fit for consumer use and payers determine if providers will be reimbursed for using it on specific patients. These payers and fiscal intermediaries have substantial influence on the product and service flow through the supply chain. Therefore, the healthcare supply chain is likely to be organized quite differently from that of product-based industrial domains. Aronsson, Abrahamsson and Spens (2011) state that supply chain management in healthcare is more complex and thus SCM practices developed in the manufacturing supply chains are not adopted readily.

Our literature review therefore indicates that the healthcare supply chain exhibits features of both industrial/product-flow based models as well as the service-flow based models. The upstream stage of the healthcare supply chain is more dominated by the physical material flow (reminiscent of a typical industrial supply chain) and the downstream stage is dominated by the service aspects (service supply chain).

2.2. Measuring Performance in Healthcare Supply Chain

Performance measurement system design in the healthcare context gets much complicated because of the duel nature of physical product and service flow. The characteristics of supply chain entities at the different stages of the healthcare supply chain

may be vastly different because of the nature of the product (goods and service) they are dealing with and the pertaining supply chain processes. These differences, in fact, could be the reason why it is hard to achieve supply chain alignment in the healthcare domain. The performance measurement system must integrate the features of the physical and service supply chains. A number of research articles have analyzed the differences between physical and service supply chains. For example, Sengupta, Heiser and Cook (2006) compare the differences of supply chain operations between services and manufacturing industries in terms of supply chain management performances metrics. They indicate different strategies and organizational performance metrics that are appropriate in manufacturing and service supply chains. In the following paragraphs, we review articles pertaining to the development of supply chain performance management systems that are popular in physical product and service contexts.

2.2.1. Measuring Performance in Product Supply Chains

The development of performance management systems started with standard descriptions of the supply chain processes and a process framework for defining the relationships among these processes. The Supply-Chain Council developed the SCOR model, which is based on five core processes (plan, source, make, deliver, and return) and three levels of process details (top level, configuration level, and process element level). The Global Supply Chain Forum Framework (GSCF) conceptualizes a supply chain that includes three elements: business processes, the management components, and the structure of the chain. Eight business processes are defined that cut across the functions within a firm and also across firms in the supply chain. The commonality among these two models is

that they focus on depicting the physical flow of goods among the members of the supply chain (Ellram, Tate and Billington, 2004). Both the models attempt to integrate the concepts of business process reengineering, benchmarking, process measurement, and best practice analysis, which allows the management of an organization to make connections between strategies and processes that have a significant impact on the overall performance of the supply chain (Lockamy and McCormack (2004) and Huang et al. (2004)). Using these models, metrics were developed to measure the operational performance of the supply chain process, such as order fulfillment cycle time, upstream supply chain flexibility, upstream supply chain adaptability, downstream supply chain adaptability, Cost of Goods Sold (COGS), and so on. These performance metrics are designed to provide a view of the overall supply chain performance at level 1 (top level), level 2 (configuration level) and level 3 (process element level) (Huang et al. (2004)). These supply chain performance measures fall into five categories: reliability, responsiveness, flexibility, cost, and asset metrics.

We next review important articles that have examined the link between the supply chain operational performance and financial performance. Presutti and Mawhinney (2007) describe the link between operational-metrics-based SCOR model and financial-metrics-based Economic Value Added (EVA). The book by Hutchison et al. (2009) describes how Cash-to-Cash (C2C) measures can be used in a supply chain to realize opportunities for improving efficiency, profitability, cash flow management, and communication channels among supply chain members. The C2C calculation includes three financial variables: inventory, accounts receivable, and accounts payable. Kremers (2010) describes how supply chain operational performance can be evaluated in terms of its impact on cash flow, market value, and internal financial

performance metrics using the SCOR model. Wisner (2011) describes how supply chain functions influence company's financial statements (income statement, balance sheet, statement of cash flows, and statement of stockholders' equity). By reviewing the extant literature, Kancharla and Hegde (2016) summarize how financial statement components (Income Statement and Balance sheet) are impacted by supply chain operational performance measures. Also, the authors present six financial ratios that are used in the performance analysis of supply chain entities in the context of physical-product-based supply chains.

2.2.2. Measuring Performance in Service Supply Chains

Similar to the manufacturing supply chains, the development of Service Supply Chain Performance Management (SSCPM) can be described in three layers. The first layer is the development of service supply chain model which started with the analysis of whether supply chain models such as SCOR and GSCF models fit the services domain. For example, Ellram, Tate and Bilington (2004) indicate that the GSCF and SCOR models may fit into some areas of services such as retail trade. However, these models do not fit the needs of the entire service sector that includes professional service and patient care in hospitals. The development of a service supply chain model or modification of the existing manufacturing-based model started by defining service supply chain processes. For example, Ellram, Tate and Billington (2004), define seven processes in the context of professional services: Information flow, capacity and skills management, demand management, customer relationship management, supplier relationship management, service delivery management, and cash flow. Baltacioglu et al. (2007) define the following processes that describe services

supply chains: Demand management, Capacity and resource management, Customer relationship management, Supplier relationship management, Order process management, Service performance management, and Information and Technology management. Giannakis (2011) explores the utility of SCOR model in services and develops a reference model for use in service organizations.

The second layer is about metrics and measures that are defined in the context of service supply chain processes identified in the service supply chain model. The topic of performance measurement in services is a well-researched topic much before the popularization of service supply chain concept. Fitzgerald et al. (1991) came up with the following six performance dimensions: Financial, Competitiveness, Quality of service, Flexibility, Resource utilization and Innovation. Among the six, the first two dimensions are financial metrics and the latter four dimensions are operational level metrics. Cho et al. (2012) provide an overview of measures/dimensions developed in the service performance domain and develop a framework of service supply chain performance measurement (SSCPM). The authors define and describe a number of operational measurements along the seven service supply chain processes described by Baltacioglu et al. (2007). This development is comparable to the development of the performance measures using SCOR/GSCF models in the manufacturing domain.

The third layer is about the financial performance measures and their linkage to the operational performance measures. As pointed earlier, two of the six service performance dimensions defined by Fitzgerald et al (1991) are financial and the type of measures in these dimensions include profitability, liquidity, capital structure and sales growth. Ellram, Tate and Billington (2004) view managing capacity as an important feature in any service. They

consider the process of providing a service as the transfer of service provider's capacity to the customer and the capacity is driven by the assets owned by the company. Hence the authors indicate that the cost associated with the assets and total cash-flow time need to be evaluated through the financial performance. Giannakis (2011) also state that service supply chain processes are balanced around the capacity of the firm. He too conceptualizes the capacity of service firms as a resource inventory required to provide service. He reports that the inventory-capacity duality is common feature of the service sector.

Service supply chain finance is also one of the nine dimensions of SSCPM framework developed by Cho et al (2012). The authors review a number of financial performance measures developed in the service business and describe the relationships among various financial measures and also relationships between operational and financial measures. The first one is the linkage between cost of assets and return on investment. The authors indicate that it is essential to determine how the costs associated with each asset, combined with its turnover, affects the total cash flow time. Once the total cash flow time is determined, it can readily be combined with profit, and provide insights into the return on investment (Gunasekaran et al., 2001). The second relationship pertains to the impact of service delivery management policies on return on investment. For example, superior customer service leads to improved sales and an increased profit, and subsequently, a higher return on investment.

In summary, the review of literature pertaining to the supply chain performance management systems shows physical product and service supply chain processes differ, which in turn impact operational and financial performances differently. The supply chain entities that operate in different healthcare supply chain stages are likely to have different performance pattern because of the dual

physical and service product that they are dealing with.

III. CONCEPTUAL FRAMEWORK AND OBJECTIVES OF THIS STUDY

As discussed in the introduction, "The Gartner Healthcare Supply Chain Top 25" ranking has become popular in the industry. The motivation behind this ranking is that other companies can learn from the leaders regarding the supply chain capabilities necessary to succeed in the complex healthcare landscape. As we have described in the literature review, the healthcare supply chain has features of both product and service based supply chains. We want to develop a framework that combines the Gartner's ranking methodology and supply chain management theory to provide a richer characterization of the healthcare supply chain utilizing the financial performance of companies in this domain. Also, this framework helps us advance our understanding of the healthcare supply chain theory and practice. We describe Gartner's ranking methodology, our framework, and our research questions next.

Gartner rates the companies across the healthcare value chain based on quantitative and qualitative measures. The quantitative measures come from financial data and Truven Health System Percentile score. The qualitative data comes from peer ratings, bond ratings (S&P rating system) and Gartner rating. For the non-health systems (such as manufacturers, distributors and retailers), Gartner analysts derive a master list of companies that are specific to healthcare business which publish audited financials and have a revenue of $1.5 billion or higher. Then,
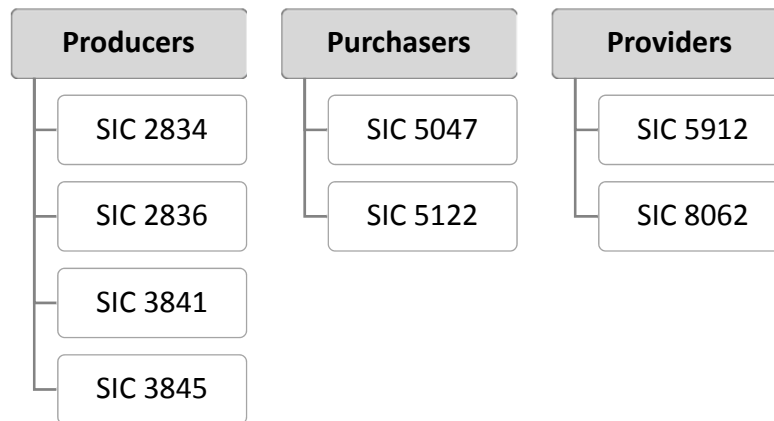
Gartner ranks companies based on a composite scoring method where 40% of the total score is based on publicly available financial data published annually by these companies. The following two financial ratios make up the 40%: ROA 20% and inventory turns 20%. They mention that inventory turns offers an indication of supply chain effectiveness, and ROA provides a general proxy for operational effectiveness. They use three years of financial data and use a weighted performance measure for ROA: year 2014 (50%), 2013 (30%) and 2012 (20%). They use the 2014 end-of-year measure for inventory turns. The remaining 60% of the total score is based on a qualitative assessment, that is, opinion from select panel members. 30% of this assessment is contributed by Gartner's analysts, representing various industry and functional specialties, who are selected to contribute opinions based on their research and work with healthcare value chain companies. Another 30% is derived from a peer opinion panel, which consists of supply chain professionals and leaders belonging to the companies that are assessed. Gartner uses a different assessment methodology for the health systems (such as hospitals) because the financial data is not always publicly available.

While the revenue cut-off remains at $1.5 billion, they include only those companies that are in the top 80% of the Truven Health Analytics 15 Top Health System study (a proxy for quality-of-care score). The percentile score published by Truven is based on publicly available data across 10 measurements of patient care performance, including mortality, complications, patient safety, core measures, 30-day patient readmits, 30-day mortality, average length of stay (ALOS), expense, operating profit margin and Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS). Bond rating was also chosen to represent operational efficiency. The weightage for different categories are as follows: peer opinion 35%, Gartner opinion 35%, bond rating 15%, Truven ranking 15%.

We started the selection of various companies for this study from the Gartner's Healthcare Top 25 listing for the year 2015. We used Compustat online database and United States Department of Labor website (https://www.osha.gov/pls/imis/sic_manual.html) to identify the SIC codes and the industry sector of the supply chain leaders. These twenty five supply chain leaders fall into eight industry groups (SICs). As shown in Figure 2, these SIC codes fall into three healthcare supply chain stages conceptualized by Burns (2002).

Producers	Purchasers	Providers
SIC 2834	SIC 5047	SIC 5912
SIC 2836	SIC 5122	SIC 8062
SIC 3841		
SIC 3845		

FIGURE 2. RESEARCH FRAMEWORK TO ANALYZE THE ROLE OF HEALTHCARE SUPPLY CHAIN LEADERS.

Table 1 includes the healthcare supply chain stages, the SIC codes that belong to the supply chain stage, the description of the SIC codes and the respective Gartner's supply chain leaders belonging to each SIC code.

Using this framework, we wanted to analyze the financial performance of the companies in each supply chain stage and draw inferences about the structure of healthcare supply chain based on the patterns in the financial performance. Further, we wanted to explore what can be learned about the supply chain practices of the leaders using the financial performance. We limited our analysis to publicly traded companies for which information is readily available. Fourteen out of the Gartner Top 25 companies listed in Table 1 are publicly traded. The remaining eleven companies belong to health systems and are not traded in the US markets or financial data is not available. Primary competitors were identified based on SIC codes of the leaders (using Compustat). We accomplish our research objectives by investigating the following two research questions:

1. Inter-Stage Comparison: What are the characteristics of companies that operate across the healthcare supply chain? What are the similarities and differences as one moves from the upstream stages to the downstream stages?

2. Intra-Stage Comparison: What are the differences between the supply chain leader(s) and its competitors in each sector? Specifically, what are the differences between the average performance of the group and the group's leaders?

TABLE 1. SIC CODES AND THE LEADERS IN THE RESPECTIVE SIC CODES.

SC Stage	SIC code	Description	Top companies (Gartner rank)
Producers	2834	Manufacturers of Pharmaceutical Preparations	Johnson & Johnson (9), Pfizer (16), Abbott (20), Glaxo (25)
	2836	Manufacturers of Biological Products (except Diagnostic Substances)	AbbVie (21)
	3841	Manufacturers of Surgical and Medical Instruments and Apparatus	Becton Dickinson (12)
	3845	Manufacturers of Electromedical and Electrotherapeutic Apparatus	Medtronic (15)
Purchasers	5047	Wholesalers of Medical, Dental, and Hospital Equipment and Supplies	Owens & Minor (4), Henry Schein (18)
	5122	Wholesalers of Drugs, Drug Proprietaries, and Druggists' Sundries	Cardinal (2), McKesson (7), AmerisourceBergen (8)
Providers	5912	Retailers of Drug Stores and Proprietary Stores	CVS (6), Walgreens (10)
	8062	General Medical and Surgical Hospitals	Mayo Clinic (1), Intermountain Healthcare (3), Mercy (5), Banner Health (11), Advocate Healthcare (13), UPMC (14), BJC Healthcare (17), Cleveland Clinic (19), Duke UHS (22), Ascension Health (23), Baptist Health South Florida (25).

IV. RESEARCH METHODOLOGY, DATA ANALYSIS AND OBSERVATIONS

4.1. Dataset and Preliminary Analysis

We downloaded the financial data for all the companies under each SIC code from Compustat database for the three years 2013-15. Table 2 provides the number of companies in each SIC code as of 2015, the average and the median revenue by SIC code for the companies that are publicly traded and based on the data for the year 2015.

From Table 2, we observe that, in general, a large number of companies exist in the upstream stage (the producers) compared to the downstream stage of the supply chain. The highly skewed distribution of the revenue (the median is a lot lesser than the average) also indicates that a large number of small companies operate in the upstream stage of the supply chain. Another measure that is interesting to look at is the Herfindahl-Hirschman Index (HHI). This index is an indication of market competition and consolidation and varies from 0 (highly fragmented) to 1 (monopoly). If there are N companies in the market, HHI is given by the following formula:

$$HHI = \sum_{i=1}^{N} s_i{}^2$$

where s_i is the market share of each company (in terms of revenue). The smaller the index, the greater is the fragmentation in the industry, whereas an higher index indicates higher consolidation in the industry. We once again observe that the upstream stage of the healthcare supply chain is fragmented, as observed from the relatively lower values of HHI for the producers.

The number of companies reduces as we move to the downstream stages (purchasers and retailers) of the supply chain. Healthcare is an industry where there has been a lot of consolidation and we can observe the same through the decreasing number of companies and the decreasing skewness as we go downstream. Though the companies are smaller in number they are bigger in size, as evident from their average revenue.

TABLE 2. SUMMARY OF COMPANIES IN THE HEALTHCARE SUPPLY CHAIN (2015).

SC Stage	SIC code	All publically traded companies				Shortlisted for analysis		
		# of companies	Average Revenue MM$	Median Revenue MM$	HHI*	# of companies	Average Revenue MM$	Median Revenue MM$
Producers	2834	233	2351.1	13.5	0.07	10	39836.9	38676.8
	2836	406	317.5	0.7	0.01	10	11827.6	8192.4
	3841	58	416.6	28.0	0.22	10	2130.4	859.9
	3845	96	599.9	17.7	0.28	10	5172.8	2031.7
Purchasers	5047	6	5169.6	5386.7	0.36	5	6033.0	5386.7
	5122	14	31448.8	906.6	0.34	10	44027.8	2174.9
Providers	5912	13	30491.8	499.0	0.29	6	39626.4	3028.4
	8062	10	9711.9	3991.8	0.26	9	10790.7	5214.3

*HHI computed only for publicly traded companies in each SIC

We also observe that while the major retailers, among providers, are publicly traded, only very few hospitals (providers) are publicly traded. In fact, none of the leaders, as ranked by Gartner, are publicly traded. Most of the major hospitals choose to obtain funding through long–term loans from financial institutions rather than through public offering. Hence in our analysis, we decided to keep these two categories (retailers and hospitals) as separate, as the publicly traded hospitals are not quite representative of the group since the leaders are missing in the data. We summarize our findings from the preliminary analysis through the following observations:

Observation 1A:
Healthcare supply chain is fragmented at the producers' end of the supply chain with a larger number of companies including many smaller ones.
Observations 1B:

The purchasers and retailers (providers) are consolidated with fewer but bigger companies.
Observations 1C:
The leading and major hospitals are not publicly traded.

For further analysis, we only looked at the top 10 companies (wherever available and subject to data availability) under each SIC code based on their total revenue in 2015 for the following reasons. The sample is more representative of the competition as observed from the decreased skewness in the revenue distribution. Since the median is closer to the mean (than when compared to the entire population) the companies in the shortlist are a lot similar to each other. The companies in each SIC code are hence closer and comparable to each other. Therefore, our sample selection method makes the inter-stage comparisons using the averages financial ratios more reliable.

4.2. Financial Performance Ratios

We chose to include financial years 2013, 2014, and 2015 and gave the same weights as that given by Gartner (20%, 30% and 50% respectively). We use the efficiency and profitability related measures as those chosen by Kancharla and Hegde (2016) to analyze the supply chain performance of the companies chosen for our analysis. The measures are summarized in Table 3.

TABLE 3. FINANCIAL RATIOS USED IN THE ANALYSIS.

Type of Ratio	Name of the Ratio	Description
Efficiency Ratio	Cost of Goods Sold (% of Revenue)	$\dfrac{Cost\ of\ Goods\ Sold}{Total\ Revenue}$
	Inventory Turnover	$\dfrac{Cost\ of\ Goods\ Sold}{Ending\ Inventory}$
	Cash Conversion Cycle (C-C-C)	Days' sales Outstanding + Days' inventory outstanding – Days' payables outstanding
	Asset Utilization	$\dfrac{Revenue}{Total\ Assets}$
Profitability Ratio	Return on Capital Employed (ROCE)	$\dfrac{Earnings\ Before\ Interest\ and\ Tax}{Capital\ Employed}$
	Return on Assets (ROA)	$\dfrac{Net\ income}{Total\ Assets}$
	Gross Profit Margin	$\dfrac{Gross\ Profit}{Total\ Revenue}$
	Operating Margin	$\dfrac{Earnings\ Before\ Interest\ and\ Tax}{Total\ Revenue}$

We present next the ratios at the aggregate level (for the companies that we shortlisted) for each of the SIC codes followed by our analysis. We then analyze the companies within each part of the supply chain to understand the difference between the leaders and their competitors.

4.3. Performance across Different Parts of the Healthcare Supply Chain

Tables 4 and 5 respectively provide a summary of the efficiency and profitability ratios at the aggregate level for each stage of the healthcare supply chain. The ratios were weighted averages of three years (2013-15): 20% for 2013, 30% for 2014, and 50% for 2015. The financial ratios presented for each SIC code is the average of all the shortlisted companies (the top 10 by revenue where available) belonging to the respective SIC codes.

The ratios for the producers and purchasers presented in the tables are a weighted average of the SIC averages, as the number of companies under each SIC code is different and two or more SICs are present in each supply chain stage. The two SICs under providers are quite distinct; also as discussed above, the publicly traded hospitals are not quite representative of the group since the leaders are missing in the data. Hence we do not compute the supply chain stage average for providers.

TABLE 4. AVERAGE EFFICIENCY RATIO BY SIC CODE.

SC Stage	SIC	Description	COGS as % of Revenue	Inventory Turnover	C-C-C	Asset Utilization
Producers	2834	Manufacturers of Pharmaceutical Preparations	22.8%	1.68	144.5	47.2%
	2836	Manufacturers of Biological Products (except Diagnostic Substances)	26.7%	1.49	237.1	51.4%
	3841	Manufacturers of Surgical and Medical Instruments and Apparatus	37.2%	2.43	215.3	63.7%
	3845	Manufacturers of Electromedical and Electrotherapeutic Apparatus	38.7%	2.73	170.2	64.9%
		Weighted Average for Producers	***31.3%***	***2.09***	***191.8***	***56.8%***
Purchasers	5047	Wholesalers of Medical, Dental, and Hospital Equipment and Supplies	66.6%	7.23	67.8	172.5%
	5122	Wholesalers of Drugs, Drug Proprietaries, and Druggists' Sundries	70.1%	9.49	39.7	204.2%
		Weighted Average for Purchasers	***69.0%***	***8.74***	***49.0***	***193.6%***
Providers	5912	Retailers of Drug Stores and Proprietary Stores	76.7%	13.89	25.0	219.9%
	8062	General Medical and Surgical Hospitals	82.0%	35.01	44.7	114.2%

In terms of efficiency ratios, we observe that the COGS as a % of revenue, similar to industrial supply chains, increases as we go downstream and so is the inventory turnover. The cash conversion cycle also decreases (an indication of lower working capital), as one moves downstream of the supply chain. The manufacturers also tend to have a lower asset utilization, given their huge fixed assets. The asset utilization increases as we move downstream. However, hospitals belonging to the downstream part of the supply chain have a lower asset utilization. This feature is perhaps arising out of a necessity of being a healthcare provider. Hospitals may have to own a variety of assets for comprehensive diagnosis and treatment. These machines and equipment may not be utilized for a majority of the patients, thus leading to lower asset utilization. Excess capacity also acts as a cushion for uncertain demand and hence lower utilization of resources which is typical of any services business.

The different SICs within each supply chain stage also show remarkable similarity. We summarize using the following key observations based on the pattern in the efficiency ratios.

Observation 2A:
COGS increases as we move downstream from producers to purchasers to retailers.
Observation 2B:
Inventory turnover and Asset Utilization increase (improve) as we move downstream from producers to purchasers to retailers.
Observation 2C:

C-C-C reduces (improves) as we move downstream from producers to purchasers to retailers.
Observation 2D:
Hospitals tend to have lower asset utilization than purchasers and retailers.

Next we discuss the profitability ratios presented in Table 5. The producers have the highest operating and gross profit margins, which also explain the reason why the industry continues to be fragmented. High margins attract more companies into the business and the incumbents continue to relish the attractive market. In contrast, the margins reduce as we move downstream to purchasers and providers, which explains the companies' attempts to consolidate and get a bigger market share. We also observe the wholesalers getting squeezed from both directions of the supply chain. It reflects the fact that wholesalers may not add significant value in the healthcare supply chain, may see their role diminished, and therefore have less bargaining/negotiating power.

The operating margins of retailers and hospitals are in between that of purchasers and producers. While retailers have a higher return on assets than the purchasers, hospitals (that are publicly traded) have negative returns.

Observation 3A:
ROCE and Profit margins are the highest at the producer end and decrease as we move downstream from producers to purchasers to retailers.
Observation 3B:
ROA and Operating margin exhibit a U-shaped nature with producers and providers (retailers and hospitals) having higher returns than purchasers.

4.4. Intra-stage Analysis of Healthcare Supply Chain Stages

We next analyze the companies under each supply chain stage; specifically, we compare the performance of the supply chain leaders with the respective SIC averages. We look at producers first. Table 6 gives a summary of the ratios for the producers: the leaders (as ranked by Gartner) and the averages for the companies in the respective SICs.

Among the manufacturers of pharmaceutical preparations (SIC 2834), the leaders (J&J, Pfizer, Abbott, and Glaxo) excel on different dimensions. Two of them (J&J and Pfizer) are better than the average while the other two are worse than the average in terms of operating margin. J&J has a very low C-C-C, and both J&J and Abbott have a C-C-C that is lower than the average. J&J and Glaxo have a superior return on capital employed and asset utilization. Pfizer has a very low cost of goods sold as a % of revenue (as also reflected in the higher margins) but is worse than the average on the other dimensions. Abbott's inventory turnover is almost twice that of the sector average. Thus, each of these leaders seem to have a different strategy towards dominance.

Among the manufacturers of biological products (SIC 2836) only Abbvie figures in the Gartner rankings. The C-C-C again stands out for Abbvie and possibly explains its leadership. Abbvie has a higher inventory turnover than the average of the others in the sector, though it is only marginal. The other measures are also higher than the average. Interestingly, Gilead has impressive figures but does not find its way into the top 25. Gilead is an example where financial data does not capture all the key aspects and here is where expert opinions play a major role. But there may be some learning opportunities from Gilead which has a surprisingly high operating margin (Gilead's revenue in 2015 was also higher than Abbvie's).

TABLE 5. AVERAGE PROFITABILITY RATIO BY SIC CODE.

SC Stage	SIC	Description	ROCE	ROA	Gross Profit Margin	Operating Margin
Producers	2834	Manufacturers of Pharmaceutical Preparations	14.0%	8.5%	77.3%	22.3%
	2836	Manufacturers of Biological Products (except Diagnostic Substances)	22.3%	12.8%	73.3%	34.4%
	3841	Manufacturers of Surgical and Medical Instruments and Apparatus	10.8%	3.3%	62.8%	14.6%
	3845	Manufacturers of Electromedical and Electrotherapeutic Apparatus	15.0%	7.7%	61.3%	19.5%
		Weighted Average for Producers	*15.5%*	*8.1%*	*68.7%*	*22.7%*
Purchasers	5047	Wholesalers of Medical, Dental, and Hospital Equipment and Supplies	10.0%	4.8%	33.4%	4.8%
	5122	Wholesalers of Drugs, Drug Proprietaries, and Druggists' Sundries	18.3%	1.7%	29.9%	-2.1%
		Weighted Average for Purchasers	*15.6%*	*2.7%*	*31.1%*	*0.2%*
Providers	5912	Retailers of Drug Stores and Proprietary Stores	3.8%	5.3%	23.3%	3.2%
	8062	General Medical and Surgical Hospitals	8.9%	-0.4%	18.0%	7.4%

TABLE 6. INTRA-STAGE ANALYSIS OF PRODUCERS.

Company Name (Gartner Ranking)	COGS as % of Revenue	Inventory Turnover	C-C-C	ROCE	ROA	Asset Utilization	Gross Profit Margin	Operating Margin
Johnson & Johnson (9)	25.4%	2.25	80.1	18.3%	11.6%	54.0%	74.6%	27.0%
Pfizer (16)	15.7%	1.18	213.1	10.2%	6.3%	29.4%	84.3%	29.4%
Abbott Laboratories (20)	39.3%	3.09	133.8	9.7%	8.2%	49.6%	60.7%	15.1%
Glaxosmithkline (25)	26.3%	1.47	159.2	16.2%	12.5%	52.67%	73.7%	21.1%
SIC 2834 Average	*22.8%*	*1.68*	*144.5*	*14.0%*	*8.5%*	*47.2%*	*77.3%*	*22.3%*
Abbvie Inc (21)	16.9%	2.60	98.1	27.2%	9.6%	56.2%	83.1%	35.0%
Gilead Sciences Inc	12.7%	1.64	152.7	48.2%	30.7%	63.0%	87.3%	60.9%
SIC 2836 Average	*26.7%*	*1.49*	*237.1*	*22.3%*	*12.8%*	*51. 4%*	*73.3%*	*34.4%*
Becton Dickinson & Co (12)	44.7%	2.44	163.0	11.5%	6.3%	52.8%	55.3%	17.3%
SIC 3841 Average	*37.2%*	*2.43*	*215.3*	*10.8%*	*3.3%*	*63.7%*	*62.8%*	*14. 6%*
Medtronic Plc (15)	26.2%	2.06	176.9	8.03%	4.1%	29.1%	73.8%	24.4%
SIC 3845 Average	*38.7%*	*2.73*	*170.2*	*15.0%*	*7.7%*	*64. 9%*	*61.3%*	*19.5%*
Producers Average	*31.3%*	*2.09*	*191.8*	*15.5%*	*8.1%*	*56.8%*	*68.7%*	*22.7%*

Among the manufacturers of surgical and medical instruments (SIC 3841) only Becton Dickinson figures in the Gartner rankings. Most of the measures are again lower than or about the same as the average for the sector except for C-C-C. In stark contrast, Globus Medical, even though has superior profit margins, has a C-C-C that is almost the double of that of the industry average. It will be interesting and insightful to track the performance of this company. Bard (its revenue in 2015 was only one-third of that of Becton Dickinson) also has superior supply chain measures including that of C-C-C. Both Bard and Globus Medical are more examples of why financial ratios cannot give the complete picture of supply chain efficiency.

Among the manufacturers of electromedical and electrotherapeutic apparatus (SIC 3845) only Medtronic figures in the Gartner rankings. Its superior performance comes from a lower cost of goods sold (as a % of revenue), which also explains its superior profit and operating margins. Its performance however is below par when it comes to efficiency ratios. The C-C-C is just above the average and whether this is a strategic requirement of this industry could be investigated.

In summary, producers differ in terms of their strategy towards the top, ranging from lower C-C-C to better utilization of resources. We summarize our findings from the intra-stage analysis of producers through the following observations.

Observation 4A:
The performance of the supply chain leaders among producers does not show any consistent pattern.

Observation 4B:
Financial ratios do not always explain leadership in the healthcare sector as some leaders perform worse than the SIC average.

Table 7 gives a summary of the purchasers. There are 5 leaders spread across two SICs. The average of their ratios are presented in Table 7.

TABLE 7. INTRA-STAGE ANALYSIS OF PURCHASERS.

Company Name (Gartner Ranking)	COGS as % of Revenue	Inventory Turnover	C-C-C	ROCE	ROA	Asset Utilization	Gross Profit Margin	Operating Margin
Owens & Minor Inc (14)	87.6%	9.45	40.0	12.8%	3.5%	357.5%	12.4%	2.18%
Schein (Henry) Inc (18)	70.5%	5.21	65.0	17.1%	7.5%	166.4%	29.5%	7.10%
SIC 5047 Average	*66.6%*	*7.23*	*67.8*	*10.0%*	*4.8%*	*172.5%*	*33.4%*	*4.84%*
Cardinal Health Inc (2)	94.3%	10.65	5.1	17.4%	3.6%	353.4%	5.7%	2.10%
Mckesson Corp (7)	93.7%	11.29	9.2	16.0%	3.3%	321.6%	6.3%	1.92%
Amerisourcebergen Corp (8)	97.4%	13.31	-5.5	26.1%	0.6%	504.7%	2.6%	1.00%
SIC 5122 Average	*70.1%*	*9.49*	*39.7*	*18.3%*	*1.7%*	*204.2%*	*29.9%*	*-2.11%*
Purchasers Average	*68.9%*	*8.74*	*49.0*	*15.6%*	*2.7%*	*193.6%*	*31.1%*	*0.21%*

Among wholesalers of medical, dental, and hospital equipment and supplies (SIC 5047), Owens and Minor and Schein (Henry) are the industry leaders. Owens and Minor scores on the C-C-C which is significantly lower than the industry average. Its asset utilization is also twice that of the industry average. Its superior performance in these measures (including that of inventory turnover), however does not reflect in its margins. Its margins are considerably below the industry average. Schein's cost of goods sold is lower than the average resulting in higher margins. Interestingly, the below average efficiency does not seem to affect its margins which can be further increased if it can also focus on its efficiency measures.

Three of the top 10 performers are among wholesalers of drugs (SIC 5122). Surprisingly, despite their ranking, their profitability measures are lower than that of the industry average. Their above average cost of goods sold explains the lower profitability. Their leadership comes from C-C-C and inventory turnover. In fact, Amerisourcebergen is so efficient that its C-C-C is negative, the only company among the 14 leaders to have so. While all the three companies have a higher-than-average asset utilization, Amerisourcebergen has an asset utilization that is more than twice the industry average. The higher efficiency does not lead to higher profitability though, and possibly explains the various attempts at consolidation (mergers and acquisitions).

In summary, we can infer that the lower margins for the purchasers have forced the leaders to focus on getting more efficient in terms of asset utilization and inventory turnover. We summarize our findings from the intra-stage analysis of purchasers through the following observations.

Observation 5A:
The leaders among purchasers have higher (better) asset utilization and higher (better) inventory turnover than the average company in the group.

Observation 5B:
COGS as percentage of revenue is worse for the leaders when compared to the sector average leading to lower profit margins than average.

Table 8 gives a summary of the retailers. CVS and Walgreens are the two leaders among the retailers.

TABLE 8. INTRA-STAGE ANALYSIS OF RETAILERS.

Company Name (Gartner Ranking)	COGS as % of Revenue	Inventory Turnover	C-C-C	ROCE	ROA	Asset Utilization	Gross Profit Margin	Operating Margin
CVS Health Corp (6)	80.7%	9.1	45.6	14.6%	5.9%	173.6%	19.3%	6.3%
Walgreens Boots Alliance Inc (10)	71.0%	8.4	22.8	11.6%	6.0%	177.5%	29.1%	4.9%
Retailers Average	*76.7%*	*13.9*	*25.0*	*3.8%*	*5.3%*	*219.9%*	*23.3%*	*3.2%*

Among the retailers of drugs, two of them are among the Gartner Top 25. Both have better operating margins than the average. Their asset utilization and inventory turnover is however lower than the average. Having a lot of physical stores with a wide variety of inventory might be the key to success in this sector, as observed from a higher ROA and ROCE.

It is also interesting to compare the two leaders here. Though Walgreens is behind CVS in terms of ranking, it is far more efficient as reflected by the efficiency measures. The C-C-C and the gross profit margins of Walgreens are better than that of CVS (the C-C-C of CVS is only half of that of Walgreens), yet its operating margins are lower. This is because CVS has lower operating expenses (as a percentage of total revenue) than Walgreens. We summarize our findings from the intra-stage analysis of retailers through the following observations.

Observation 6A:
The leaders among the retailers perform better than average in terms of ROA and ROCE but worse in terms of inventory turnover and asset utilization.

Observation 6B:
There is no consistent pattern on other dimensions namely, profit margin and C-C-C.

V. DISCUSSION OF THE FINDINGS AND CONCLUSIONS

We made several observations by reviewing the academic literature as well as the trade press pertaining to the healthcare supply chain. First, the notion of healthcare supply chain is new and there are discussions about the need to re-conceptualize the definition of healthcare supply chain. Second, supply chain management in healthcare domain is more complex, is different from other domains, and hence the practices developed in the industrial/product supply chains may not be adopted readily into healthcare. Third, the healthcare industry is increasingly looking to apply supply chain management principles to increase efficiency. The Gartner's annual ranking of supply chain leaders in healthcare "The Gartner Healthcare Supply Chain Top 25" is one of such developments aimed towards establishing the supply chain best practices in the healthcare domain. The question on how and what we can learn from the supply chain leaders in terms of their supply chain practices motivated this research. Specifically, our research objective was to explore whether financial performance measurement developed in the supply chain finance area and used by Gartner's methodology, helps us in understanding the nature of healthcare supply chain.

This research has several contributions towards understanding the nature of healthcare supply chains and the companies that operate in it. First, we conceptualized a framework by reviewing the supply chain literature, which describes the link between healthcare supply chain structure and financial performance measurement. Second, from the analysis of financial data and ratios, we find that the companies that operate in different stages of the supply chain do exhibit different financial performance patterns. We are able to explain the reasons behind these differences using the framework we developed and state our observations based on the patterns identified, which are both valuable in understanding the characteristics of the healthcare supply chain. The financial patterns in turn will influence/determine the operational performance and supply chain configurations.

Third, we explored whether healthcare supply chain leaders ranked by Gartner outperform the competitors in their respective supply chain stages. Different leaders excelled in different financial performance dimensions; however, we did not find a consistent pattern among the leaders in the respective stage of the healthcare supply chain. In fact, some of

the leader's financial performances were not better than the sector average, which could be attributed to the following reasons. Gartner considers only two financial ratios and gives only 40% weight to the two ratios, whereas the remaining 60% weight is given to qualitative/expert opinions. Gartner stresses on sharing of supply chain best practices and successes, considering the unique nature of healthcare supply chain. The sharing dimension is perhaps not directly explained using traditional measures and hence the need for expert opinions. Therefore, all the supply chain leaders may not show dominant financial performance in their respective supply chain stage. Other reasons could be the limitations in either the Gartner methodology or the supply chain finance theory in explaining the supply chain performance or excellence in the healthcare domain.

We do acknowledge a few limitations of this study, which are also opportunities for potential extensions to this stream of research that we are planning to pursue. First, we looked into the financial performance of only the top ten companies (based on revenue) in each category and used only three years (2013-2015) of financial data. Second, we have used the financial ratios that are typically used in the analysis of traditional product supply chain; it is likely that additional financial performance measurements are necessary for the healthcare supply chain because of the involvement of services and regulatory aspects. Irrespective of these limitations, our research advances our understanding of the nature of healthcare supply chain, demonstrates how publicly available data can be used to make inferences about supply chain practices, and identifies several avenues to advance the theoretical development.

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