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The Role Of Industry Structure On Customer Value In Robotic Surgery

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The Role Of Industry Structure On Customer Value In Robotic Surgery

By

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ACCEPTANCE

This dissertation was prepared under the direction of the BERKLEY BAKER'S Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctoral of Philosophy in Business Administration in the J. Mack Robinson College of Business of Georgia State University.

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ABSTRACT

The Role Of Industry Structure On Customer Value In Robotic Surgery

BY

Berkley Baker

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Spending on robot surgery is expected to increase by $17 billion in the next 6 years. This new surgical treatment has challenged hospitals with higher costs and varying performance. Healthcare executives struggle balancing the adoption of medical innovations with managing healthcare costs. This dilemma can be further complicated by industry structures relative to capital-intensive medical innovations. This research explores the interaction between industry structure and customer value. Specifically, how can hospitals apply an understanding of supplier industry structure and customer value to improve the value of a robotic surgery program (RSP)? This industry study represents an exhaustive longitudinal review of over 15 years of public data relative to robotic surgery, across three distinct time periods. Within the research, industry structure is evaluated using Porter's 5-forces model. A framework based upon contributions from Grönroos as well as Menon, Homburg, and Beutin is introduced to assess customer value based upon clinical, financial and strategic (CFS) value. The implications of periodic industry structure on customer value were examined to identify opportunities for hospital executives to increase RSP customer value.

There were several empirical and theoretical findings from this research. First, in the face of increasing industry structure the identification of favorable forces may create opportunities to increase RSP value. Secondarily, exploring customer value through the lens of core, add-on, relational and transactional benefits in the sub-context of CFS value aids in the identification of market power influences on customer value. The implications of the absence of high levels of relational and transactional benefits without high levels of core and add-on benefits may influence avenues of pursuit in improving RSP value overall. The research also suggests that clinical and strategic value was present despite varying degrees of industry structure. Finally, this study represents an empirical joint analysis of industry structure and customer value in robotic surgery. Some proponents may find the introduction of an integrative model for measuring customer value in robotic surgery, applicable to other capital-intensive medical innovations or disruptive technologies at large.

I HEALTHCARE AND CAPITAL-INTENSIVE MEDICAL INNOVATIONS

I.1 Introduction

At present, the United States healthcare system consists of about 6,500 hospitals with a combined annual revenue exceeding $700 billion (First Research, Inc. 2009). America's 76 million surviving baby boomers began turning 65 in 2011, while the life expectancy of seniors is growing (Plunkett Research, Ltd., 2013). Meanwhile, healthcare costs continue to increase, outpacing inflation. In the United States, healthcare spending is expected to reach nearly five trillion dollars by 2022 (Munro, 2014). Changes in healthcare have pressured hospital executives to decrease infections and shorten patients' length of stay. Healthcare executives struggle to design solutions for a growing aging patient population, improve clinical outcomes, reduce the cost of care, and remain competitive in a hypercompetitive industry. This industrial environment is representative of a VUCA environment, volatile, uncertain, complex, and ambiguous (Casey, 2014), as defined by General Casey, retired Army Chief of Staff and Commanding General of Multinational Force in Iraq. Faced with an increasing amount of change, many hospital executives are considering robotic surgery to address their multifaceted needs.

Largely regarded as a capital-intensive medical innovation, robotic surgery created a new market while muddling the existing markets of traditional and laparoscopic surgical techniques. Today hospital stakeholders are investing and re-investing in robotics to solve problems related to patient demand, physician retention, recruiting, and brand imaging, among other concerns. Many hospital executives have chosen robotic surgery as an advanced technology to improve patient outcomes, address surgical shortcomings, and to develop competitive advantages. As a result, robotic surgery systems have become one of the fastest growing medical devices in the history of U.S healthcare.

In 2000, Intuitive Surgical introduced the first immersive robotic surgery platform, the *da Vinci*® Surgical System, which enables surgeons to perform complex surgical procedures in a minimally invasive fashion (Kalan et al., 2010). This surgical technique provides surgeons with increased dexterity, improved vision, and augmented control through a series of technological innovations. Many of these benefits have been heralded as advantages over other surgical techniques, such as conventional open and laparoscopic surgery (Kalan et al., 2010). As one of the most successful medical device success stories in the history of U.S. healthcare, industry sales were reported in excess of $2 billion annually in 2014 (Intuitive Surgical, Annual Report 2014). In December 2002, there were approximately 12 da Vinci® Surgical Systems (Intuitive Surgical, Annual Report 2000). Today there are almost 3,000 da Vinci® Surgical Systems operating in healthcare institutions across the world (Intuitive Surgical, Annual Report 2014).

Despite its initial market success, many consumers question the value of robotic surgery programs (RSPs). This new surgical treatment has challenged hospitals with higher surgical costs and varying performance. As new RSPs further penetrate the marketplace, many question robotic surgery's impact on improved patient outcomes, surgeon performance, and value to hospitals. This research suggests that this questioning is rooted in the role of industry structure on the creation of customer value.

Industry structure is the configuration of a company's industry, which influences competition and profitability (Magretta, 2013). A competitive environment contains an element of struggle between multiple parties striving for similar goals. Industry structure or market power allows organizations to see themselves within the context of the big picture and to competitively position themselves toward increased value and profitability, demystifying the behavior of buyers, suppliers, new entrants, and existing competitors within a marketplace. This research applied Michael Porter’s 5-Forces model to evaluate the strength of the robotic surgery manufacturer’s market power. A comprehensive analysis of the robotic surgery industry may contribute to understanding the ways in which industry structure influences customer value.

Moreover, the adoption of a capital-intensive medical innovation by hospitals absent an understanding of supplier industry structure may detract from the benefits of the innovation. The purpose of this research is to explore the role of supplier industry structure on the creation of value for hospital RSPs. I accomplished this by analyzing robotic surgery industry structures and the resulting implications for customer value. Specifically, this study will be based upon an exhaustive review of over 15 years of secondary data relative to robotic surgery.

I.2 Literature Review

I.2.1 Robotic Surgery.

Conventional surgery is generally associated with an incision made by a surgeon to gain access to targeted anatomy. The invasiveness of traditional surgery is typically more pronounced because the surgeon uses either his hands or surgical tools to directly manipulate the anatomy. By the early 1990’s, laparoscopy began to gain traction in the surgical community. In a laparoscopic surgical approach the surgeon gains access to the target anatomy through multiple small incisions (Figure 1: Laparoscopic Surgery).

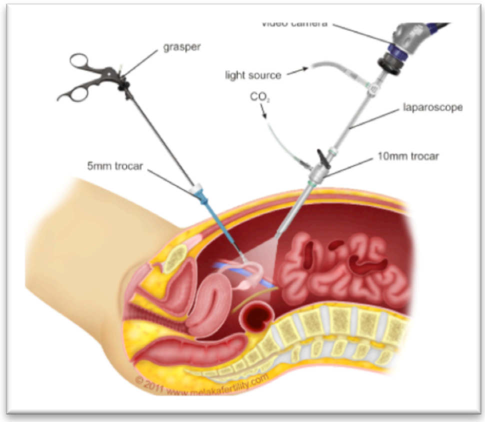

Figure 1 Laparoscopic Surgery

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This less invasive surgical approach generally offers patients a faster recovery time with equivalent or better clinical outcomes. Laparoscopic procedures require instrumentation designed to manipulate key anatomy with specialized instruments that replicate many of the tools designed for the traditional surgical approach. Although laparoscopic surgery presented limitations, as surgeons were no longer able to palpate tissue and tumors with their hands, physicians quickly adapted to this less invasive surgical method.

Nonetheless, this approach offered new challenges. The surgeon now observed the procedure using a camera, which provided a 2-D image. This two-dimensional viewing made judging depth extremely difficult. Surgeons became more dependent on staff, as surgical technicians and nurse practitioners frequently controlled the camera directing the surgeon’s line of sight. Occasionally, operating with longer, non-wristed instruments made it difficult for surgeons to manipulate target anatomy. These new instruments also exacerbated surgeon tremor, as small movements from surgeons’ hands were heightened at the tips of the instruments. Consequently, these limitations in surgeon adaptability and procedural complexity disrupted the broad adoption of the laparoscopic technique.

In spite of these challenges, many procedures once performed exclusively in an open surgical environment are now performed laparoscopically as standard of care. This trend is very Schumpeteresque in its application, exemplifying ‘creative destruction’ demonstrated by surgeons as they innovated beyond the limitations of traditional surgery (Schumpeter, 2013). As a result of this trend in creative destruction, surgeons are once again exploring technology beyond the innovations of traditional laparoscopic surgery, potentially expanding the population of physicians practicing minimally invasive approaches to a broader surgeon population across an extended segment of simple and complex procedures.

Specifically, the da Vinci® Surgical System translates the surgeon’s hand movements on instrument controls at a console into micro-movements of instruments positioned inside patients through miniature incisions (Intuitive Surgical, Annual Report 2013). The console provides the surgeon with a 3-D stereoscopic view in high definition, replicating the traditional open surgeon view, while operating with a minimally invasive surgical technique (Intuitive Surgical, Annual Report 2013). From the console, the surgeon is able to control 3-4 robotic arms located on the patient cart, giving the surgeon control over the camera and 2-3 instrument arms (Intuitive Surgical, Annual Report 2013). Overall, this robotic system provides surgeons with immersive 3DHD visualization, precise and tremor-free endoscope control, intuitive instrument movements, EndoWrist® instruments, scaled-tremor free instrument movement, improved surgical ergonomics, a multi-specialty platform, and advanced training tools (Figure 2:Robotic Surgery System) (Intuitive Surgical, Annual Report 2013).

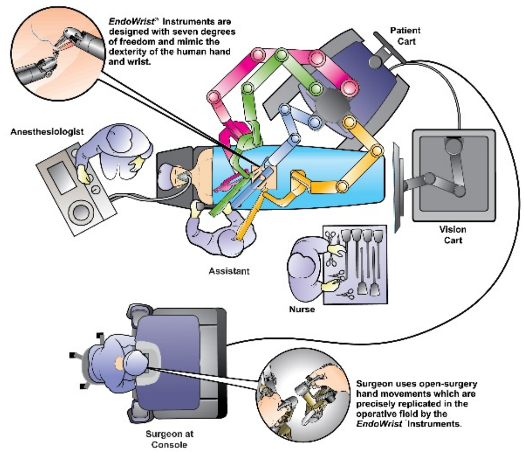

Figure 2 Robotic Surgery System

While global laparoscopy annual sales are expected to grow from $8.1 billion in 2012 to $12.3 billion by 2018, the annual global robotic surgery expenditure is expected to outpace that growth, from $3.2 billion in 2012 to $19.9 billion by 2019 (WinterGreen Research, 2013). Robotic procedures have catapulted from less than 25,000 in 2005 (Kowalczyk, 2013) to over 570,000 procedures performed in 2014 (Intuitive Surgical, Annual Report 2014). The popularity, and resulting growth, of robotic surgery is a result of the clinical, financial and strategic (CFS) value it affords. By driving minimally invasive benefits to patients across multiple surgical specialties, this technological innovation is poised to expand and greatly influence patient demand, surgical techniques, product usage, and purchasing patterns in the future.

I.2.2 Industry Structure.

Warren Buffet indicated that industries demonstrate distinct economic characteristics (Williams, 2014), which influence the profitability of industry participants, and Jack Welch utilized industry structure in divestiture decisions as the CEO of General Electric (Suutari, 2000). Analysts tend to understand the influence of industry structure as it relates to competitive strategy or investing. The preponderance of industry structure research addresses the impact of industry structure on profitability, firm performance, strategic choices (Porter, 1980), and even how firms can influence industry structure to improve their own profitability (Makadok, 2013). In many cases, researchers have utilized the constructs of industry structure in conjunction with other frameworks or topics of interest (Table 1: Industry Structure and Related Topics).

Table 1 Industry Structure and Related Topics

SOURCE	RELATED TOPIC
Datta, D. K. and Rajagopalan N. (1998). Industry Structure And CEO Characteristics: An Empirical Study Of Succession Events. *Strategic Management Journal 19.9* (833).	CEO Characteristics
Nohria, N. and Garcia-Pont, C. (1991) Global Strategic Linkages And Industry Structure *Strategic Management Journal12,* 105-124. DOI: 10.1002/smj.4250120909.	Global Strategic Linkages
Gong, J., & Srinagesh, P. (1996). Network competition and industry structure. *Industrial and Corporate Change*, *5*(4), 1231-1241.	Network Competition
Jamison, M. (1999). *Industry structure and pricing: the new rivalry in infrastructure* (Vol. 22). Springer.	Pricing Strategy
Erhemjamts, O., Raman, K., & Shahrur, H. (2010). Industry structure and corporate debt maturity. *Financial Review*, *45*(3), 627-657.	Corporate Debt
Hunt, R. M. (2004). Patentability, industry structure, and innovation. *The Journal of Industrial Economics*, *52*(3), 401-425.	Patents and Licensing
Flaherty, M. T. (1980). Industry structure and cost-reducing investment. *Econometrica: Journal of the Econometric Society*, 1187-1209.	Cost Reductions
Demsetz, H. (1973). Industry structure, market rivalry, and public policy. *Journal of Law and economics*, 1-9.	Public Policy

In 1980, Harvard University professor Michael Porter introduced the 5-Forces model, which explored the forces driving industry competition (Porter, 1980). A survey of the leading Strategic Management textbooks found the inclusion of Porter's model in each one (Dobbs, 2012). According to Google Scholar, Porter's work regarding competitive advantage and industry structure has been cited almost 240,000 times. As language influences the behavior of individuals subjected to cultural context, industry structure influences the behavior of firms that are subjected to industry context (Porter, 1980.) Industry structure not only affects the nature of competition (Baumol, Panzar, Willig and Bailey, 1982) and profitability (Makadok, 2013), but it also impacts the nature of strategic choices available to firm participants (Porter, 1980). Through the introduction of the 5-Forces framework (Figure 3: 5-Forces), Porter explored industry influencers beyond economic structure (Porter, 1980). The 5-forces are captured as the threat of new entry, industry rivalry, threat of substitution, bargaining power of buyers and bargaining power of suppliers (Porter, 1980).

Figure 3 Forces

(Porter, 1980)

As an economist, Porter's work largely simplified areas of microeconomics into a template of terms for practical usage (Recklies, 2001). See Table 2: 5-Forces and Microeconomic Constructs. This template enables decision makers to apprehend competitive influences that go beyond typical competitors to a broader set of participants. Given the applicability of the model, 5-Forces was used to evaluate industries (Powell, 1996), firms

(Bowen, Daigle, Dion, and Valentine, 2014), marketing strategies (Renko, Sustic and Butigan, 2011), and even the delivery of vascular surgery (Sumpio, 2013). In most cases, the theoretical and practical application of Porter's model is a measure to assess the current status of an industry.

Table 2 5-Forces and Microeconomic Constructs

(Source: Recklies, 2001)

5-FORCES	MICROECONOMIC CONSTRUCTS
Threat of New Entry	Market entry barriers
Industry Rivalry	Market structures, number of players, market size and growth rates
Threat of Substitution	Substitution effect
Bargaining Power of Buyers	Supply and demand theory, customer behavior, price elasticity
Bargaining Power of	Supply and demand theory, cost and production theory, price elasticity

Despite its widespread application, the 5-Forces model has frequently come under fire. Critique of the model surfaced during the growth of the Internet and the dotcom era, arguing that 5-Forces does not account for dynamic changes that have influenced many industries (Dälken, 2014). Others derided the retrospective nature of the model, citing its ability to explain but its ineptitude in the area of prediction (Stewart, 2009). Some critiqued the model as too macroeconomic in focus, noting poor linkages to management options based upon assessment, and criticized its excessive fixation on industry boundaries (Grundy, 2006). In 2008, Michael Porter critiqued the lack of quantitative measures to bolster the model (Dobbs, 2012). Porter also conveyed disappointment regarding the application of the model solely as an assessment of industry appeal as opposed to a method of gaining strategic insight (Dobbs, 2012). Some have stated that the model does not account for the speed and nature of change that has characterized so many disruptive innovations (Raina, 2014). In essence, the model's focus on strategic initiatives, profitability, and minimizing competition engendered some of the harshest criticism. One author stated, "In the theoretical landscape that Porter invented, all strategy worthy of the name involves avoiding competition and seeking out above-average profits protected by structural barriers. Strategy is all about figuring out how to secure excess profits without having to make a better product or deliver a better service" (Denning, 2012).

Without a focus on delivering better service or enhancing customer value, the value of the 5-forces model has been limited. This limitation of value is, in part, due to the model's application within the context of the industry; the other limitation is related to the lack of depth and rigor in its application in creating customer value. Thus far, there have been relatively few contributions seeking to extend the application of the 5-force model in either direction. However, there have been a few attempts worth exploring.

There have been extensions of the model within the context of industry structure analysis. "Rethinking and reinventing Michael Porter's five forces model" is an article that explores enhancing the practical application of the 5-Forces model (Grundy, 2006). Grundy considered expanding the use of the 5-forces model to map competitive force variations, explore competitive dynamics, prioritize the forces, and examine force interdependencies (Grundy, 2006). The point of his work was to develop the 5-Forces model to "improve its analytical power and increase its range of application" (Grundy, 2006:216). A few interesting potential applications from (Grundy, 2006) were as follows:

- Combining the use of the 5-forces model with the PEST factors model to explore the interdependencies between industry structure and political, economic, social and technological factors.
- Extending evaluation of the 5-forces from favorable, neutral, and unfavorable to a vector-based approach, which allows for the assessment of favorability as well as priority.

- Evaluating each force not simply independently, but relative to the others.
- Exploring, at a macro level, how the forces impact longitudinally (Grundy, 2006).

One of the most notable evolutions of the model originated from Michael Porter himself, who, in 2011, co-authored an article in the *Harvard Business Review* titled, "Creating Shared Value" (Porter, 2011). In the article, Porter assesses the problem with modern day capitalism as, "They [Companies] continue to view value creation narrowly, optimizing short-term financial performance in a bubble while missing the most important customer needs and ignoring the broader influences that determine their longer-term success (Porter, 2011:4)." Critics declare that a narrowly focused view is an outgrowth of an overly strategic one (Denning, 2012). Some conclude that this is an example of Porter's own evolution and adaptation as he weighed the effectiveness of an evaluation of industry structure without connecting the resulting assessments into a conversation regarding the creation of customer value.

In 2006, Porter and Teisberg (2006) introduced "Redefining Health Care", which sought to improve healthcare through the application of competitive principals in order to influence patient value (Porter, 2006). This evolution in Porter's thinking is further evident when comparing Michael Porter's discussion of the structural analysis of industries in his book, "Competitive Strategies: Techniques for analyzing industries and competitors," published in 1980, with the same discussion in his book, "On Competition," updated and published in 2008. In the later edition, Porter concludes a chapter with a discussion of competition and *value* (Porter, 2008). He further builds on the topic in the end of the book with a discussion on corporate social responsibility (Porter, 2008). It is appropriate to incorporate shared value into the discussion, because it is based upon the "premise that both economic and social progress must be addressed using value principles" (Porter and Kramer, 2011:6). Does this accurately capture the essence of value creation in healthcare? A discussion of value creation within robotic surgery is irrelevant and inadequate without addressing the context of societal value creation. The literature review of robotic surgery and industry structure provides the basis for attempts to expand customer value through an understanding of industry structure.

I.2.3 Taxonomy of Customer Value.

Many business researchers have contributed to the classifications of business or customer value. Christian Grönroos' (1997) work explored the impact of relational and transactional intent on customer value. Both behaviors can bring value, but relational intent carries a long-term focus on value, while transactional intent has more of a short-term focus (Grönroos, 1997). Menon, Homburg, and Beutin (2005) contributed a rare look at customer value within the context of the business-to-business environment. Their research pursues an understanding of the topic of customer value by equating it to the summation of core benefits and add-on benefits minus purchase price, acquisition costs, and operational costs. In the face of high (purchase, acquisition, and operational) cost in robotic surgery (Menon, Homburg, Beutin, 2005), this exploration is especially relevant to the topic of value.

Smith and Colgate (2007) first approached the topic of value creation by exploring much of the previous research conducted on the topic. They furthered that research by suggesting a new conceptual framework for customer value creation. Their framework evaluates the tenets of customer value based upon functional/instrumental value, experiential/hedonic value, symbolic/expressive value, and cost/sacrifice value (Smith and Colgate, 2007). The intent of this framework was not simply to identify what customers get in contrast to the cost of those benefits, as present in the previous three equations; rather, the intent of this framework was to identify taxonomies of value that could lead to differentiation in value (Smith and Colgate, 2007).

Research on customer value also hinges on the contributions of Jay Barney related to resource-based view (Barney, 1991). Similar to Porter, Barney built on the discussion of value as being unique, but he added the constructs of rarity, imitability, and substitutability (Barney, 1991). To date, Michael Porter has produced the preponderance of the work regarding the creation of value through the use of value propositions, value chains, and value systems. Porter details strategic opportunities that will result in superior economic performance based on the following five assessments: 1) unique value, 2) activity differentiation, 3) trade-offs, 4) organizational fit, and 5) sustainability (Magretta, 2013). These considerations provide the outline for a company's value proposition, value chains, and overall value system. Competitive advantages, or value proposition, have been defined as the unique value a company may create for its customers (Porter, 1998). The contributions of the RBV not only complement and reinforce the discussion of competitive advantage (Porter, 1980), but they also introduce the importance of heterogeneity and immobility relative to customer value (Barney, 1991).

As early as 1993, the logic regarding value systems began to progress. Researchers understood the advent of value propositions built upon competitive advantages, and value chains were heavily discussed as firms endeavored to identify their value activities and associated costs. The predominant viewpoint towards improving customer value included either increasing the value proposition or reducing costs within the value chain. In their article, "From Value Chain to Value Constellation: Designing Interactive Strategy," Normann and Ramirez (1993) attempted to alter that thinking. While prior thinking regarding value systems focused on attempts to influence the value equation by altering either the value proposition or the value chain, Normann and Ramirez focused attention on neither component individually, but rather on the collective system application (Normann and Ramirez, 1993). This integrated approach led to a distinctive framework based upon the following propositions: 1) the goal of business is not to provide something valuable for customers, but rather to enable customers to create value for themselves; 2) the most attractive offerings are no longer produced by a single company, but rather by new combinations of customers, suppliers, and business partners; and 3) the only true source of competitive advantage is the ability to construct the entire value-creating system (Normann and Ramirez, 1993). This contribution is significantly relevant to robotic surgery in that it encourages firms to maintain more of a systematic approach to value, with a concentration on enabling customers to experience new and customized streams of value. This viewpoint suggest that there is value enclosed not only in the individual value components, but in the system – which, in our example, is represented by the interactions between patients, surgeons, hospitals, robotic manufacturers, robotic substitutes, and others.

Vandenbosch and Dawar (2002) also found that much of the previous value system research focused primarily on the "levers of cost and risk," which reference the cost related to the value chain and the risk of not actualizing the value proposition (Vandenbosch and Dawar, 2002). They suggested a systematic approach of value to 1) unlock economies of interaction; 2) simplify the route to benefits; 3) integrate activities; 4) be the nexus; and 5) form the future. This approach suggests the reinforcing relationship between a transactional and relational view of value.

Consider next the progression of views relative to the creation of value as examined by Stanley Slater, who discussed the neoclassic view of the firm, which focuses on the impact of labor and capital on the production of product to maximize profits (Slater, 1997). The behavioral view seeks to account for goals dispersant from profit maximization by introducing a framework which allows for the views of individuals or groups having their own goals (Slater, 1997). This may, in part, contribute to local optimization and the problem of latent value. The transactional cost view emphasizes the opportunities relative to firms in the creation of value due to scaled economies (Slater, 1997).

Lastly, Barney found these views inadequate since they focused predominantly on value creation relative to the firm, to the exclusion of the customer. Slater's approach was a customer-oriented view in which the firm's existence was to satisfy the customer (Slater, 1997). This view introduced the concept of a more customer-centric "market orientation," with the constructs of value nestled in 1) continuous learning about the customer, 2) a commitment to innovation, and 3) a customer value process-focused organization (Slater, 1997).

This customer-oriented value approach, with the inclusion of a feedback loop, continued. In 2013, Moryosseff Gertner cited the work of Normann and Ramirez but added a crucial component to their work: the inclusion of a feedback loop to identify and satisfy consumers' fluctuating needs (Gertner, 2013). This contribution was essential in that it identified the need for the value system to enhance collective value through the exchange of information (Gertner, 2013). These contributions add to the conversation by highlighting the delineation between one-time foundational approaches to value and more iterative and interactive approaches to creating value.

These constructs are of particular importance to value within the conversation of robotic surgery. Many hospitals have approached RSPs assuming that the value is inherent in the implementation of the program or the initial purchase of the robotic system. This transactional view fails to consider the impact of heterogeneity and immobility, both of which greatly influence organizational ability to create sustainable competitive advantages in the delivery of customer value. These taxonomies will prove useful in exploring the dynamics of clinical, strategic and financial (CSF) value within RSPs. (Figure 4: RSP Value Triangle).

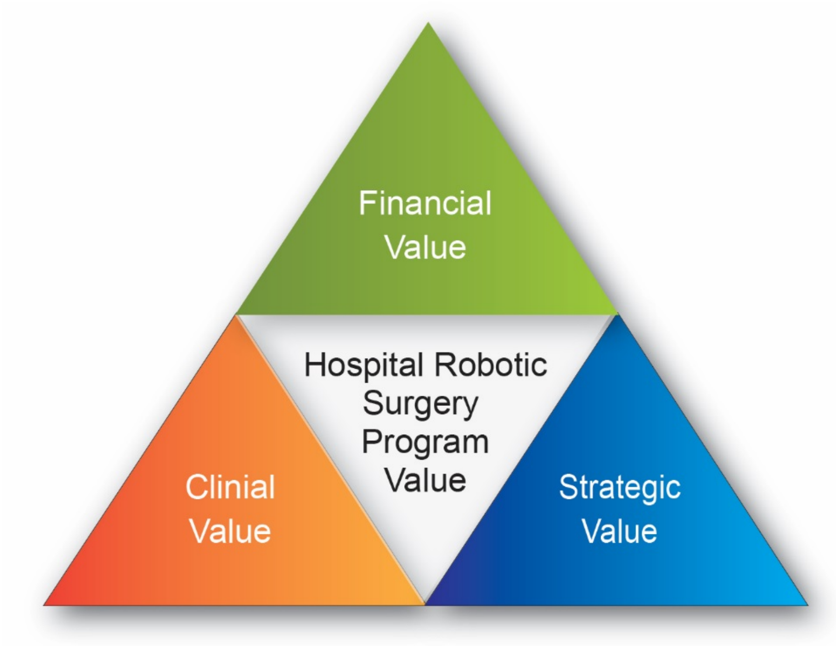

Figure 4 Robotic Surgery Program Value Triangle

The literature review included an introduction to the robotic surgery industry, a discussion of industry structure using Porter's 5-forces framework, and a culminating look at the topic of customer value creation. Taken together, the results provide a basis for exploring a new approach to studying the role of industry structure and customer value in robotic surgery. The key research question for this proposal is: *How can hospitals apply an understanding of supplier industry structure and customer value to improve the customer value of a RSP*? I approached this proposal by evaluating the industry structure using 5-forces, predicting the role of the industry structure on customer value, appraising customer value based upon CFS value, and exploring the interactions between industry and customer value to discover new ways for value creation (Figure 5: Research Model).

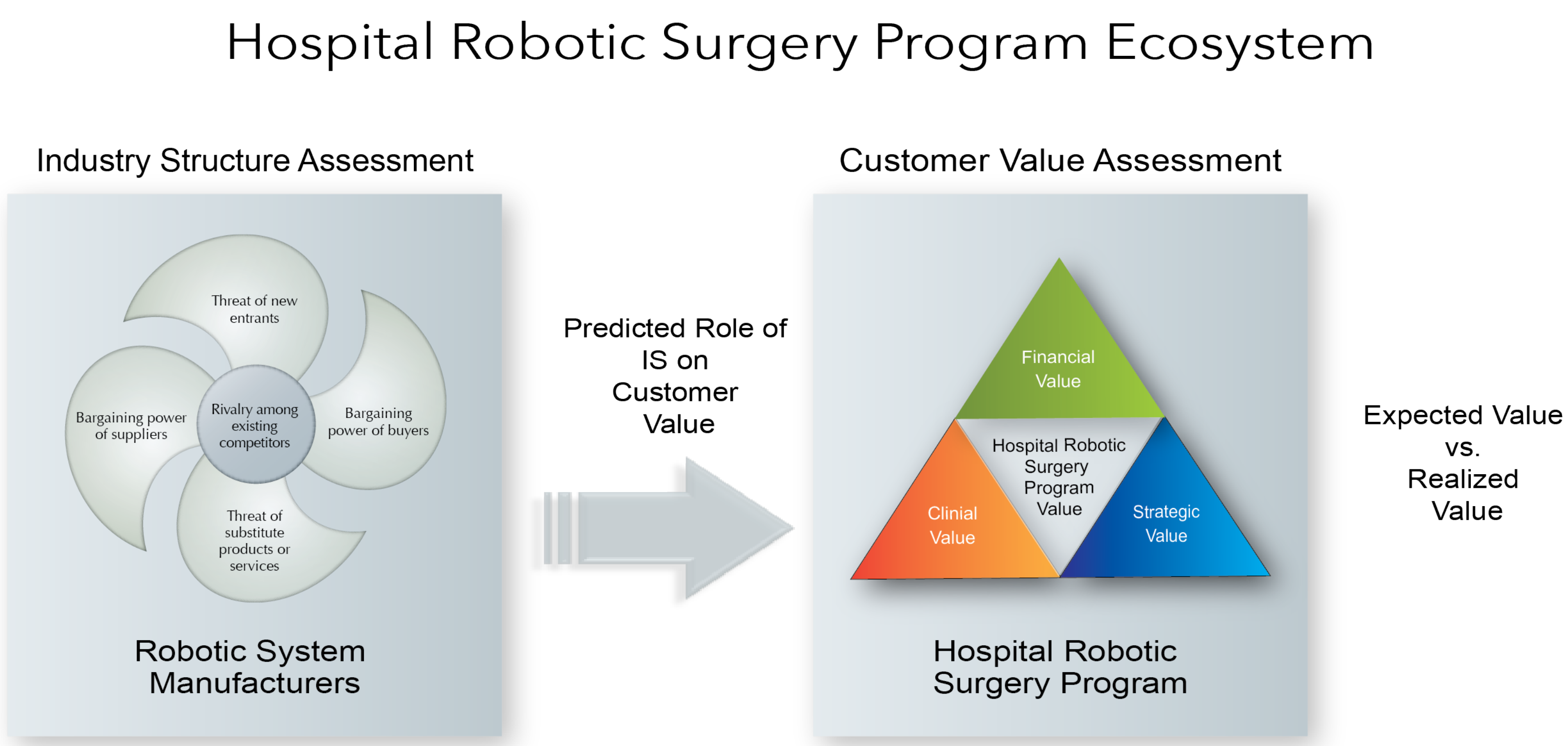

Figure 5 Research Model

II CUSTOMER VALUE AND INDUSTRY STRUCTURE: AN INTEGRATED & INTERACTIVE APPROACH

II.1 Research Methodology

This research is designed as a process study with the objective of understanding how industry structure influences the customer value of a RSP. To that end, I conducted a longitudinal study of the robotic surgery industry formation and the process in which that formation influenced customer value. In addition to industry structure, I examined associated customer value across three distinct time periods: 1999 – 2004; 2005 – 2009; and 2010 – 2014. I have chosen these periods to capture the introduction of robotic surgery, the adoption of robotic surgery, and the establishment of robotic surgery. For the purpose of this research, the customer will be defined as hospitals. The design of this research is an industry study with a focus on showing how industry structure can impact value attained by various customers in the robotic surgery industry. The unit of analysis will be at the industry level, which includes physicians, hospitals, and industry participants.

II.1.1 5-Forces

I conducted the research from the industry vantage point of robotic surgery manufacturers. Analysis was conducted by examining each force and sub-component and aggregating the appraisal to determine the overall influence of each force. Each force influences profitability and competitiveness. In order to account for each force, I utilized the definitions and criteria included in Table 3:5-Forces Definitions and Criteria and Appendix 1: Industry Structure Definitions.

Table 3 5-Forces Definitions and Criteria

(Source: Porter, 2008)

	THREAT OF NEW ENTRY	INDUSTRY RIVALRY	SUBSTITUTIONS	BUYER BARGAINING POWER	SUPPLIER BARGAINING POWER
Definitions	The likelihood that a new firm will enter the industry to compete with existing firms.	The current level of competitive intensity among existing firms.	The applicability of using similar products that perform the same functions.	The ability of buyers to demand lower prices, more expensive services, higher quality, and/or other terms that increase manufacturer costs.	The ability of suppliers to demand higher prices, and/or other terms that increase manufacturer costs.
Criteria	• Economies of Scale • Demand-side Benefits of Scale • Government Policy • Capital Requirement • Switching Costs • Access to Distribution • Incumbency Advantages Independent of Size • Expected Retaliation	• Competitive Balance • Industry Growth • Fixed/Marginal Costs • Differentiation • Overcapacity • Competitive Diversity • Strategic Stakes • Exit Barriers	• Price-performance Trade-off • Buyer's Cost of Switching to Substitute	• Buyer Concentration • Service Differentiation • Industry Purchases • Backward Integration • Switching Costs • Buyer Margins • Service Importance • Full Information	• Concentration • Dependency • Switching Costs • Differentiation • Substitutes • Forward Integration

II.1.2 Threat of New Entrants.

As described by Porter, the threat of new entrants can impact industry profitability due to increased capacity, price pressures, increased cost to compete, and higher rates of reinvestment (Porter, 1980). The results, when analyzed, question the likelihood that a new manufacturer will enter the robotic surgery industry to compete with existing firms (Porter, 1980).

II.1.2.1 Economies of Scale.

Porter describes economy of scale as larger volumes leading to lower cost per unit, which can appear in almost every activity in the value chain including sales, marketing, research, etc. (Porter, 1980). Economy of scale serves to improve profitability and improve competitive positioning by reducing marginal costs (Porter, 1980). I utilized statements related to production costs, sales volumes, and employee resources to evaluate the deterrence capability of robotic manufacturers based upon economy of scale.

II.1.2.2 Demand-side Benefits of Scale.

Porter identifies demand-side benefits of scale by the presence of network effects, generally described as increasing the buyer's willingness to pay as the number of like buyers increases (Porter, 1980). Demand-side benefits of scale serve to increase profitability and strengthen competitive positioning as the size of the network increases (Porter, 1980). Within the robotic industry, I utilized installation base, pricing, procedural volumes, and clinical publications data to evaluate the deterrence capability of network effects.

II.1.2.3 Government Policy.

Government rules and procedural formalities can negatively or positively impact profitability and competitiveness, especially in highly regulated industries like healthcare (Porter, 1980). Regulatory environments can influence competiveness based upon entrance standards and can also affect profit margins via operational costs of government compliance. I utilized narratives regarding compliance with the Food and Drug Agency (FDA) in the United States, as well as international equivalents, to evaluate the deterrent capability of government policy related to robotic surgery (FDA, 2014).

II.1.2.4 Capital Requirement.

Capital requirement can be summed up simply as the funds necessary to compete (Porter, 1980). Industries such as aerospace and robotic surgery may have fewer manufacturers because of the capital necessary to enter the industry. These capital requirements can impact competitiveness based upon the size of competitive firms and may impact profitability given the investment position necessary to produce a viable product and operate within the industry. To evaluate the presence of capital requirements as deterrence, I utilized current available research, development funding, and accumulated debt as my primary measurements.

II.1.2.5 Switching Costs.

Switching costs are used in various contexts throughout Porter's evaluation. In the context of threat of new entrants, they are the costs buyers face when changing providers, in this case robotic system providers (Porter, 1980). If hospitals can easily switch between robotic manufacturers, there is limited deterrent capability presented by the robotic surgery offering. Moreover, ease of switching has a mitigating impact on pricing and profitability. I considered installed base and the amount of robotic surgery units in the market as measures of market penetration that might make switching cost more influential. I also utilized implementation capital costs, average annual recurring costs, estimates of customer inventory levels, on-going service obligations, and training costs to evaluate the cost of switching.

II.1.2.6 Access to distribution.

Access to distribution relates to the ability of the sales and distribution channel to generate more customers, or, in this case, the ability to implement or expand hospital RSPs. Current competitors are rewarded with the opportunity to occupy current channels, which is enhanced if sales channels are limited (Porter, 1980), thereby influencing competitiveness. Differing sales channels are also characterized by varying cost, and some sales channels may offer reduced cost of sales. In order to evaluate these factors, I utilized the number of sales and marketing personnel as well as narratives related to sales and distribution.

II.1.2.7 Incumbency Advantages Independent of Size.

As opposed to economy of scale advantages, incumbency advantages independent of size are related to advantages such as proprietary technologies, preferential access, raw materials, experience curve, etc., which may exist regardless of the size of the organization (Porter, 1980). These advantages influence product competitiveness and profitability. I examined the number of patents and procedural experience (by volume) to evaluate the deterrent capability of these advantages.

II.1.2.8 Expected Retaliation.

This sub-construct relates to ways competitors are expected to retaliate based upon competitive moves (Porter, 1980). This is often related to industry precedent, means to retaliate, openness of price slashing, or presence of slow industry growth (Porter, 1980). In this industry, I utilized cash available and legal action as measures to evaluate the deterrence of expected retaliation.

II.1.3 Intensity of Rivalry: Current Competitors.

Competition typically drives down price, diminishing industry participant growth and profitability. Industry rivalry explores the current level of competitive intensity among existing firms (Porter, 1980).

II.1.3.1 Competitive Balance.

Porter describes competitive balance as relating to the intensity of rivalry based upon size and power. Rivalry is greater between firms when they are similar in size and power within an industry (Porter, 2008). I utilized company revenue, market cap, sales, employee base, and accumulated deficit to compare manufacturers' competitive balance.

Industry Growth. This sub-component is simply the rate of growth for the overall industry. Industries experiencing slower growth rates typically experience intensified rivalry, as slow growth makes it harder to stay in business (Porter, 1980). I used the overall industry growth rate to demonstrate this measure.

II.1.3.2 Fixed/Storage Costs.

A high fixed and storage cost creates pressure on manufacturers to cut prices, which intensifies industry rivalry (Porter, 1980). I considered total assets as a measure to evaluate fixed and storage costs.

II.1.3.3 Differentiation.

How unique is the product or service offered by each manufacturer? The lack of differentiation between offerings will reduce switching costs and increase industry rivalry (Porter, 1980). I utilized product characteristics to evaluate the differentiation between product offerings.

II.1.3.4 Overcapacity.

If economies of scale require capacity to be added in large increments, overcapacity and subsequent price-cutting may result (Porter, 1980). I utilized comments regarding production levels and evidence of price-cutting to evaluate overcapacity.

II.1.3.5 Competitive Diversity.

A robotic manufacturer with different goals or business methods may confuse fellow competitors in the market (Porter, 1998). When firms cannot read competitors' actions and signals well, competitive diversity is broad and industry rivalry may intensify (Porter, 1980). I compared corporate goals, objectives, and strategies to evaluate the diversity of industry competitors.

II.1.3.6 Strategic Stakes.

Rivalry intensifies if firms have a high need to achieve success in a particular industry (Porter, 1980). In some cases, the importance of the industry may not only increase competitiveness but also sacrifice profitability (Porter, 1980). I utilized language from annual and quarterly reports to gauge corporate aspirations and evaluate the importance attached to the industry.

II.1.3.7 Exit Barriers.

What are the factors that prevent an industry participant from exiting the industry? Sometimes there are assets, costs, or strategic relationships that create high exit barriers, holding some industry participants captive (Porter, 1980). I utilized an estimation of assets, inventories, and accumulated debt as measures of the extent of high exit barriers.

II.1.4 Pressure from Substitutes.

Substitutes are similar products that perform the same functions (Porter, 1998). In robotic manufacturing, substitution consists of alternative minimally invasive surgical treatments, minimally invasive non-surgical treatments, and traditional surgical approaches. Substitutions generally limit industry profitability by placing a ceiling on potential returns when compared to the cost of the next best alternative (Porter, 1998). I determined the threat level of industry substitutes by examining the sub-constructs of price-performance trade-off and the buyer's cost of switching to the substitute.

II.1.4.1 Price-performance Trade-off.

This sub-component is the relative value of a substitute product or service (Porter, 1998). In the robotic industry, price-performance trade-off is the relative value provided through alternative surgical techniques, like laparoscopy, in comparison to robotic surgery. I used clinical comparison data to evaluate the comparative value of open surgery and laparoscopy to robotic surgery.

II.1.4.2 Buyer's Cost of Switching to Substitute.

As opposed to exploring relative value, this sub-component focuses on the cost for the buyer to switch to or from the substitute. Within the robotic surgery industry, this involves the cost for hospitals to switch to or from alternative surgical techniques to robotic surgery. I utilized capital cost, instrument cost, and procedural cost data to evaluate the deterrence of buyer's cost of switching to substitute.

II.1.5 Buyer Bargaining Power.

Buyers compete with manufacturers for profitability within the value chain. Formidable buyers reduce industry participants' profitability by demanding lower prices, more expensive services, higher quality, and other activities that increase manufacturer costs (Porters, 1998). To understand buyer influence, eight factors must be examined: concentration of buyers, service differentiation, industry purchases, backward integration, switching costs, buyer margins, service importance, and full information (Porter, 1980 and 2008).

II.1.5.1 Buyer Concentration.

This sub-group relates to the quantity of buyers or the aggregation purchases (Porters, 1998). Buying in volume affords buyers influence over price, quality, or alternative terms. I utilized data regarding hospital purchasing, groups purchasing organizations, and the hospital industry to evaluate buyer concentration.

II.1.5.2 Product or Service Differentiation.

Similar to the discussion of industry rivalry, differentiation relates to uniqueness of products or services for each hospital customer. The lack of customization increases buyer power as buyers play one vendor against another for improved terms (Porter, 1998). I utilized product characteristics to evaluate the differentiation between product offerings.

II.1.5.3 Industry Purchases.

What percentage does the cost of product purchases in the robotic industry represent in relation to total cost structure, or specifically, to operating room cost structure (Porter, 1998)? Buyers tend to be less cost sensitive if industry purchases represent a small fraction of total expenditures. Since this is not generally the case regarding robotic surgery investments, capital cost, procedural cost, and recurring operating cost were used as a measure of industry purchases in this study.

II.1.5.4 Backward Integration.

This concept represents the ability of a customer to credibly provide the product or service produced by the industry manufacturer (Porter, 1998). Can hospitals manufacture and sell robotic surgery systems? To answer this question, competitive activity and narrative information were used to evaluate the ability of customers to create and distribute robotic surgery systems.

II.1.5.5 Switching Costs.

Similar to the evaluation of switching costs within threat of new entries, here I evaluated switching costs involved with changing vendors (Porter, 1998). How well does the purchase commit a buyer to a particular vendor (Porter, 1980)? In the case of robotic surgery, the purchase of a robotic system locks a hospital into an instrument vendor and service contract. I utilized instrument and system cost information to evaluate the strength of switching costs to influence buyer behavior.

II.1.5.6 Buyers Margins.

When buyers experience tight profit margins or pressure to reduce costs, they tend to be more price sensitive (Porter, 1998). Within the healthcare industry, hospitals are seeing reimbursements decrease while cost of care is increasing. Consequently, the industry tends to be price sensitive. I utilized hospital industry data and narratives to evaluate cost pressures of buyer margins.

II.1.5.7 Product or Service Importance.

This construct evaluates the impact of the product or service on the buyer's offering when the offering is largely affected by the manufacturer's product or in cases where service buyers tend to be less cost sensitive (Porter, 1980). In the robotic surgery industry, this is a measure of robotic surgery's effect on a hospital's ability to deliver care or particular outcomes. I utilized clinical data and narrative information to assess the importance of robotic surgery to a hospital's clinical offerings.

II.1.5.8 Full Information.

The more information the buyer has regarding the product offering, the greater his ability to influence price and negotiated terms (Porter, 1980). In the robotic industry, manufacturers largely drive disclosure. I estimated industry disclosure based upon published secondary reports.

II.1.6 Supplier Bargaining Power.

Suppliers also compete with industry participants to increase margins and profitability through higher supply costs, quality of goods and services, labor costs, and other more favorable terms (Magretta, 2013). To evaluate supplier bargaining power I considered the following six factors: *supplier concentration, supplier group dependency, supplier switching costs, supplier differentiation, supplier substitution, and supplier credibility to integrate forward* (Magretta, 2013).

II.1.6.1 Concentration.

If the supplier industry is less fragmented than the industry it is supplying, then suppliers exhibit increased bargaining power (Porter, 1980). In the robotic surgery industry, this measure fluctuates between necessary materials. For example, the 3D endoscope manufacturing industry is more concentrated than the paper or medical drapes industry. I utilized product knowledge specific to the robotic surgery industry and its limited manufacturers to estimate supplier concentration.

II.1.6.2 Dependency.

Greater supplier dependency on a particular industry weakens the bargaining power of suppliers within an industry (Porter, 1980). If endoscope manufacturers only produced robotic endoscopes, for example, they would have limited negotiating power. Since supplier volumes are greater in general laparoscopy than in robotic surgery, bargaining power with robotic manufacturers is enhanced. I utilized robotic surgery industry product knowledge, as well as the importance of those products based upon product contributions, to estimate supplier dependency.

II.1.6.3 Switching costs.

In this case, switching costs measure the cost of robotic manufacturers switching suppliers. As with other switching costs, the higher the cost of the switch, the weaker the bargaining power of the entity contemplating the switch (Porter, 1998). I utilized robotic manufacturer statements regarding alternative suppliers to evaluate the presence of switching costs.

II.1.6.4 Differentiation.

In this context, differentiation refers to the uniqueness of supplier parts or services (Porter, 1980). Higher levels of customization result in higher supplier bargaining power. I utilized robotic manufacturer statements regarding customized parts and services to evaluate the influence of differentiation.

II.1.6.5 Substitution.

Here, substitution relates to whether there is an alternative product or service for what the supplier provides (Porter, 1980). The more applicable the substitute, the lower the supplier bargaining power. I utilized robotic manufacturer statements regarding supplier alternatives solutions to evaluate the influence of substitutions.

II.1.6.6 Forward Integration.

Can the supplier realistically create the end product? Can the endoscope manufacturer not only manufacturer the vision system, but also manufacture and sell a robotic surgery system? I estimated the likelihood of supplier ability to forward integrate based upon supplier core competencies, demonstrated capabilities, and corporate statements.

The topics of robotic surgery and healthcare are both contemporarily and socially complex. The industry analysis not only supports the practicum of our recommended use for practitioners, but this format also affords increased boundary flexibility to explore issues of context based upon the vast and extensive nature of publically available information on the industry.

II.2 Customer Value

In order to assess the customer value of robotic surgery, one must define the customer and specify ‘what value is’ for that particular customer. As previously discussed, this research defines ‘customers’ as hospitals. Although patients and surgeons could also be included, value to hospitals inherently reflects perception of value to patients and/or surgeons. Representative value for these stakeholders has been defined as clinical, financial, and strategic value (Table 4: Value Framework Definitions and Criteria).

Table 4 Value Framework Definitions and Criteria

	CLINICAL	FINANCIAL	STRATEGIC
Definitions	Outcomes or Perceived outcomes	Revenue or cost related	Organizational advantages
Criteria	• Convert open procedures • Length of stay • Est. blood loss • Complications • Facilitation of transition to minimally invasive surgery • Patient Satisfaction • Procedural Times	• Reimbursement • Instrument cost • Capital cost • Service cost • Program revenue • Program profitability	• Recruiting physicians and patients • Market leadership • Surgeon satisfaction • Marketing

Based on the literature review, value was assessed based on the sub-constructs of *core benefits, add-on, relational, and transactional (CART) benefits.* See Appendix 2: Customer Value Definitions. The integration of CFS value, with emphasis on CART benefits results in the CFS-CART Framework.

II.2.1 Clinical value.

This construct relates to the medical benefits or perceived medical benefits of robotic surgery. Clinical core benefits are defined as medical benefits or perceived medical benefits of converting open procedures to minimally invasive surgery (MIS) (i.e. patient benefits of MIS). Clinical add-on benefits are benefits or perceived benefits of creating unique medical value (i.e. patient benefits specific to robotics). Clinical relational benefits or perceived benefits are long-term or interpersonal benefits between hospitals and patients (i.e. patient satisfaction). Lastly, transactional medical benefits or perceived benefits are short-term or procedural operational benefits (i.e. procedural times).

These benefits are specifically discussed in clinical articles and include length of stay, estimated blood loss, complication rates, facilitation to minimally invasive surgical approaches, and other general medically related statements. In addition to specific clinical benefits, clinical value also accounts for more generally perceived benefits of robotic surgery. These perceived benefits are generally mentioned in mainstream media publications, corporate presentations, and hospital marketing materials. This construct allows the incorporation of relational and transactional or indirect benefits (Grönroos, 1997) specific to robotic surgery. It also allows the exploration of core benefits, as discussed by Menon, Homburg, and Beutin (2005). See Appendix 2.

II.2.2 Financial value.

This component captures revenue or cost, or potential revenue or cost, related to robotic procedures. Financial core benefits are defined as financial benefits or perceived benefits of converting open procedures to MIS (i.e. lower treatment costs). Financial add-on benefits are benefits or perceived benefits that create unique financial value (i.e. incremental revenue). Financial relational benefits or perceived benefits are long-term or interpersonal benefits between program stakeholders (i.e. program profitability). Lastly, transactional financial benefits or perceived benefits are short-term acquisition and/or operational costs (i.e. robotic costs).

Exemplars of financial value include reimbursement data; instrument, capital and service costs; and affiliated RSP revenue and cost data. This construct incorporates transactional value (Grönroos, 1997) and purchase, acquisition, and operational cost (Menon et al., 2005) as reported in clinical, mainstream and corporate publications. See Appendix 2.

II.2.3 Strategic value.

Implementing a RSP is a macro-level decision implemented to support the hospital's strategic plan. Strategic core benefits are defined as benefits or perceived strategic benefits of converting open procedures to MIS (i.e. attracting physicians and patients). Strategic add-on benefits are benefits or perceived benefits that create unique strategic value (i.e. new market leadership positions). Strategic relational benefits or perceived benefits are long-term or interpersonal benefits between hospitals and surgeons (i.e. surgeon satisfaction). Lastly, transactional strategic benefits or perceived benefits are short-term acquisition or operational benefits (i.e. marketing).

This value construct captures the value related to the decision. Benefits or potential benefits are exemplified in statements related to physician/patient retention or recruitment, marketing or organizational branding, etc. as discussed in mainstream articles, surgeon or hospital marketing material, and robotic manufacturer filings or corporate presentations. This construct allows us to incorporate core and add-on as direct benefits (Menon et al., 2005), indirect benefits (Grönroos, 1997), value creation (Smith and Colegate, 2007), and unique value or rarity (Barney, 1991; Magretta, 2013; Mintzberg et al., 2005; Porter, 1980; Prahalad and Hamel, 1990; Vandenbosch, 2002). See APPENDIX 2. These customer value constructs are synthesized into the following expression:

	Clinical (CART benefits)	} CFS-CART Framework
+	Financial (CART benefits)	
+	Strategic (CART benefits)	
=	Customer Value derived from Capital-Intensive Medical Innovations	

II.3 Data Collection

While there are several robotic surgery manufacturers, the preponderance of this research will be based upon a sole manufacturer because of its market dominance. This research is particularly relevant since the leading manufacturer announced its newest robotic surgery addition this year. As a result, many hospitals are considering investing in this new technological offering while pondering the latent value within their existing RSP. Public data sources from 1995 through 2014 were utilized to structure a longitudinal study for the following periods: Period 1 (1999-2004), Period 2 (2005-2009), and Period 3 (2010 – 2014). By Period Two, the robotic surgery industry consolidated to a single firm. Though exploring a single firm can mitigate the generalization of findings, an industry study can still be beneficial in illustrating the unique benefits of a value system approach for hospital executives. Data was collected from the following sources: government data, university research, mainstream media, company reports, website material, corporate presentations, published earnings, analyst reports, industry publications, and hospital press releases. These sources provide comprehensive analysis including historical, attitudinal, and behavioral insight into the research (Mathiassen and Vainio, 2007).

II.4 Data Analysis

The general strategy employed for data analysis relied on theoretical proposition, with the addition of an exploration of rival explanations to enhance this strategy. The units of observation and the unit of analysis are the robotic surgery industry, relying on Porter's model as a foundation for these constructs, expanded as necessary to reflect the nuances and complexities of a RSP and the broader healthcare arena. I used the constructs of CFS customer value. This data analysis process will also conform to Yin's principals of high quality analysis: 1) demonstrating attention to all the evidence; 2) addressing major rival explanations; 3) addressing the most significant aspect of the study; and 4) the application of prior experience in the robotic surgery industry.

In exploring the impact of industry structure on value, the research involves a cross sectional look at the implications each of the 5-forces had on each value construct. For example, the research considered the impact of industry rivalry on clinical value. Some of the tools utilized to accomplish this task are Nvivo, coding, pattern matching, data displays, matrices, arrays, and tabulated frequencies.

II.5 Limitations and Key Assumptions

While the research methodology seems plausible, there are several assumptions and limitations worth discussing. First, this research does not include interviews or direct observation regarding clinical outcomes of robotic procedures. There are over 5,000 peer-reviewed articles, most of which discuss the clinical value of robotic procedures. The intent of this research is to examine the vastly unexplored gap in robotic surgery value from an industry perspective across multiple stakeholders. This gap largely relates to the non-clinical/outcome specific data, and moreover, the programmatic or systems approach to RSPs.

Second, the research did not focus on physician training, surgical experience, surgical technique, etc. While surgeon performance has direct implication on cost per procedure, procedural time, program throughput, and other operational matters, I elected to limit the research to public clinical data that may account for variations in physician training, surgical experience, and technique. Cost metrics were derived from publicly provided information such as annual reports, quarterly earnings transcripts, published articles, etc. This does not account for nuances in programs based on size, geography, academic or community orientation, etc.;

nonetheless, lessons garnered from an exploration of the industry data may prove useful at the individual RSP level. I also based utilization metrics on publicly provided information from the manufacturer. These metrics do not account for individual hospital team effectiveness, which clearly contributes to team performance.

III ROBOTIC SURGERY INDUSTRY ANALYSIS

III.1 Period 1: The Introduction of Robotic Surgery (1999-2004)

III.1.1 Period Synopsis

III.1.1.1 Key Events.

On September 2nd, 1999, Dr. Robert Michler performed a robotic- assisted heart bypass performed at Ohio State University, which was the first reported use of the da Vinci Computer-Enhanced Surgical System (Ohio State University, 1999). The robotic surgery revolution had begun. In 2000, the U.S. Food and Drug Administration approved the da Vinci robotic surgical system (Figure 17: da Vinci Standard Robotic System) (Intuitive Surgical, Annual Report, 2000). The next year, the U.S. FDA approved the ZEUS Robot (Figure 18: Zeus Robotic System), manufactured by Computer Motion (Annual Report, 2002). Over the next six years, the robotic surgery installation base went from zero to almost three hundred worldwide (Intuitive Surgical, Annual Report, 2004). At the beginning of this period, the only industry competitors were Intuitive Surgical, manufacturer of the *da Vinci*® Surgical System, and Computer Motion, manufacturer of the Zeus Robot. Initially, robotic surgery was used primarily in converting conventional cardiac procedures and/or prostatectomy to a minimally invasive surgical technique (Computer Motion, Annual Report, 2002). During this period, robotic surgery was approved for several procedures (Table 5: Procedural Approvals).

Table 5 Procedural Approvals

PERIOD 1	
PROCEDURE	FDA APPROVAL
General Laparoscopic	July 2000
Non-cardiac thoracoscopic	March 2001
Prostatectomy	May 2001
Cardiotomy/Mitral valve repair	November 2002
Totally Endoscopic Atrial Septal Defect	January 2003
Cardiac revascularization	July 2004

The key alternatives to robotic surgery were conventional open surgery or laparoscopic, also known as minimally invasive surgery. The primary manufacturers for conventional and laparoscopic medical devices at the time were Ethicon Endo-Surgery (EES) of Johnson and Johnson, and Tyco, Inc. The main customers for robotic surgery systems were surgeons, as end users, and hospitals, as technical and economic buyers. Lastly, key suppliers during this period included endoscope and video equipment manufacturers (Table 6: Industry Participants).

Table 6 Industry Participants

PERIOD I	
New Entrants	None
Industry Competitors	Intuitive Surgical and Computer Motion
Substitutes	EES and Tyco, etc.
Buyers	Hospitals and Surgeons
Suppliers	Olympus, Panasonic, etc.

III.1.2 5-Forces

III.1.2.1 Threat of new entrants.

As described by Porter, the threat of new entrants can impact industry profitability due to increased capacity, price pressures, increased cost to compete, and higher rates of reinvestment (Porter, 1980). What is the likelihood that a new firm will enter one of the robotic surgical specialty groups to compete with existing firms (Porter, 1980)? To answer this question, one must examine potential barriers to this scenario.

Regarding economy of scale during this period, several manufacturer reports contained the statement, "We have limited experience in manufacturing our products and may encounter manufacturing problems or delays that could result in lost revenue" (Intuitive Surgical, 2000, 2001, 2002, 2003, 2004). In 1999, only 12 *da Vinci*® Surgical Systems were sold (Intuitive Surgical, 2000). While that number increased to 76 by 2004 (Intuitive Surgical, 2004), total units sold during the six year period totaled only 286 units, making it difficult to significantly reduce production costs based upon volume, resulting in higher cost per unit. Moreover, with limited employees in sales, marketing, and R&D, and with only 321 total employees in the industry by 2004 (Computer Motion, 2002 and Intuitive Surgical, 2002), there were limited signs of scale economies in the fields of manufacturing, research, engineering, or sales during the period. Economies of scale served as a non-deterrent, resulting in thinner profit margins and contributing to lower negotiating power with buyers and suppliers.

Demand-side benefits of scale or network effects did not serve as a deterrent. One manufacturer clearly states the inclusion of network effects as part of its four point strategy, two points of which include a focus on key institutions and a focus on leading surgeons to drive adoption (Intuitive Surgical, 2000). However, there were only 286 RSPs and only 207 robots in the United States market of over 4,500 hospitals (Intuitive Surgical, 2004). Buyers' willingness to pay remained relatively flat during the period, with the reported average sales price staying below $950,000 (Intuitive Surgical, 2002). Lastly, procedural numbers for the period were not given. The absence of these numbers is an assumed indication of limited procedural experience and a further indication of the limited developed network of robotic surgeons and RSP at this point.

In a highly regulated industry, government policy can have a significant impact on sector revenue. In its 2001 annual report, leading robotic surgery manufacturer Intuitive Surgical states that, "our products are subject to a lengthy and uncertain domestic regulatory process. If we do not obtain and maintain the necessary domestic regulatory approvals, we will not be able to market and sell our products in the United States" (Intuitive Surgical, 2001:34). Although this level of regulation may serve as a deterrent for some, it does not appear to have served as a deterrent for other medical device manufacturers and healthcare organizations accustomed to submitting product requests to the FDA. During the period, both major robotic surgery manufacturers submitted and received approval for their respective surgery systems, multiple procedural indications, and multiple instruments (Computer Motion, 2002 and Intuitive Surgical, 2002).

Historically, capital requirement represents the need to invest in large financial resources to compete (Porter, 2008). By 2003, one manufacturer had an accumulated deficit of almost 140 million dollars (Intuitive Surgical, 2003), an amount that did not decrease until 2004, by which time the company had invested over 110 million dollars in R&D alone (Intuitive Surgical, 2004). This served as a deterrent to poorly funded subsequent investors. Given the limited adoption of robotic surgery, switching costs were less of a measure of switching between two robotic surgery systems and more of an instance of switching from traditional or laparoscopic surgical techniques to a robotic surgery technique. As a result, the switching cost included such factors as the cost of acquiring and operating the robot. The average robot sales price during this period was $930,000, while the average annual recurring cost was approximately $135,000. One manufacturer attempted to offset this high switching cost with customer discussions regarding market share advantages related to early adoption (Intuitive Surgical, 2001). Although switching costs may have served as a deterrent for hospitals and physicians switching from alternative surgical techniques, it did not serve as a deterrent for manufacturers considering entering the robotic space, given the extremely low level of market penetration.

In 2002, Computer Motion had 79 sales and marketing personnel, and Intuitive Surgical had 94 (Computer Motion, 2002 and Intuitive Surgical, 2002), for a total of 173 robotic sales and marketing sales personnel across the industry. These sales and marketing personnel were responsible for domestic and international markets, with both marketing and sales responsibility, as well as the task of adhering to capital (buying a robot) and clinical needs (operating a robotic program) of customers. By 2004, following the merger of Computer Motion and Intuitive Surgical, that number was reduced to 140 sales and marketing personnel (Intuitive Surgical, 2004). During the period neither robotic manufacturer benefited from unequal access to distribution channels. In fact, both companies shared similar international distribution channels, yielding no competitive advantage or deterrent against newcomers.

Incumbency advantages independent of size were in their infancy. Prior to its merger with Computer Motion, Intuitive Surgical held 70 United States patents, approximately 40 foreign patents, and outright owned 15 U.S. patents (Intuitive Surgical, 2001). After the merger, Intuitive Surgical held over 100 US patents, 35 foreign patents, and owned 91 U.S. patents

(Intuitive Surgical, 2004). The deterrence level was moderate for incumbency advantages independent of size. The intellectual property landscape did not present much deterrence early in the period; but following the merger, these entry barriers became more daunting.

With revenue growth from 1999 to 2004 over 1000 percent, industry growth was exponential, which would not incentivize retaliation between Intuitive Surgical and Computer Motion. However, Computer Motion had accumulated deficits of over 110 million by FY2002 (Computer Motion, 2002). Intuitive Surgical was running an accumulated deficit of over 100 million with cash and investment averaging less than 100 million for most of the period, putting them in no position to conduct a price slashing campaign. Overall, the threat level to new entrants during the period was low. The only threat of new entry criteria to serve as a deterrent was capital requirements (Table 7: Threat to New Entrants Assessment).

Table 7 Threats to New Entrants Assessment

THREAT OF NEW ENTRANTS CRITERIA	PERIOD I
Economies of Scale	Non-Deterrent
Demand-side Benefits of Scale	Non-Deterrent
Government Policy	Non-Deterrent
Capital Requirement	Deterrent
Switching Costs	Non-Deterrent
Access to Distribution	Non-Deterrent
Incumbency Advantages Independent of Size	Non-Deterrent
Expected Retaliation	Non-Deterrent
OVERALL ASSESSMENT	LOW BARRIERS TO ENTRY

Industry Rivalry. Regarding competitive balance, Computer Motion and Intuitive Surgical were both relatively the same size. Comparatively, in the year prior to the proposed merger, Intuitive Surgical had 290 employees (94 sales and marketing), while Computer Motion had 185 employees (79 sales and marketing) (Intuitive Surgical, 2002; Computer Motion, 2002). Research and development investments were only off by 20%, with Intuitive Surgical investing $42 million and Computer Motion investing $34 million (Intuitive Surgical, 2002; Computer Motion, 2002). Computer Motion partnered with Covidien, Stryker, and Karl Storz, while Intuitive Surgical partnered with Ethicon Endo-Surgery and Olympus (Intuitive Surgical, 2002; Computer Motion, 2002). As discussed earlier, the accumulated debt in 2002 for Intuitive Surgical and Computer Motion was $128 million and $148 million, respectively (Intuitive Surgical, 2002; Computer Motion, 2002). Much of this period was defined by competition between equals, which intensified rivalry.

From 2000 to 2002, industry growth was approximately 118% as industry revenues grew from $35 million to $78 million. During the period Intuitive Surgical experienced high revenue growth of 1261% due to increases in system, instrument, and service revenue, with sales growth proving expressly lower. Total growth rates by unit sales were 133%, 75%, 22%, 2%, and 25% from 2000 to 2004 for Intuitive Surgical, with an average increase of only one robot sale per month, while Computer Motion’s revenue and sales lapsed due to delayed purchases attributed to delayed FDA approval (Computer Motion, 2002). The lower sales growth rates contributed to intensified competitiveness between Intuitive Surgical and Computer Motion.

Fixed and storage costs as illustrated by inventory and property and equipment were approximately $18 million. Despite these cost, low sales volume limited pressure that may have caused sales price to go below average costs. The lack of differentiation between the two offerings added to competitive intensity between Intuitive Surgical and Computer Motion in the period. See Table 8: Intuitive Surgical and Computer Motion Similarities. This low level of differentiation led to high levels of industry rivalry, as evidenced by multiple lawsuits (Intuitive Surgical, 2002 and Computer Motion, 2002).

Limited information exists regarding Computer Motion's Zeus pricing during the period. Intuitive Surgical saw relatively flat pricing changes during the same period, with an average price of approximately $930,000. There is no evidence of expansion leading to issues of overcapacity. There is a low level of competitive diversity between robotic surgery manufacturers. Regarding further similarities in product offerings, see Table 8: Intuitive Surgical and Computer Motion Language, Font and Messaging Similarities. These similarities not only lowered competitive diversity, but they also may have contributed to the subsequent successful merger between the two companies in 2003.

Table 8 Intuitive Surgical and Computer Motion Language, Font and Messaging Similarities

COMPUTER MOTION	INTUITIVE SURGICAL
Computer motion, Inc. ("computer motion" or the "company") is committed to developing, manufacturing and marketing proprietary robotic and computerized surgical systems that are intended to enhance a surgeon's performance and centralize and simplify the surgeon's control of the operating room ("OR").	We design, manufacture, and market the da Vinci surgical system, an advanced surgical system that we believe represents a new generation of surgery. The da Vinci surgical system consists of a surgeon's console, a patient-side cart, a high performance vision system and proprietary instruments.
As of December 31, 2002, the company had 184 full-time employees including 79 employees in sales and marketing, 53 employees in research and development, 28 employees in production and 24 employees in administration.	As of December 31, 2002, we had 290 employees, 54 of whom were engaged directly in research and development, 93 in manufacturing and service and 143 in marketing, sales, and administrative activities.
IF THE COMPANY'S PRODUCTS DO NOT ACHIEVE MARKET ACCEPTANCE, THE COMPANY WILL NOT BE ABLE TO GENERATE THE REVENUE NECESSARY TO SUPPORT ITS BUSINESS.	IF OUR PRODUCTS DO NOT ACHIEVE MARKET ACCEPTANCE, WE WILL NOT BE ABLE TO GENERATE THE REVENUE NECESSARY TO SUPPORT OUR BUSINESS.
IF THE COMPANY DOES NOT OBTAIN AND MAINTAIN NECESSARY DOMESTIC REGULATORY APPROVALS, THE COMPANY WILL NOT BE ABLE TO MARKET AND SELL ITS PRODUCTS IN THE UNITED STATES.	OUR PRODUCTS ARE SUBJECT TO A LENGTHY AND UNCERTAIN DOMESTIC REGULATORY PROCESS. IF WE DO NOT OBTAIN AND MAINTAIN THE NECESSARY DOMESTIC REGULATORY APPROVALS, WE WILL NOT BE ABLE TO MARKET AND SELL OUR PRODUCTS IN THE UNITED STATES.
THE COMPANY'S PRODUCTS ARE SUBJECT TO VARIOUS INTERNATIONAL REGULATORY PROCESSES AND APPROVAL REQUIREMENTS. IF THE COMPANY DOES NOT MAINTAIN THE NECESSARY INTERNATIONAL REGULATORY APPROVALS, THE COMPANY WILL NOT BE ABLE TO MARKET AND SELL ITS PRODUCTS IN FOREIGN COUNTRIES.	OUR PRODUCTS ARE SUBJECT TO VARIOUS INTERNATIONAL REGULATORY PROCESSES AND APPROVAL REQUIREMENTS. IF WE DO NOT OBTAIN AND MAINTAIN THE NECESSARY INTERNATIONAL REGULATORY APPROVALS, WE WILL NOT BE ABLE TO MARKET AND SELL OUR PRODUCTS IN FOREIGN COUNTRIES.
IF SURGEONS OR INSTITUTIONS ARE UNABLE TO OBTAIN REIMBURSEMENT FROM THIRD-PARTY PAYERS FOR PROCEDURES USING THE COMPANY'S PRODUCTS, OR IF REIMBURSEMENT IS INSUFFICIENT TO COVER THE COSTS OF PURCHASING THE COMPANY'S PRODUCTS, THE COMPANY BE UNABLE TO GENERATE SUFFICIENT SALES TO SUPPORT ITS BUSINESS.	IF INSTITUTIONS OR SURGEONS ARE UNABLE TO OBTAIN REIMBURSEMENT FROM THIRD-PARTY PAYERS FOR PROCEDURES USING OUR PRODUCTS, OR IF REIMBURSEMENT IS INSUFFICIENT TO COVER THE COSTS OF PURCHASING OUR PRODUCTS, WE MAY BE UNABLE TO GENERATE SUFFICIENT SALES TO SUPPORT OUR BUSINESS.

(Intuitive Surgical, 2002 and Computer Motion, 2002)

The strategic stakes were high for both companies. They mutually expressed the importance of market leadership in their corporate reports. “As the leader in computer-enhanced surgical systems for minimally invasive procedures….” (Computer Motion, Quarterly Report, 2002:13). Similarly, Intuitive stated, “We intend to maintain our leadership advantage by continuing to develop and enhance our technology and to communicate the benefits of our da Vinci Surgical System to surgeons, hospitals and patients” (Intuitive Surgical, 2002:11). The strategic stakes were even higher for Intuitive Surgical, because they lacked the expanded product offering available to Computer Motion (Intuitive Surgical, Annual Report, 2002 and Computer Motion, Annual Report, 2002). The importance of this product offering contributed to an intensified competitiveness. Both companies specialized in robotic or computer-enhanced surgery and were highly committed to the industry. This commitment was exacerbated by the high levels of accumulated debt, totaling $245 million in December of 2002. However, the willingness to merge appears to have lowered the barrier to exit for Computer Motion. Overall, the threat of intensified industry rivalry or competiveness during this period was high (See Table 9: Intensity of Rivalry Assessment).

Table 9 Intensity of Rivalry Assessment

INTENSITY OF RIVALRY CRITERIA	PERIOD I
Competitive Balance	Equal Competitors
Industry Growth	Slow sales growth
Fixed/Marginal Costs	Limited pressure to cut price
Differentiation	Little differentiation
Overcapacity	Not apparent
Competitive Diversity	Signaling clear, but competitive
Strategic Stakes	High
Exit Barriers	Moderate
OVERALL ASSESSMENT	**HIGHLY COMPETITIVE**

III.1.2.2 Threat from Substitutes.

The industry focus for the period was to position robotic surgery as advantageous and preferential in comparison to open surgery. The price-performance tradeoff for most procedures approved by the FDA during the period represented the comparison to open surgical techniques. Consider these statements from Intuitive Surgical's annual report regarding the relative value of open surgery in comparison to a robotic surgical technique.

> "Radical prostatectomy using the da Vinci Surgical System allows for positive oncologic results, reduced operative blood loss, less postoperative pain, improved cosmesis, and potentially a better nerve-sparing technique. The da Vinci Surgical System has enabled a large number of surgeons to convert from using an open surgical technique to a minimally invasive technique" (Intuitive Surgical, 2004:10).

Regarding cardiac procedures, "Our system has already enabled heart valve repairs to be performed through small ports in a manner that could not have been accomplished with open surgery" (Intuitive Surgical, 2004:9). This focus on the transition from open surgery to robotic surgery is also evident in customer statements. Consider the following quote found in HCA's annual report: "Surgical teams at select HCA hospitals use the da Vinci Surgical System to perform a variety of the latest medical procedures, including mitral valve repairs, prostatectomies and single vessel endoscopic coronary artery bypass surgery" (HCA Healthcare, 2003:3). In later periods, clinical reports challenge the relative value of robotic surgery in comparison to laparoscopy; but during this period, the majority of clinical references promoted on Intuitive Surgical's website were examples of open procedures switching to robotic (Clinical References, 2014). The relative value of open surgery compared to robotics, for the procedures approved by the FDA during this period, was low in relative value trade-off.

The buyer's, or hospital's, cost of switching from open surgery to robotic surgery is high, with an average implementation price of $930,000. "Another disadvantage of these systems is their cost. With a price tag of a million dollars, their cost is nearly prohibitive" (Lanfranco, Castellanos, Desai, and Meyers, 2004:6). This does not include the escalating operational cost, which grew from $84,000 per system for instruments and accessories and service in 2001, to approximately $209,000 in 2004. One hospital found that "The da Vinci™ system, used in telesurgical laparoscopic radical prostatectomy, would require an initial investment of $800,000 and an additional maintenance cost of $100,000 per year, adding approximately $1,500 – 2,000 to the cost of each procedure" (Holt, Zaidi, Abramson, and Somogyi, 2004:54). "Many hospitals have found it difficult to invest in robotic surgery, said Dr. Jeffrey Matthews, chairman of surgery at the University of Cincinnati Medical Center" (Bonfield, 2003). The cost of making room for these robots and the cost of the robots themselves make them an especially expensive technology (Lanfranco et al., 2004). The pressure from substitutes is low to moderate during this period, because the focus remained on surgical procedures not as minimally invasive without the use of the robot (See Table 10: Pressure from Substitutes Assessment).

Table 10 Pressure from Substitute Assessment

PRESSURE FROM SUBSTITUTES CRITERIA	PERIOD I
Price-performance Trade-off	Open to MIS comparison
Buyer's Cost of Switching to Substitute	Switching to robotic surgery is expensive
OVERALL ASSESSMENT	**LOW/MODERATE**

III.1.2.3 Buyer Bargaining Power.

One manufacturer identified the potential impact of buyer concentration on revenue during this period. One annual report stated, “because a small number of customers have and are likely to continue to account for a substantial portion of our revenues, our revenues could decline due to the loss or delay of a single customer order a relatively small number of customers account for a significant portion of our total revenues” (Intuitive Surgical, 2000:28). This level of concentration was evident throughout the period. As a result, this disproportionate impact on corporate revenues gave early adopters of robotic surgery leverage in pricing, evidenced by historically low prices in comparison to later periods.

As discussed earlier, differentiation between the offerings of Intuitive Surgical and Computer Motion are limited. Product characteristics were utilized to evaluate the differentiation between product offerings. Significant limitations in product uniqueness strengthen buyer bargaining power between robotic manufacturers. With regards to industry purchases, hospitals did not view robotic surgery as an essential service offering for patients and surgeons. This is evidenced by the sale of fewer than 300 systems during the entire period, which was less than average annual unit sales by 2008. Moreover, Computer Motion and Intuitive Surgical did not have the option of selling surgical robots to industries outside of healthcare, which increased hospital buyer power. The possibility of backwards integration, a surgeon or hospital manufacturing and distributing a competitive robotic system, was highly unlikely. However, during this period, there was evidence of Johns Hopkins University Engineering Research Consortium exploring the possibility of backwards integration in robotics (Intuitive Surgical, 2000). Nonetheless, this option remains highly unlikely because it deviates from the core competencies of most hospitals.

Intuitive Surgical acknowledged the challenge related to switching cost by saying, "Our success depends in part on convincing hospitals, surgeons and patients to convert procedures to Intuitive surgery from open or existing" (Intuitive Surgical, 2002:20). With the infancy of the installation base, there was little discussion of hospitals switching back to alternative surgical techniques like open surgery or laparoscopy after purchasing a robot. During this period, rising costs for goods and services accounted for a significant amount of hospital spending (American Hospital Association, 2008). Additionally, hospitals faced cost pressures due to the rising demand for care due to an aging population and other factors influencing increasing service demands (American Hospital Association, 2008). "Hospitals pay close attention to costs, because they usually receive a fixed amount of revenue per patient and must bear actual costs themselves" (First Research, Inc. 2009:1). These tighter margins caused hospitals to pay more attention to pricing, thereby increasing price sensitivity toward robotic purchases during the period.

This period marked the introduction of robotic surgery into the marketplace, so service importance was weak. "Our products represent a fundamentally new way of performing surgery" (Intuitive Surgical, 2000:37). Given its newness to the market, during this period, robotic surgery was not viewed as an important service offering or product for hospitals. The industry was striving for acceptance, not standardization; "Achieving physician, patient and third-party payer acceptance of Intuitive surgery as a preferred method of performing surgery will be crucial to our success" (Intuitive Surgical, 2000:37). Consequently, the robotic surgery service line was not yet of tremendous importance to hospitals, which diminished the manufacturer's ability to increase price.

In his classic work, *Diffusion of Innovation*, Everett Rogers described the challenges regarding the rate at which a new idea is accepted and promulgated throughout a community (Rogers, 2010). This work is relevant to the criteria of full information. Rogers suggested that the spread of innovation goes through five categorized customer bases with respect to market share: innovators, early adopters, early majority, later majority, and laggards (Rogers, 2010). Hospitals and surgeons that purchased robotic surgery systems during this period were largely innovators. Typically part of the product development process, innovators often gain access to more information. Within the healthcare environment, innovators often participate in both clinical trials and the establishment of procedural discoveries and refinements. One innovator, Dr. Barry Gardiner, San Ramon Regional Medical Center's (SRRMC) new director of minimally invasive surgery and principal investigator for the da Vinci™ Surgical System's FDA trials in general surgery, shared that "The da Vinci™ Surgical System is expected to advance minimally invasive techniques. This system is designed to expand surgeons' capabilities, improve their dexterity, and give them a better level of control over their hand movements" (San Ramon Regional Medical Center, 2000:1). This innovator role can result in increased bargaining power for the customer. "SRRMC invested $900,000 in the computer-enhanced Surgical System, which is awaiting final FDA approval" (San Ramon Regional Medical Center, 2000:1). This was lower than the average sales price for the da Vinci system during the period. Overall, buyer bargaining power during the period was high, which reduced the industry's ability to increase price and profitability and to negotiate more favorable terms (See Table 11: Buyer Bargaining Power Assessment).

Table 11 Buyer Bargaining Power Assessment

BUYER BARGAINING POWER CRITERIA	PERIOD I
Buyer Concentration	Disproportionate impact on revenue
Service Differentiation	Zeus or da Vinci
Industry Purchases	Hospitals exclusive purchaser
Backward Integration	University study programs
Switching Costs	Few; inception of robotics
Buyer Margins	Low Margins
Service Importance	Not important service line
Full Information	Customers As Informed (Technologist)
OVERALL ASSESSMENT	HIGH BUYER POWER

III.1.2.4 Supplier Bargaining Power.

Suppliers also compete with industry participants to increase margins and profitability through higher supply costs, quality of goods and services, labor costs, and other more favorable terms (Magretta, 2013). To evaluate supplier bargaining power, the following six factors must be considered: concentration, group dependency, switching costs, differentiation, substitution, and credibility to integrate forward (Porter, 1980).

For certain products, there were few manufacturers that could supply the robotic surgery manufacturers. For example, there were few companies that could manufacture 3D endoscopes at the time. Due to concentration, these suppliers had a high level of bargaining power during the period.

Due to dependency, suppliers did exhibit some enhanced bargaining power with robotic surgery manufacturers. Computer Motion stated, “The Company relies on independent manufacturers, some of which are single source suppliers for the manufacture of the principal components of its products” (Computer Motion, 2002:11). Computer Motion recognized that, “the company's reliance on sole or single source suppliers could harm its ability to meet demand for the company's products in a timely manner or within its projected budget" (Computer Motion, 2002:37).

There are some products that robotic manufacturers found difficult to switch. According to one manufacturer, "While alternative suppliers exist and could be identified for sole-sourced components, the disruption or termination of the supply of components could cause a significant increase in the costs of these components, which could affect our operating results" (Intuitive Surgical, 2004:15). In an early report Intuitive stated,

> "If we are required to change the manufacturer of a key component of our products, we may be required to verify that the new manufacturer maintains facilities and procedures that comply with quality standards and with all applicable regulations and guidelines. The delays associated with the verification of a new manufacturer could delay our ability to manufacture our products in a timely manner or within budget" (Intuitive Surgical, 2002:51).

These comments are indications of costly switching costs, which empowered suppliers with a higher level of bargaining power during this period.

During the period, both robotic manufacturers stated "We purchase both custom and off-the-shelf components from a large number of certified suppliers" (Intuitive Surgical, 2003:17); and "The Company purchases both custom made and stock components" (Computer Motion, 2002:11). Product differentiation from suppliers enhanced supplier bargaining power; "Our reliance on sole and single source suppliers could harm our ability to meet demand for our products in a timely manner or within budget" (Intuitive Surgical, 2003:49). While some products may allow substitutes, there are other products without alternatives. For these, "Shortages of raw materials, production capacity constraints, or delays on the part of the Company's suppliers could negatively affect the Company's ability to ship products and derive revenue" (Computer Motion, 2002:11).

Some of the larger organization could threaten forward integration. One report stated, "We also face competition from several companies that are developing new approaches and products for the minimally invasive surgery market… Ethicon Endo-Surgery, Inc., a division of Johnson & Johnson…" (Intuitive Surgical, 2001:16). Interestingly, Intuitive Surgical no longer mentioned Ethicon Endo-Surgery as a potential competitor but referred to them as an alliance partner the following year (Intuitive Surgical, 2001). Overall, supplier bargaining power during the period was high, which decreased the robotic manufacturer's ability to reduce costs and negotiate favorable terms with suppliers (See Table 12: Supplier Bargaining Power Assessment).

Table 12 Supplier Bargaining Power Assessment

SUPPLIER BARGAINING POWER CRITERIA	PERIOD I
Concentration	Very Concentrated
Dependency	High
Switching Costs	High
Differentiation	Moderate
Substitutes	Few
Forward Integration	Possible
OVERALL ASSESSMENT	**HIGH SUPPLIER POWER**

III.1.2.5 Overall Industry Structure (5-Forces).

During the period, robotic manufacturers faced the threat of new robotic system manufacturers due to low entry barriers and attractive industry revenue growth. They experienced an extremely high level of industry rivalry as Intuitive Surgical and Computer Motion engaged each other through price, competitive alliances, and multiple lawsuits. Pressure from substitutes was moderately evident. Robotic surgery served as a minimally invasive surgical technique to perform largely "complex" surgical procedures. The vast majority of these complex procedures could not be performed with alternative endoscopic tools; however, less complex procedures could be performed laparoscopically. With the focus on complex surgical procedures during this period, the strength of substitutes (alternative minimally invasive surgical techniques) was moderate at best. Hospitals and surgeons had significant bargaining power during this period, given the limited adoption base. Lastly, suppliers had tremendous bargaining power due to the importance of their products and the need for customization given the uniqueness of a robotic surgical system. Overall, the robotic surgery manufacturer's market power for this period was weak. See Table 13: 5-Forces Overall Assessment.

Table 13 5-Forces Overall Assessment

PORTER 5-FORCES	PERIOD I
Threat of New Entrants	Low Barriers to Entry
Intensity of Rivalry	Highly Competitive
Pressure from Substitutes	Low to Moderate
Buyer Bargaining Power	High
Supplier Bargaining Power	High
OVERALL ASSESSMENT	**WEAK INDUSTRY STRUCTURE**

III.1.2.6 Predicted Role of Industry Structure on Customer Value.

Porter asserts that competition for profits exist between each of the five forces (Porter, 2008). Conventional wisdom might expect this competition to influence the overall value hospitals may experience in their robotic surgery programs due to varying industry structures. Predictively speaking, the weak industry structure of robotic surgery manufacturers during this period should result in hospitals experiencing high levels of value within their robotic surgery programs. However, the following analysis of customer value illustrates the three factors which hindered hospital RSP value realization during the period.

III.1.3 Customer Value

III.1.3.1 Clinical Value.

The medical benefits for procedures during this period were influenced largely by procedural complexity. Procedural adoption for robotic surgery began with FDA approval for general laparoscopy in 2001 (Intuitive Surgical, 2004). This was followed by FDA approval for non-cardiac thoracoscopy and oncologic urology in 2001 (Intuitive Surgical, 2004), to multiple cardiac applications for FDA approval between 2002 and 2004 (Intuitive Surgical, 2004) (See Figure 6 Period 1: Event and Procedural Approval Timeline).

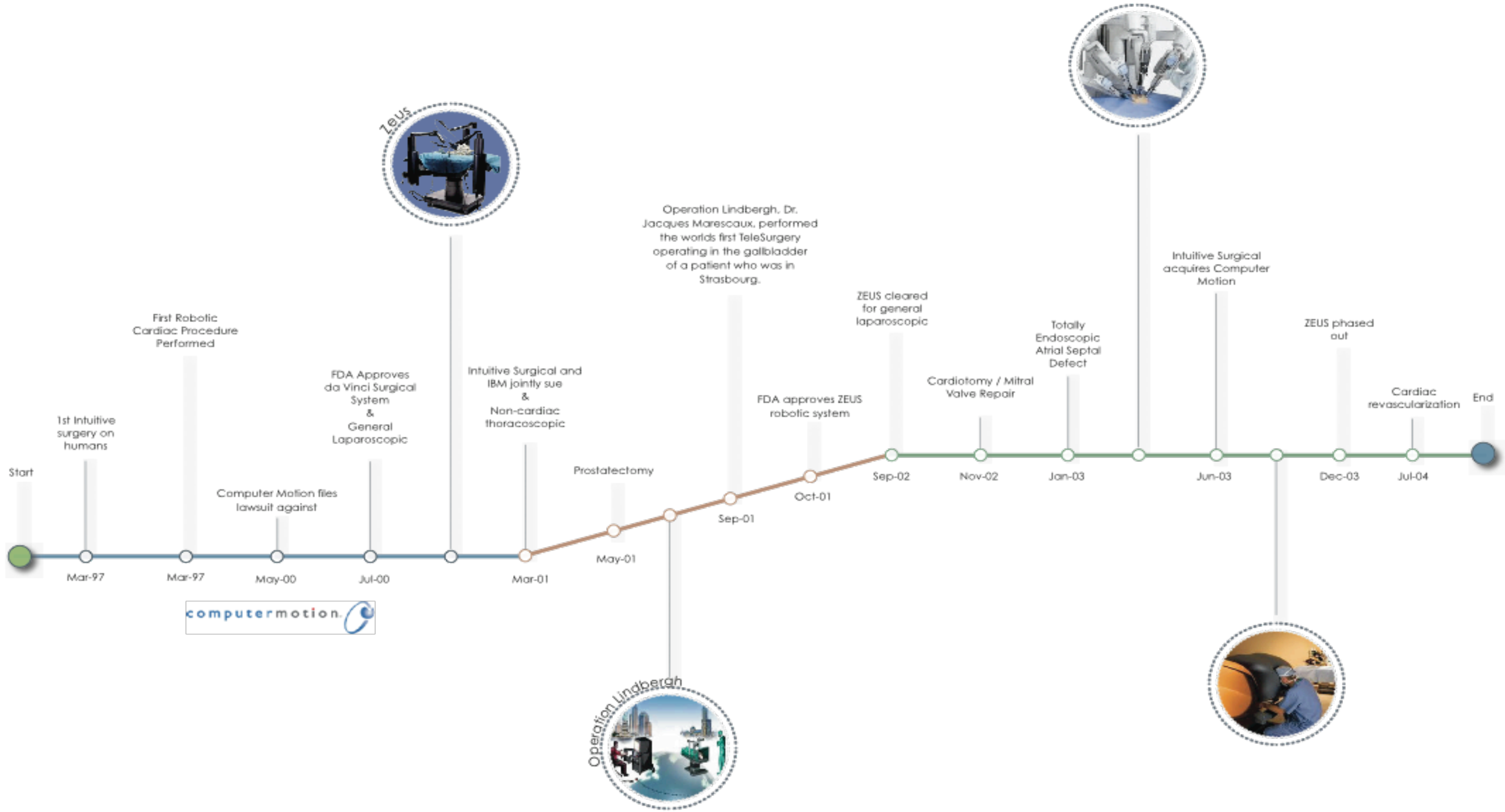

Figure 6 Period I: Event and Procedural Approval Timeline

Procedure complexity supported the high core benefits of converting traditional open procedures to MIS, including reduced blood loss, reduced length of stay, fewer complications, etc. One clinical trial found that robotic assisted prostatectomy was a longer procedure than the traditional retropubic prostatectomy, but blood loss decreased and patients experienced less postoperative pain (Menon M., Tewari A., Baize B., Guillonneau B., and Vallancien G., 2002). In 2003, the Vattikuti Institute released an additional study which found their robotic approach to be "safer, less bloody and require[ing] shorter hospitalization…." (Tewari A., Srivasatava A. and Menon M., 2003). In 2004, urologic oncologist Dr. Ahlering compared his robot-assisted surgical approach to his traditional open radical prostatectomy. Exploring his 100 case experiences, he found that his robot-assisted laparoscopic prostatectomies had the additional benefits of minimally invasive surgery without compromising the oncologic and urinary outcomes of his traditional approach (Ahlering T. E., Woo D., Eichel L., Lee D.I., Edwards R., Skarecky D.W., 2004). This experience was not unique to urologic procedures. Nonetheless, robotic surgery was in its infancy with fairly little evidence or outcome-based medicine being performed during the period (Figure 19: Citations). Consequently, the core benefit of robotic surgery, converting open procedures to MIS, was moderately high during the period.

For cardiac procedures using the Zeus Robotic system, one group of physicians found that robotic cardiac surgery offered the potential benefits of reduced morbidity, blood loss, and hospital stays by reducing the need for a median sternotomy and/or cardiopulmonary bypass (Detter, C., Reichenspurner, H., Boehm, D. H., and Reichart, B. 2001). While using the da Vinci Surgical robot, Chitwood, Kypson, & Nifong stated "This system allows the surgeon to perform complex mitral valve operations through small port sites rather than a traditional median sternotomy" (Chitwood, W. J., Kypson, A. P., and Nifong, L. W. 2003:1) (Figure 20: Mitral

Valve Port-site Robotic Approach). Given the high level of oncologic and cardiovascular procedural complexities, the core benefits were equivalent to add-on benefits of robotic surgery, because these complex procedures could not be performed in a MIS manner without a surgical robot.

This procedural complexity helped increase relational value between patients and physicians, as surgeons were able to improve patient satisfaction through less invasive surgical techniques. Demand for robotic surgery was predominantly surgeon-led rather than patient-demanded. The relational value between patient and surgeon was moderate. However, the transactional value of robotic procedures was mitigated given the difficulty surgeons experienced in successfully navigating the challenges of the robotic learning curve. One article during the period suggested that becoming proficient in performing robot-assisted prostatectomies requires 40-60 cases (Descazeaud, A., Peyromaure M. and Zerbib M., 2007). However, cardiac procedures are even more complex and present steep learning curves (Bonatti, J., Schachner, T., Bernecker, O., Chevtchik, O., Bonaros, N., Ott, H., Friedrich G., Weidinger, F. and Laufer, G., 2004). As a result, the transactional value during the period was low. Overall, the ability to perform complex procedures in a minimally invasive fashion was the driving factor in offering core benefits, add-on benefits, relational and transactional benefits for hospitals, leading to moderate clinical value (See Table 14: Clinical Value Assessment).

Table 14 Clinical Value Assessment

CLINICAL CRITERIA	PERIOD I
Core Benefit	Moderately High
Add-on Benefit	Moderately High
Relational Benefit	Moderate
Transactional Benefit	Low
OVERALL ASSESSMENT	**MODERATE**

III.1.3.2 Financial Value.

During the period, procedural complexity was a dominant theme that impacted financial value. The potential financial value impact associated with these procedures demonstrated the benefits of lower condition costs, increased revenue, and improved robotic program profitability, despite higher procedural costs. The core benefit of converting open procedures to robotic surgery was evaluated for delivering financial benefit beyond the operating room. For example, a review of radical prostatectomy found,

> "The costs of new technology are typically borne out in the first years of use and RAP [robot assisted prostatectomy] is no exception with high robot costs for purchase, maintenance and operative equipment overshadowing savings gained by shorter length of stay. While RRP [radical retropubic prostatectomy] is currently the least costly approach, LRP [laparoscopic radical prostatectomy] has proved to be almost as cost competitive as RRP, whereas RAP will require a significant decrease in the cost of the device and maintenance fees" (Lotan, Cadeddu, and Gettman, 2004:1).

An alternative evaluation of robotic mitral valve surgery stated,

> "Despite enthusiasm, caution cannot be overemphasized. Surgeons must be careful because indices of operative safety, speed of recovery, level of discomfort, procedural cost, and long-term operative quality have yet to be defined. Traditional valve operations still enjoy long-term success with ever-decreasing morbidity and mortality, and remain our measure for comparison. Surgeons must remember that we are seeking the most durable operation with the least human trauma and quickest return to normalcy, all done at the lowest cost with the least risks. Although we have moved more asymptotically to these goals, surgeons alone must map the path for the final ascent" (Chitwood, Kypson & Nifong, 2003).

Despite financial advantage of shorter length of stays, the high acquisition, instrument cost, and cost associated with longer operative times mitigated the financial benefits of converting open procedures (Lotan et al., 2004). Given the novelty of robotic surgery, on-going operating cost and areas of potential savings were unclear. Some expected robotic surgery to create savings by reducing the need for operating personnel (Holt et al., 2004). Due to the absence of substantive evidence related to reduced treatment costs, the benefit of lower treatment cost related to robotic surgery during this period was low to moderate.

By enabling hospitals and surgeons to create unique value, procedural complexity contributed to increased incremental revenue during this period. The Cincinnati Enquirer reported, "In 1999, Dr. Randall Wolf, then a heart surgeon at Christ Hospital, traveled to Europe to become the first U.S. surgeon to use the da Vinci to complete a cardiac bypass. But Wolf left for Ohio State later that year after officials at Christ Hospital decided not to buy the machine" (Bonfield, 2003:2). In the case of Dr. Wolf, "The team at Ohio State went on to grab several headlines for advances in robotic surgery…." (Bonfield, 2003:2). This add-on benefit was evident by hospitals providing unique service offerings, which stimulated patient awareness and increased demand in high reimbursement procedures. Low level market adoption allowed for bigger incremental gains but made those gains more difficult to realize due to the lack of broad market adoption. As a result, the ability to generate financial add-on benefits was low.

Some proponents early on expressed a long-term program view of robotics, with a focus on program profitability. Sam Gerszonowicz, an analyst from Brenner Securities, concluded, "…if a typical hospital gets 15% profit from most medical operations, it earns about $8000 per robotic procedure (Shields, 2001:18)." Although some may dispute the view of hospital procedural profitability, the robotic procedures during this period were largely oncologic or cardiovascular. These procedures experienced higher than average reimbursement due to their complexity, however they received no additional reimbursement due to robotics (Binder, Brätigam, Jonas, & Bentas, 2004). As a result, the relational value of RSP during this period was low.

The vast majority of the literature during this period focused on the high transaction cost of robotic surgery. At the time, the acquisition cost of a da Vinci or Zeus robotic system was approximately $1 million, which does not include instrument and service costs (Darmiento, 2002; Intuitive Surgical, 2002; Chandra & Frank, 2003; Chitwood, 2003) See Table 15 Period I: Acquisition and Operational Cost.

Table 15 Period I: Acquisition and Operational Costs

	ACQUISITION COST		MAINTENANCE COST		PROCEDURE	
	DA VINCI	ZEUS	DA VINCI	ZEUS	DA VINCI	ZEUS
Stanford Report, 2000		$875,000				
Shields, 2001	$750,000 - $1,000,000					
Darmiento, 2002	$1,000,000	$1,000,000				
Intuitive Surgical, 2002	$912,000					
Intuitive Surgical, 2002	$948,000					
Gerhardus, D. 2003	$1,000,000	$975,000	$100,000	$100,000	$100,000	
Chitwood et al, 2003	$1,000,000	$1,000,000				
Binder et al, 2004	€ 1,250,000				$1,600-1,900	
Holt et al., 2004	$800,000	$1,000,000	$100,000		$1,500-2,000	
Lotan at al., 2004	$1,200,000		$100,000			
El-Hakim and Tewari, 2004	$1,200,000		$100,000		$1,500	
Bodner et al., 2005	€ 1,000,000		€ 100,000			
Ontario Health Technology Assessment Series, 2004	$800,000	$1,000,000				

Most publicized opinions at this time expressed concern regarding the high price tag. For example, hospitals like Christ Hospital in Cincinnati, Ohio took a largely transactional approach and decided that the price tag was prohibitive (Bonfield, 2003). Nonetheless, the short-term goals of purchasing a robot during this period varied and were assessed as moderate. See Table 16: Financial Value Assessment. Overall, the financial value of robotic surgery during the period was low to moderate.

Table 16 Financial Value Assessment

FINANCIAL CRITERIA	PERIOD I
Core Benefit	Low/Moderate
Add-on Benefit	Moderate
Relational Benefit	Low
Transactional Benefit	Moderate
OVERALL ASSESSMENT	**LOW/MODERATE**

III.1.3.3 Strategic Value.

Strategic benefits are related to physician or patient retention or recruitment, organizational branding or marketing. The core strategic benefit of converting open procedures to robotic surgery is to attract new physicians and patients. During the period Dr. Vip Patel shared, “We thought we would maybe perform 50 cases a year with the robot, but now we're estimating over 300 a year, and all because patients come in and say they want it” (PSA Rising, 2004:1). Ohio State’s ability to recruit Dr. Wolf during this period was an example of this benefit. Also, Dr. Joseph De Rose, “the first surgeon in this country to perform a completely robotic biventricular pacemaker procedure,” was recruited to St. Luke’s –Roosevelt Hospital (St. Luke’s Roosevelt, 2014:1). Although some physicians and patients were recruited based on robotic surgery, robotic sales, averaging little more than 7 system sales per quarter during the period, marginalized the benefits (Intuitive Surgical, Annual Reports, 2000-2004). As a result, the strategic core benefits were assessed as low.

The strategic add-on benefit of creating unique value equipped hospitals to capitalize on new patient trends as patients and insurance companies began demanding less invasive surgical techniques during the period (Shields, 2001). For example, Dr. Mani Menon, of the Vattikuti

Urology Institute performed the first outpatient robotic prostatectomy in 2001. By the end of the period, Dr. Menon and the Vattikuti team had the highest volume robotic series in the world, performing over 2000 robotic prostatectomies (Henry Ford Health System, 2014). Dr. Vip Patel shared,

> "Robotic-assisted radical prostatectomy is not yet widely available. The da Vinci ® Surgical System is frequently used by surgeons to perform heart surgery and general laparoscopic procedures, such as gallbladder removal, treatment of gastroesophageal reflux disease, and gynecologic treatment. However, only about 100 centers in the United States and Europe offer robotic-assisted prostate surgery…." (PSA Rising, 2005:1).

During this period, programs like the Vattikuti Urology Institute and others were able to create new positions in market leadership, though this was more of the exception than the rule. Generally, the opportunity for hospitals to create new value during this period was moderate.

An early example of the ability of robotic surgery to recruit innovative surgeons is not only an example of core benefit, but also an example of the technology's ability to influence surgeon satisfaction. This is representative of the relational value of robotic surgery. As discussed earlier, Dr. Wolf left Christ Hospital dissatisfied because he did not have access to a surgical robot (Bonfield, 2003). While Dr. Sudhir Srivastava, a leading robotic cardiac surgeon, shared his satisfaction over Alliance's $1.5 million purchase in 2002, saying, "the personnel who pursued this at the hospital were fantastic, practicing day in and day out and backing a total commitment by the surgeons to make use of the new robotic surgery" (Imbesi, 2007:1). Multiple examples of the technology's ability to satisfy surgeons during this period were difficult to discover, which is not surprising given the level of adoption and acceptance. Overall, relational value was assessed as low during this period.

The transactional value associated with a robotic purchase, represented by the immediate marketing of the newly purchased system, varied. In 2000, Dr. Schauer of UPMC Presbyterian stated regarding an investment in the Zeus robotic system, “no other hospital has yet packed quite so many cutting edge technologies into one operating suite” (Spice, 2000:1). A 2004 Annuals of Surgery article summed up the transactional value offered by RSPs as follows:

“Robotic surgery is a new and exciting emerging technology that is taking the surgical profession by storm. Up to this point, however, the race to acquire and incorporate this emerging technology has primarily been driven by the market. In addition, surgical robots have become the entry fee for centers wanting to be known for excellence in minimally invasive surgery despite the current lack of practical applications. Therefore, robotic devices seem to have more of a marketing role than a practical role. Whether or not robotic devices will grow into a more practical role remains to be seen (Lanfranco et al., 2004:1).”

There was a moderate amount of transactional strategic value during the period. Overall, the strategic value of robotic surgery to recruit physicians and patients, create new and/or unique value, contribute to surgeon satisfaction, and influence hospital marketing was low/moderate during the introduction period. See Table 17: Strategic Value Assessment

Table 17 Strategic Value Assessment

STRATEGIC CRITERIA	PERIOD I
Core Benefit	Low
Add-on Benefit	Moderate
Relational Benefit	Low
Transactional Benefit	Moderate
OVERALL ASSESSMENT	**LOW/MODERATE**

III.1.3.4 Overall Customer Value.

During this introduction period, robotic surgery provided stakeholders with low to moderate levels of value, with value largely mitigated by limited market experience. There were three dominating themes worth exploring: *procedural complexity, transition to minimally invasive surgery and validity of first mover advantages*. As previously discussed, the procedural complexity trend during this period increased significantly (Table 5: Procedural Approvals). Robotic surgery has largely been understood as a technology with a focus on performing complex surgical procedures in a minimally invasive environment. However, one manufacturer's annual report discussed the three ways robotic technology could forever change surgery, with the third being "Simplifying Existing, High-Volume MIS Procedures" (Intuitive Surgical, 2000:9). By 2003, the focus had simplified to transitioning complex procedures to a minimally invasive surgical technique, which was evident by the growth in prostatectomy and cardiac procedures (Intuitive Surgical, 2002; Computer Motion, 2002).

The same manufacturer removed the focus of simplifying existing, high volume MIS procedures from their annual report (Intuitive Surgical, 2002). The transition to MIS in procedures that previously had not been successfully performed laparoscopically, like prostatectomy or mitral valve, represented an opportunity to drive substantial clinical value. These complex procedures were also associated with relatively higher levels of reimbursement in comparison with other procedures with robotic approval during this period, like robotic cholecystectomy. This higher reimbursement and associated complexity level facilitated higher financial value and faster returns on investment (Gerhardus, D. 2003). However, the gains in clinical and financial value were moderated by the difficulty of the learning curve and robotic costs.

Comparatively, strategic value based upon procedural complexity was enhanced by authentic market shifts due to early adoption. During this period, hospitals implemented robotic programs largely driven by innovative surgeons, which contributed significantly toward industry establishment. Historically, innovators aggressively approach new technologies; they are the visionaries, the explorers, the customers that rejoice in the purchase of a new technology simply because of its newness, independent of its pragmatic applications (Moore, 2002). Consider the examples during this period, such as the FDA approval for the *da Vinci*® Surgical System, followed by a trial led by Dr. Chitwood at East Carolina University (ECU News Services, 2002). Also worth noting is the admission at UPMC that "the new systems do have a few bugs" (Spice, 2000:3), illustrating a willingness to work through early stage challenges. This period empowered innovative surgeons to participate in the creation of an industry, an opinion promulgated by manufacturers during this period:

> "The current customer profiles are made up of early adopters that share the Company's pioneering vision for these new technologies" (Computer Motion, 2002:57).

> “We believe these efforts will benefit early-adopting hospitals by increasing their market share in the procedures and specialties that benefit from Intuitive surgery” (Intuitive Surgical, 2004:8).

> “We also train our sales representatives to educate hospital management on the potential benefits of early adoption of our technology and the potential for increased local market share that may result from Intuitive surgery” (Intuitive Surgical, 2004:8).

Early adoption enabled hospitals to capitalize on potential clinical benefits, moderate to high financial benefits, despite transactional limitations as well as strategic opportunities. As Dr. Lanfranco stated:

> “In today's competitive healthcare market, many organizations are interested in making themselves "cutting-edge" institutions with the most advanced technological equipment and the very newest treatment and testing modalities. Doing so allows them to capture more of the healthcare market. Acquiring a surgical robot is in essence the entry fee into marketing an institution's surgical specialties as "the most advanced." It is not uncommon, for example, to see a photo of a surgical robot on the cover of a hospital's marketing brochure and yet see no word mentioning robotic surgery inside” (Lanfranco et al., 2004:8).

However, gains in strategic value had to overcome the difficulty of limited adoption and procedural acceptance during this time. Figure 21: Marketing Robotic Surgery demonstrated the efforts of hospitals to enhance, extend, and differentiate their surgical brands featuring surgical robotics. In support of the CFS value that accompanied robotic surgery, over 300 RSPs were implemented during this period. Overall the CFS value of robotic surgery during this period was low/moderate. See Table 18: Customer Value Overall Assessment.

Table 18 Customer Value Overall Assessment

ROBOTIC SURGERY CUSTOMER VALUE	PERIOD I
Clinical Value	Moderate
Financial Value	Low/Moderate
Strategic Value	Low/Moderate
OVERALL ASSESSMENT	LOW/MODERATE

III.1.3.5 Hospital Value Predicted vs. Hospital Value Assessed.

From 1999-2004 the robotic surgery industry consisted of a relatively weak industry structure for robotic manufacturers, while providing low to moderate value for hospitals. This is in contrast to the expectations of higher customer value, due to limited market power of robotic surgery manufacturers. What factors mitigated the creation of high levels of customer value during this period? As expected, the weak industry structure presented some opportunities for hospitals to enhance value during this time. For instance, low barriers to entry, high rivalry between robotic manufacturers, and high buyer bargaining power provided surgeons with the opportunity to drive clinical value regardless of the manufacturers' focused assertion. The period began with manufacturers targeting robotic utilization in higher volume procedures already performed using minimally invasive techniques. Due to weak market power, robotic manufacturers didn't drive clinical usage; hospitals drove clinical application to procedures benefitting specifically from robotic usage, despite lower volume instrument usage.

However, RSP value realization was hampered due to three factors: 1) Learning curve challenges, 2) Healthcare reimbursement stagnation and 3) Limitations in market presence. Clinical transactional benefits reflected the difficulty of the learning curve, which despite weak industry structure, resulted in longer operating times and increased complication rates. Low financial relational benefits reflected the adoption of innovative technologies in healthcare, without commensurate changes in procedural reimbursement. Unlike other industries, in which a firm can adopt a new technology and charge more due to higher value delivered, hospitals increases in financial value were largely limited to cost reductions. Low strategic core and relational benefits illustrate early stage adoption challenges. Hospitals were not fully able to take advantage of the strategic value of a RSP during this period because the industry was still in the first phase of the technology adoption curve. (See Table 19: Period I: Integrated Industry Structure and Customer Value).

Table 19 Period I: Integrated Industy Structure and Customer Value

1999-2004	ROBOTIC SURGERY CUSTOMER VALUE (HOSPITAL VIEWPOINT)		
	Clinical	Financial	Strategic
Overall Industry Structure Assessment (Weak)	C – Present A – Present R – Slightly Present T – Not Present	C – Not Present A – Slightly Present R – Barely Present T – Slightly Present	C – Slightly Present A – Slightly Present R – Slightly Present T – Slightly Present

III.2 Period II: The Rapid Adoption of Robotic Surgery (2005-2009)

III.2.1 Period Synopsis

III.2.1.1 Key Events.

In April 2005, the FDA approved gynecology for robotic usage (Intuitive Surgical, 2005). See Table 20: Procedural Approvals. This announcement was followed by the introduction of a new surgical robot, the da Vinci S system in January 2006 (Intuitive Surgical, Annual Report, 2006). The addition of this system and the introduction of robotic hysterectomy catapulted robotic sales and procedural growth throughout the period. The period began with the robotic installation base approaching 300, but during this time the installation base would grow by more than 1,000 systems (Intuitive Surgical, Annual Report, 2009). In fact, robotic prostatectomy would become the leading surgical treatment for localized prostate cancer, which would serve as the first procedure where the robotic technique would be considered the industry standard (Intuitive Surgical, 2008). This period would also see multiple co-development projects between the robotic manufacturer and traditional medical device manufacturers in designing procedure-specific instrumentation. Near the end of the period, the United States endured a financial crisis, a component of the larger global financial crisis and continued recession. This economic environment contributed to the smallest incremental sale increase in robotic systems in the history of the market leader (Intuitive Surgical, Annual Report, 2009).

Table 20 Procedural Approvals

PROCEDURE	FDA APPROVAL
PERIOD I	
General Laparoscopic	July 2000
Non-cardiac thoracoscopic	March 2001
Prostatectomy	May 2001
Cardiotomy/Mitral valve repair	November 2002
Totally Endoscopic Atrial Septal Defect	January 2003
Cardiac revascularization	July 2004
PERIOD II	
Urologic Surgery Approval	March 2005
Gynecology	April 2005
Pediatric Surgery	June 2005
Transoral Otolaryngology	December 2009

During this period, there was one new entrant, Titan Medical incorporated. In terms of FDA approved systems, however, there were no new entrants, which left Intuitive Surgical as the sole robotic surgery manufacturer in the market. Substitutes to robotic surgery techniques varied by procedure; however, they were largely represented by Ethicon Endo-Surgery and Covidien, Inc. as manufacturers of both open and laparoscopic surgical instruments. Other treatments to prostate surgery, such as brachytherapy, served as substitutions as well. The buyers for the period remained hospitals, while the suppliers remained largely undisclosed with some exceptions. (Table 22: Industry Participants).

Table 21 Industry Participants

	PERIOD I	PERIOD II
New Entrants	None	Titan Medical
Industry Competitors	Intuitive Surgical and Computer Motion	Intuitive Surgical
Substitutes	EES and Tyco, etc.	EES and Tyco, etc.
Buyers	Hospitals and Surgeons	Hospitals and Surgeons
Suppliers	Olympus, Panasonic, etc.	EES, Gyrus, etc.

III.2.2 5-Forces

III.2.2.1 Threat of new entrants.

Overall the barriers of entry changed drastically from the previous period, as the sole robotic manufacturer began to experience some economies of scale. According to corporate reports beginning in 2006, "higher gross profit…was driven by higher 2006 product revenue … lower product material costs and lower manufacturing costs" (Intuitive Surgical, Q2 Quarterly Report, 2006:25). In fact, throughout the rest of the period, "instrument and system material cost reductions and leveraging manufacturing costs across higher production volumes" continued to be a contributing factor to higher product gross profit (Intuitive Surgical, 2009:43). There were more robotic procedures performed in 2008 than from the period of 1999 – 2006. These higher volumes contributed to lower margining cost, creating a higher barrier to entry through economies of scale.

As discussed previously, the creation of network effects through leading institutions, as well as a focus on key physicians, were two strategic points from one manufacturer's annual report the previous period. These points continued to be a part of the strategy at the outset of this period (Intuitive Surgical, 2005). One manufacturer reported, referencing these network effects, "Some of the leading academic centers around the world have begun to make da Vinci standard within these procedures." (Seeking Alpha, 2008:5). In the first quarter of 2008, "117 da Vinci related clinical papers published within the peer view Journals across multiple surgical specialties" (Seeking Alpha, 2008:4) contributing to the establishment of a robotic surgery network of hospitals. By the end of the period, there was at least one RSP in every state in the United States (Intuitive Surgical, Investor Presentation, and Q4 2009). Over 1,100 robotic surgery units were sold, many of which to surgical thought-leaders and key institutions. Unlike the first period, where price largely remained flat, in this period the robotic unit average sales price grew every year, equaling an approximate 32% price increase from the beginning to end of the period. These enhanced network effects led to increased willingness to pay. Procedural experiences increased as well, with over 500,000 robotic procedures performed during this period. This further demonstrated extended demand-side benefits of scale.

Throughout this time, the role of government policy remained consistent. The sole manufacturer introduced a new robotic system, but fewer new procedures were approved. While surgical robotics remained a highly regulated industry, the market focus on robotics was not a deterrent. However, the capital requirements became a deterrent as the industry sole manufacturer spent 3 times, $270 million (Intuitive Surgical, 2005-2009), as much money on research and development during this period in comparison to the previous period. Switching cost served as a deterrent, which became increasingly stronger as the period transpired. At the beginning of the period the robotic installation base was approximately 350 hospitals, but by the end of the period the installation base had grown to almost 1,400 hospitals (Figure 7: Robotic Surgery System and Procedural Growth) (Intuitive Surgical, 2009).

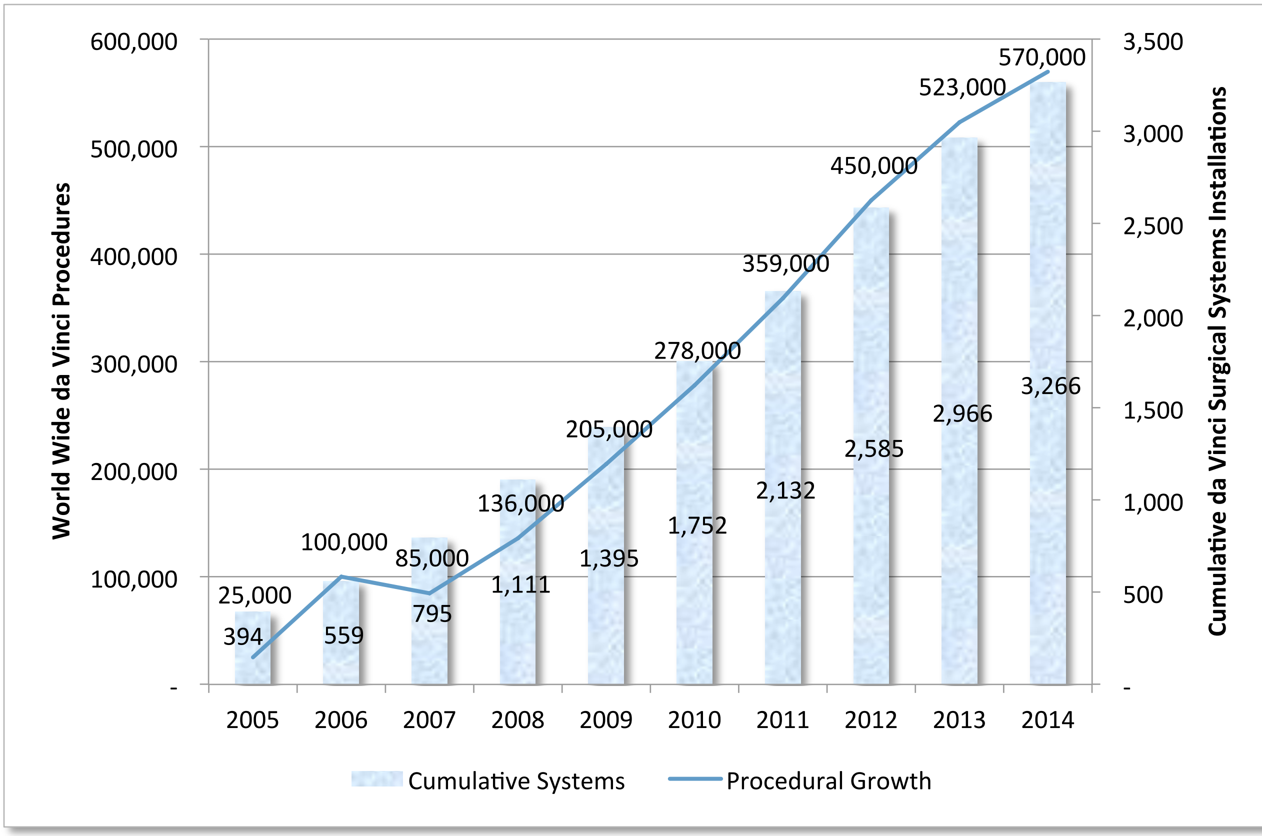

Figure 7 Robotic Surgery Systems and Procedural Growth

Although there was no alternative system available during the period, the cost to switch included capital cost, unused inventory, and service cost and training, which could be estimated to be in excess of $1.8 million (average sales price plus average recurring costs) per robotic system by the end of the period. Access to distribution actually improved significantly, with approximately 500 field sales and service employees in comparison to 140 at the beginning of the period (Intuitive Surgical, 2004 & 2009). With only one robotic surgery manufacturer following last period's merger, the additional headcount and monopolistic positioning created unequal access to distribution channels. Moreover, there was a steady increase in advantages independent of size due to increased procedural experience and intellectual property gains. By the end of this period, there were over 840 patents or patents pending. Expected retaliation increased as the industry demonstrated a willingness to litigate in the previous period. Moreover, the cash available to litigate had improved substantially as Intuitive Surgical achieved profitability in 2006 (Intuitive Surgical, 2006), with cash balances exceeding $1.1 billion by 2009 (Intuitive Surgical, 2009). Overall, the threat level to new entrants during this period was high (Table 22: Threat to New Entrants Assessment).

Table 22 Threat to New Entrant Assessment

THREAT OF NEW ENTRANTS CRITERIA	PERIOD I	PERIOD II
Economies of Scale	Non-Deterrent	Deterrent
Demand-side Benefits of Scale	Non-Deterrent	Deterrent
Government Policy	Non-Deterrent	Non-Deterrent
Capital Requirement	Deterrent	Deterrent
Switching Costs	Non-Deterrent	Deterrent
Access to Distribution	Non-Deterrent	Deterrent
Incumbency Advantages Independent of Size	Non-Deterrent	Deterrent
Expected Retaliation	Non-Deterrent	Deterrent
OVERALL ASSESSMENT	**LOW BARRIERS TO ENTRY**	**HIGH BARRIERS TO ENTRY**

III.2.2.2 Industry Rivalry.

There was no industry rivalry during the period, due to the merger between Intuitive Surgical and Computer Motion and the absence of a new entry robotic manufacturer competitor. As a result, there was no competitive balance during the period as there was only one FDA approved robotic surgery system in the market. There was a high industry growth rate during this time (Figure 8: Industry Revenue Growth).

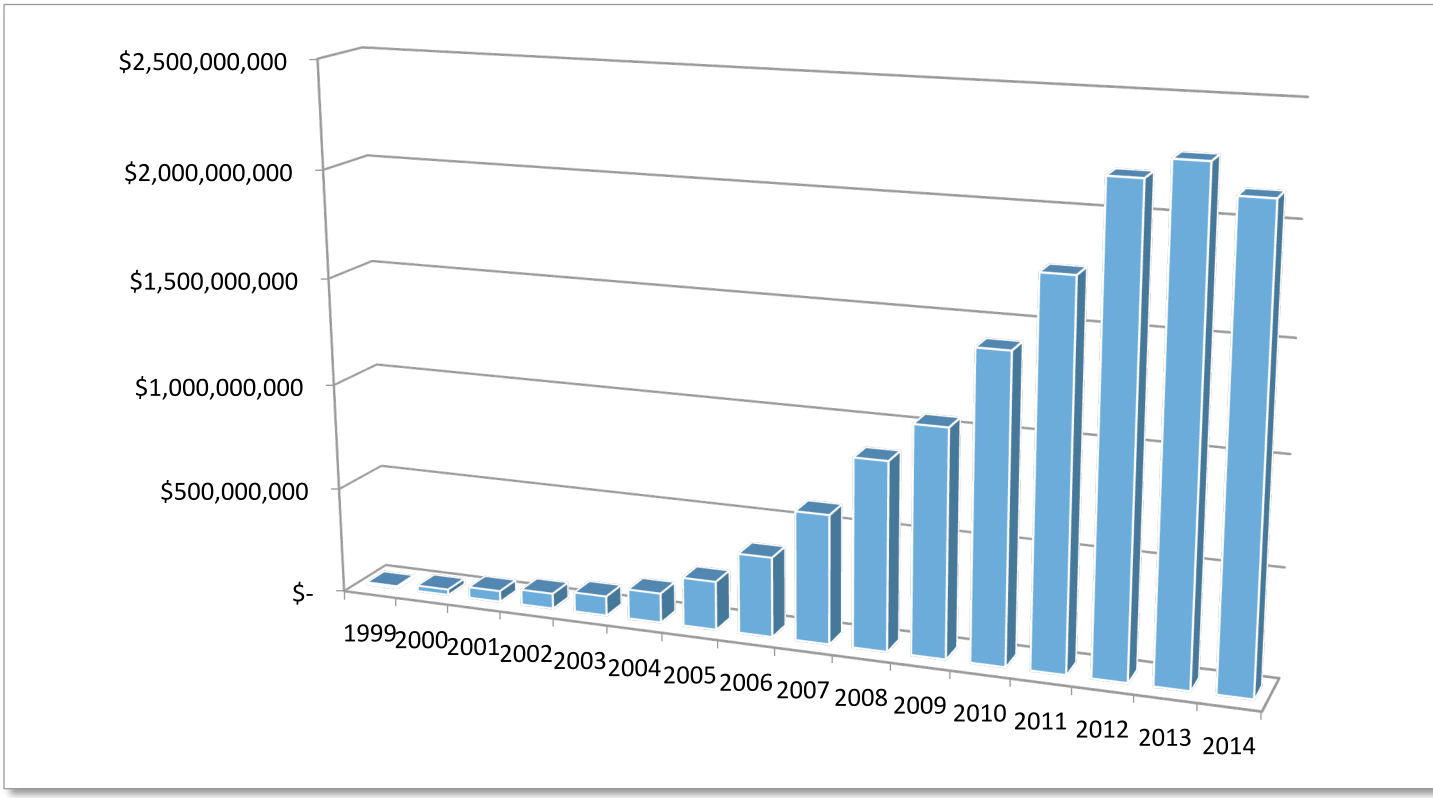

Figure 8 Industry Revenue Growth

(Intuitive Surgical 2000 - 2014)

Consequently, there was no pressure to cut price due to fixed or marginal costs, product differentiation, and/or the lack of competitive diversity. The strategic stakes for the sole manufacturer remained high, as there was no market for robotic surgery systems outside of the hospital industry. Lastly, the exit barriers did dissuade other players. Overall, the threat of industry rivalry or competitiveness during the period was exceptionally low (See Table 23: Intensity of Rivalry Assessment).

Table 23 Intensity of Rivalry Assessment

INTENSITY OF RIVALRY CRITERIA	PERIOD I	PERIOD II
Competitive Balance	Equal Competitors	Sole competitor
Industry Growth	Slow sales growth	High Sales Growth
Fixed/Marginal Costs	Limited pressure to cut price	No pressure to cut price
Differentiation	Little differentiation	Sole competitor
Overcapacity	Not apparent	Not apparent
Competitive Diversity	Signaling clear, but competitive	No signaling
Strategic Stakes	High	High
Exit Barriers	Moderate	Low
OVERALL ASSESSMENT	**HIGHLY COMPETITIVE**	**NOT COMPETITIVE**

III.2.2.3 Threat from Substitutes.

As described earlier, robotic surgery substitution consists of alternative minimally invasive surgical treatments, minimally invasive non-surgical treatments, and traditional surgical approaches. The procedures that received FDA approval during this period were other urologic surgeries, gynecology, and pediatrics. These approvals were unlike the prior period, when the procedures approved did not have strong minimally invasive alternatives. Several of the procedures approved this period, like nephrectomy, pyeloplasty and hysterectomy, had strong laparoscopic options. These alternatives changed the price-performance trade-off from simply comparing the cost of open to minimally invasive surgery, to evaluating both the cost of open to minimally invasive surgery and the cost of converting laparoscopic cases to robotic. The robotic industry navigated this change in substitution positioning by focusing on surgeons that had elected not to pursue a laparoscopic surgical technique and still performed open surgery, like gynecologic oncology. Following the hysterectomy approval in April 2005, the manufacturer announced, “We believe that the da Vinci Surgical System has the potential to address a significant portion of the sizable hysterectomy market, specifically cases relating to cancer and complex fibroid conditions” (Intuitive Surgical 2005:36). These cases represent oncologic and complex gynecologic procedures more commonly performed with traditional open, not laparoscopic, surgical techniques. Once again, the manufacturer stated, “Our goal is to establish da Vinci surgery as the standard approach for complex surgical procedures, displacing both open surgical technique and standard MIS within this segment” (Intuitive Surgical 2005:9). By focusing on the complex cases, the industry improved the price-performance trade-off comparison because complex laparoscopic cases were more apt to require the surgeon to convert the procedure to open surgery. These complex cases also experience higher complication rates. This became evident in physician published clinical trials highlighted during industry earning calls, as stated by the vice-president of business development and strategy of Intuitive. He shared,

> “During the SGO postgraduate course, Dr. John Boggess from the University of North Carolina shared his outcomes data for da Vinci Radical Hysterectomy, in which he compared 50 Radical dVH's [ph] for cervical cancer to 50 radical hysterectomies performed through traditional open incisions. His comparisons were pretty telling, beginning with over time, which was 210 minutes for its dVH's, compared to 247 minutes for his open hysterectomies. Blood loss for his dVH's was 95 milliliters and 416 milliliters for his open hysterectomies….Dr. Lynn Kowalski, a surgeon from Nevada

> Surgery & Cancer Care in Las Vegas, presented a simple comparison and her radical hysterectomies with the addition of transfusion rates and published her results in excepted clinical poster. And Dr. Kowalski's series of 31 patients, she reported loss to be 182 milliliters with zero transfusions within a dVH co-work [ph], as compared to 415 and three transfusions for her open procedures. dVH lymph node of 20.7, verses 16 for open and dVH hospitalizations of 1.4 days, versus 6.1 days for her open radical hysterectomies" (Seeking Alpha, 2008:4).

This clinical study makes the case for the superiority of robotic surgery when compared to traditional open surgery for complex gynecologic cases. During the same earnings call the point was also made in regard to the other substitute, laparoscopy. Consider the following,

> "This analysis compared the outcomes of an initial experience with robotic Partial/Wedge Nephrectomy performed by an experienced open surgeon to that of our standard Laparoscopic Partial Nephrectomy being performed by two experienced Laparoscopic surgeons. Their initial clinical results were as follows: the mean tumor size was 3.1 centimeters for the da Vinci Partial Nephrectomy patients and 2.3 centimeters for their Laparoscopic patients. Mean total procedure time was reduced by an hour using da Vinci to 228 minutes versus 289 minutes during their Laparoscopic procedures. Estimated blood loss was 115 milliliters with da Vinci versus 198 millimeters during laparoscopy" (Seeking Alpha, 2008:5).

This clinical study compares robotic surgery to traditional laparoscopy for complex procedures, which became an ongoing practice during industry-related earning calls from 2007-2009.

(Seeking Alpha, 2007-2009). Hospitals that firmly believe in the clinical value of the robotic approach create a captured end-user market. This varies by patient population, procedure, physician, etc. The trade-off becomes extreme once physician or patient is convinced of the clinical benefits of robotics; in such cases, substitutes appear as less attractive and least viable options.

The cost of switching to open and/or a traditional laparoscopic technique after selecting robotic surgery became more difficult during this period as well. Robotic surgery involves more switching cost to alternative treatments than vice versa. Consider the following cost that surgeons and physicians must consciously switch away from when electing to return to traditional open or laparoscopic techniques:

> "The first cost includes the purchase price of the robotic system, which ranges between $1,000,000 and $1,500,000 and requires a 10% annual maintenance fee for repair and service as well as software upgrades to the system. The second cost is the procedure disposable cost, which includes the robotic instruments ($200/use), drapes to maintain sterility of the system, and a few other accessories and ports required to perform the surgery that are specific to robotics. The third cost is the cost of training new personnel and initial delays in setup time and procedure time during the learning curve. The fourth cost is the expense of training and/or proctoring until the surgeon is certified" (Boggess, 2007:35).

The alternative techniques generally precedes the multi-million dollar investment; but once the investment is made, there are political, financial and community pressures to legitimize the capital purchase over alternative treatments. As a result, the threat of substitutes, following the initial investment, is low to moderate during this period. The threat of substitutes is higher than last period as more procedures have minimally invasive alternatives. Nonetheless, the switching costs of these substitutes are extremely high following the purchase of a robotic system. Overall, the threat of substitutes during this period was moderate (See Table 24: Pressure from Substitutes Assessment).

Table 24 Pressure from Substitute Assessment

PRESSURE FROM SUBSTITUTES CRITERIA	PERIOD I	PERIOD II
Price-performance Trade-off	Open to MIS comparison	Primarily, open to MIS comparison Limited robotic to MIS comparison
Buyer's Cost of Switching to Substitute	Switching to robotic surgery is expensive	Switching to substitute after robotic purchase is prohibitive
OVERALL ASSESSMENT	**LOW/MODERATE**	**MODERATE**

III.2.2.4 Buyer Bargaining Power.

During the previous period, concentration of robotic purchases was disproportionately reduced to a few key customers. This was last cited by Intuitive Surgical in late 2005 (Intuitive Surgical, Quarterly Report, 2005) but was no longer the case through the remainder of the period, as over 1,000 new robotic customers were added throughout the period (Intuitive Surgical, 2009). Consequently, hospital and surgeon bargaining power became more consistent with the limitations of a fragmented industry where "the top 50 organizations hold less than 30% of the market" (Industry Guidebook: Healthcare, 2009). In the previous period, service differentiation proved slight between robotic manufacturers; during this period, however, given the single manufacturer position, service differentiation was absolute..

The risk of backwards integration decreased. In fact, partnerships between robotic manufacturers and academic institutions, like the one between Intuitive Surgical and the California Institute of Technology, became more likely (Intuitive Surgical, 2007). Industry purchases for buyers remained high, as robotic surgery manufacturers did not have alternative industries to sell their products. Regarding switching costs, “The da Vinci Surgical System has enabled a large number of surgeons to convert from using an open surgical technique to a minimally invasive technique” (Intuitive Surgical, 2009:9). This increase in conversions also represents an increase in switching cost for hospitals and surgeons due to the lack of choice in the robotic industry. The buyer margins remained low as hospitals continued to struggle with increasing cost pressures (Kaiser Family Foundation, 2009) and the challenges of the 2008-2009 economic crises, which increased price sensitivity towards capital purchases like robotics (Intuitive Surgical, 2009).

Unlike the previous period, service importance of robotic surgery increased substantially. One article on the application and cost of robotic surgery stated,

> “The most common application for robotic surgery in the field of urology is the radical prostatectomy. The use of the robot for radical prostatectomy increased from 1% of all prostatectomies performed in the United States in 2001 to almost 40% in 2006–2007. More than 50% of all prostatectomies performed in the US in 2009 will be robot assisted” (Leddy, Lendvay & Satava, 2010:101).

The absence of the leading treatment for prostate cancer would diminish the brand of a cancer center, urology residency program, or community hospital in the marketplace. Near the end of this period the service importance of having a RSP increased significantly, which increased the manufacturer's ability to increase price.

In the first period, consistent with the work of Everett Rogers, the research observed high robotic utilization by innovators. During this period, I saw the acceptance of the technology by early adopters. Early adopters also enjoy the newness of a technology, but they are interested more in the potential advantage that the technology offers, rather than the technology alone. They are considered the pivotal customer to new technology markets, because they don't require references or the comfort of industry opinion; early adopters only need to see how the technology offers a unique advantage (Moore, 2002). Because early adopters are less involved in making a technical contribution to the technology, they are often less informed. Innovators were involved in FDA trials, system designs and redesigns, etc. On the other hand, early adopters had less information than innovators, which was reflected in decreased buyer bargaining power. Overall, buyer bargaining power was very low for hospitals by the end of the period (See Table 25: Buyer Bargaining Power Assessment).

Table 25 Buyer Bargaining Power Assessment

BUYER BARGAINING POWER CRITERIA	PERIOD I	PERIOD II
Buyer Concentration	Disproportionate impact on revenue	Fragmented
Service Differentiation	Zeus or da Vinci	Single Manufacturer
Industry Purchases	Hospitals exclusive purchaser	Hospitals exclusive purchaser
Backward Integration	University study programs	Less Likely
Switching Costs	Few; inception of robotics	High
Buyer Margins	Low Margins	Low Margins
Service Importance	Not important service line	Important
Full Information	Customers As Informed (Technologist)	Customers Less Informed
OVERALL ASSESSMENT	**HIGH BUYER POWER**	**LOW BUYER POWER**

III.2.2.5 Supplier Bargaining Power.

With many manufactured goods, a listing of external suppliers is not always readily available; this may be an indication of limited supplier power. Conversely, in the computer industry, it's generally accepted many computers have "Intel Inside." Supplier concentration within the robotic manufacturing industry was assumed to consist of several firms. In a January 2009 Deco magazine article, Swiss Precision's president commented about his firm being one of many suppliers considered by Intuitive Surgical (Deco Magazine, 2009).

In this period, the robotic manufacturer remained dependent upon sole-source suppliers. The manufacturer continued to mention this group dependency in annual reports (Intuitive Surgical, Annual Reports, 2005-2009). However, it is not uncommon for robotic parts suppliers to be more dependent on robotic manufacturers (RMs). For example, although the harmonic shears were jointly developed by Ethicon Endo-Surgery and Intuitive Surgical, the robotic manufacturer also had the option of working with Gyrus on an energy based vessel sealing solution, while Ethicon Endo-Surgery only had one choice of robotic manufacturer in which to utilize its robotic instrument (Intuitive Surgical, Annual Report, 2005 and Intuitive Surgical, Annual Report, 2006). Regarding switching costs, the robotic manufacturer expressed concerns related to alternative suppliers throughout the period (Intuitive Surgical, Annual Report, 2005-2009). Similarly, the manufacturer also continued to "purchase both custom and off-the-shelf components from a large number of certified suppliers" (Intuitive Surgical, 2009:14), which demonstrated continued product differentiation from suppliers and potential difficulty in product substitution.

Although larger partial suppliers could still threaten to forward integrate, Ethicon Endo-Surgery was no longer named as a competitor. Alternatively in 2007, Intuitive Surgical stated, "We have formed alliances with, among other companies, Ethicon Endo-Surgery, Inc., Gyrus ACMI, Olympus Corporation…", which may have mitigated the threat of forward integration (Intuitive Surgical, Annual Report, 2009:12). Overall, supplier bargaining power during the period was low/moderate, which increased the robotic manufacturer's ability to reduce costs and negotiate favorable terms with suppliers (See Table 26: Supplier Bargaining Power Assessment).

Table 26 Suppliers Bargaining Power Assessment

SUPPLIER BARGAINING POWER CRITERIA	PERIOD I	PERIOD II
Concentration	Very Concentrated	Less Concentrated
Dependency	High	Moderate
Switching Costs	High	Moderate
Differentiation	Moderate	Moderate
Substitutes	Few	Few
Forward Integration	Possible	Unlikely
OVERALL ASSESSMENT	**HIGH SUPPLIER POWER**	**LOW/MODERATE SUPPLIER POWER**

III.2.2.6 Overall Industry Structure (5-Forces).

In this period the robotic manufacturer faced a limited threat of new entrants due to high industry barriers to entry. The pressure on pricing from industry rivals was greatly reduced given the absence of other industry competitors. The pressure from substitute offerings, such as traditional surgery or alternative minimally invasive techniques, was moderate. Although the presence of laparoscopy presented a credible substitute, the trade-offs to returning to open or laparoscopic surgery after the substantial investment of time and money in robotics was becoming less plausible. The bargaining power for hospitals decreased drastically over this period, given the increased adoption and importance of robotic surgery. Lastly, supplier power decreased as the sole manufacturer identified ways to become less dependent on sole-source agreements. Overall, the robotic surgery manufacturer's market power for this period was very strong. See Table 27: 5-Forces Overall Assessment.

Table 27 5-Forces Overall Assessment

PORTER 5-FORCES	PERIOD I	PERIOD II
Threat of New Entrants	Low Barriers to Entry	High Barriers to Entry
Intensity of Rivalry	Highly Competitive	Not Competitive
Pressure from Substitutes	Low to Moderate	Moderate
Buyer Bargaining Power	High	Low
Supplier Bargaining Power	High	Low/Moderate
OVERALL ASSESSMENT	**WEAK INDUSTRY STRUCTURE**	**VERY STRONG INDUSTRY STRUCTURE**

III.2.2.7 Predicted Role of Industry Structure on Customer Value.

As industry structure strengthens robotic surgery firms have more control over the direction of the industry, which could reflect in less hospital customer value. During this period, the robotic surgery manufacturer moved from a weak industry structure to a very strong industry structure. Porter's model might predict that this resulted in lower levels of value for hospitals within their robotic surgery programs.

III.2.3 Customer Value

III.2.3.1 Clinical Value.

The medical benefits for procedures during this period were an amalgamation of benefits driven by procedures approved during last period and benefits experienced from procedures approved during this period. This period experienced the extension of the core benefit of robotic surgery, converting open cases to robotic. In the first period, this value was experienced primarily in cardiovascular and prostate procedures. During this period, those benefits extended to urologic oncology, gynecologic oncology, and hysterectomy (Seeking Alpha, Quarter 3, 2008). However, as discussed earlier, some of the high volume procedures introduced in this period, like hysterectomy, had a compelling laparoscopic alternative. As a result, the clinical value remained high overall due to growing adoption, but the clinical value in transitioning a laparoscopic procedure to robotic was generally less compelling than the clinical value of converting an open case to robotic.

This period created opportunities for hospitals to experience add-on benefits as well. Hospitals began to leverage their unique positions based upon their clinical expertise. By the beginning of the period, the robotic prostatectomy team at Henry Ford Medical in Detroit, Michigan had performed over 1,000 robotic prostatectomies (Hakim and Tewari, 2004) and Dr. Randy Chitwood completed over 300 robotic mitral valve procedures by November 15th, 2006 (ECU News, 2006). As procedural experience grew, many physicians began to deliver clinical benefits unique to robotics. Within prostatectomy, physicians demonstrated improvements in urinary continence and erectile function (Ficarra, Novara, Fracalanza, D'Elia, Secco, Iafrate & Artibani, 2009) in comparison to traditional approaches while also experiencing faster operating times, reduced blood loss and reduced hospitalization in comparison to a laparoscopic approach (Rocco, Matei, Melegari, Ospina, Mazzoleni, Errico & de Cobelli, 2009). During this period, physicians began to compare robotic surgery directly with laparoscopic surgery, as evidenced in the above citation. Although not directly stated in their corporate presentation, this was evidence of a market return to Intuitive Surgical's original strategy "Simplify Existing, High-Volume MIS Procedures" (Intuitive Surgical, Annual Report, 2000:9). In 2008, Drs. Payne and Dauterive published their landmark study comparing total laparoscopic hysterectomy to robotically assisted hysterectomies (Payne and Dauterive, 2008). Their study indicated a higher likelihood of converting to an open procedure in the laparoscopic cohort as opposed to the robotic cohort (Payne and Dauterive, 2008). Robotic surgery demonstrated a high level of unique and/or add-on value, even in comparison to laparoscopy. At the end of the period, the following equation was added to the annual report: Patient Value = Efficacy / Invasiveness, which was described as, "Most patients will place higher value on procedures that are not only more efficacious, but also less invasive than alternative treatments. Our goal is to provide patients with procedure options that are both highly effective and less invasive than other surgical options" (Intuitive Surgical, Annual Report, 2011:11). This equation is simply a combination of the direct benefits, within clinical value.

These advantages also helped to increase relational value between patients and physicians, as surgeons were able to improve patient satisfaction through less invasive surgical techniques. Consider the following example, citing "high patient satisfaction with a minimum of one year follow up" (Seeking Alpha, Q2 ISRG Earning Call Transcript, 2008), in reference to robotic sacral colpopexy; and "with GYN meeting reviews… increased patient satisfaction were common themes" (Seeking Alpha, Q4 ISRG Earning Call, 2008). The vast majority of robotic applications during the period were for traditionally open procedures, resulting in a high level of patient satisfaction and relational value for hospitals.

Transactional value also increased this period as surgeons became more comfortable with the technology. Likewise, as early adopters grew in procedural experience, clinical trials and publications regarding surgical techniques, complications, benefits, etc. became more prevalent (See Figure 19: Citations) (Cecile C., Arnaud S., Mark L. and De Laet C., 2009). From 2007-2009, approximately 426,000 robotic surgeries were performed, and over half of those procedures were prostatectomies (Intuitive Surgical, Annual Reports, 2007 – 2009). Consider the fact that the FDA approved robotic prostatectomy in 2001 and mitral valve repairs in 2002. In this period, many surgeons and hospital teams were going beyond procedural introduction to procedural mastery leading to reduced complications, lower blood loss, and faster operating times. In spite of the proliferation of robotic surgery for certain procedures, the average number of procedures being performed per robotic system dropped dramatically during the period. (See Figure 9: Mean Utilization Rates).

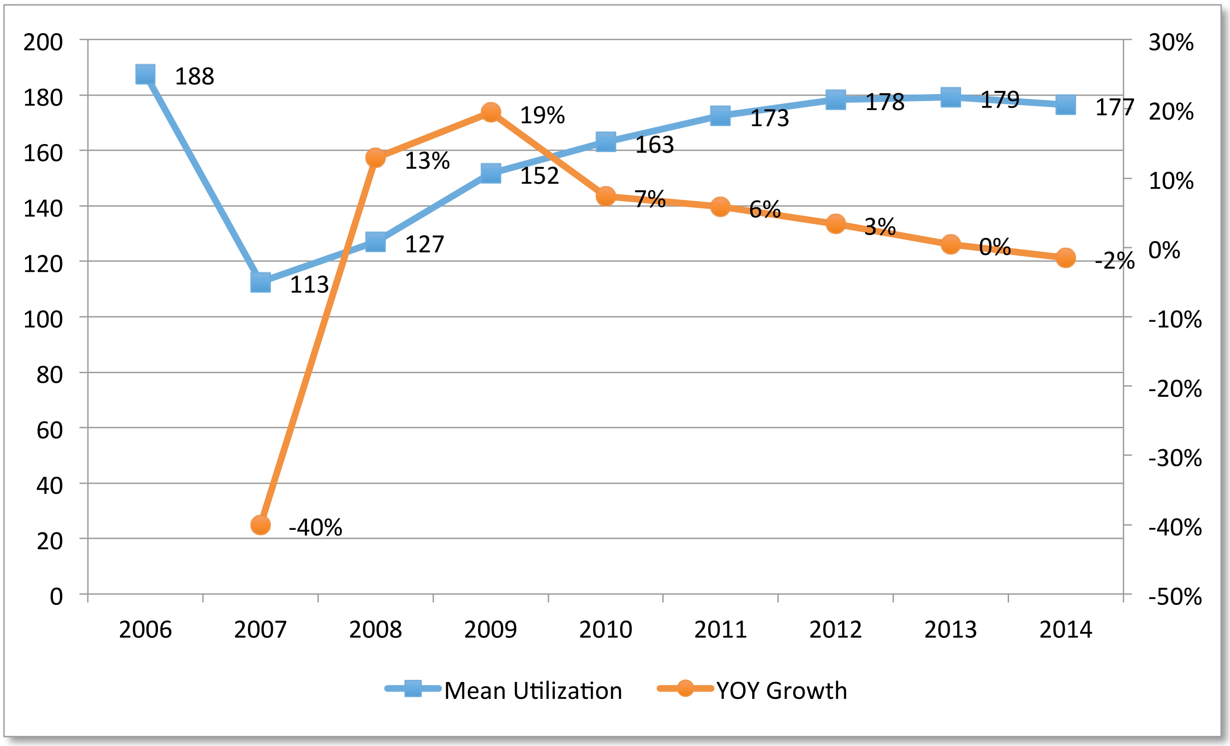

Figure 9 Mean Utilization Rates

The transactional value of robotic surgery actually increased to moderate during this period as surgical teams became more comfortable, although the learning curve remained a significant obstacle. The overall clinical value for robotic surgery during this period, despite the introduction of less complex procedures, increased to high (See Table 28: Clinical Value Assessment).

Table 28 Clinical Value Assessment

CLINICAL CRITERIA	PERIOD I	PERIOD II
Core Benefit	Moderately High	High
Add-on Benefit	Moderately High	High
Relational Benefit	Moderate	High
Transactional Benefit	Low	Moderate
OVERALL ASSESSMENT	**MODERATE**	**HIGH**

III.2.3.2 Financial Value.

Procedural complexity continued to be an important theme. The core financial benefit is the ability of robotic surgery to demonstrate lower treatment cost when converting open procedures to minimally invasive surgery. In published clinical trials, this benefit was discussed across multiple specialties. In the Journal of Cardiac Surgery one group of physicians shared,

> "Robotic technology did not significantly increase hospital cost. While the absolute cost for robotic surgery was higher than conventional techniques after taking into account the institutional cost of the robot, the major driver of cost for robotic procedures will likely continue to decrease, as the surgical team becomes increasingly familiar with robotic technology. Furthermore, other benefits, such as improvement in postoperative quality of life and more expeditious return to work may make a robotic approach cost-effective. Thus, it is possible that the benefits of robotic surgery may justify investment in this technology" (Morgan, Thornton, Peacock, Hollingsworth, Smith, Oz and Argenziano. 2005:1).

In an article in the Thoracic Surgery Clinics the author stated, “The average cost of VATS [Video Assisted Thoracic Surgery] is substantially less than thoracotomy primarily because of a decreased length of stay. The cost of robotic assistance for VATS is still less than thoracotomy, but greater than VATS alone” (Park and Flores, 2008:1). Lastly, an article comparing traditional, laparoscopic, and robotic techniques in robotic gynecologic oncology concluded, “the average cost for hysterectomy and staging was highest for laparotomy, followed by robotic, and least for standard laparoscopy” (Bell, Torgerson, Seshandri-Dreaden, Suttle and Hunt, 2008:1). These articles highlight the financial advantages of robotic surgery when compared to traditional open surgical techniques. However, the treatment cost in comparison to laparoscopy was frequently higher. The core benefit assessment for this period was moderate.

Over this period, market adoption and acceptance grew substantially, thereby increasing the ability to create unique value. There were roughly 1,000 clinical papers in peer-reviewed journals written about robotic surgery in 2009, in comparison to less than 250 papers only two years earlier. From 2005 – 2009, approximately 500,000 robotic surgery procedures were performed. By then end of the period, there were over 1,000 RSPs in the United States alone. Many hospital executives during this period began to see robotic surgery as an opportunity to create a unique tool that could provide incremental revenue. The CEO of the Ford Health System in Detroit said "We've seen double-digit increases in the number of prostate cases performed since we introduced the da Vinci Surgical System" (Klein, 2008:1). The Sarasota Memorial Healthcare Foundation raised over 1.5 million dollars from an anonymous donor for the purchase of a second robotic system (Vim and Vigor, 2008). During this period, the add-on financial benefits of robotic surgery to enhance revenue were increased by market adoption and acceptance, rendering an overall assessment of high.

Financial relational value based upon a long-term program focus increased during this period. This was largely evident in the amount of robotic reinvestments made (See Figure 10: Repeat System Sales).

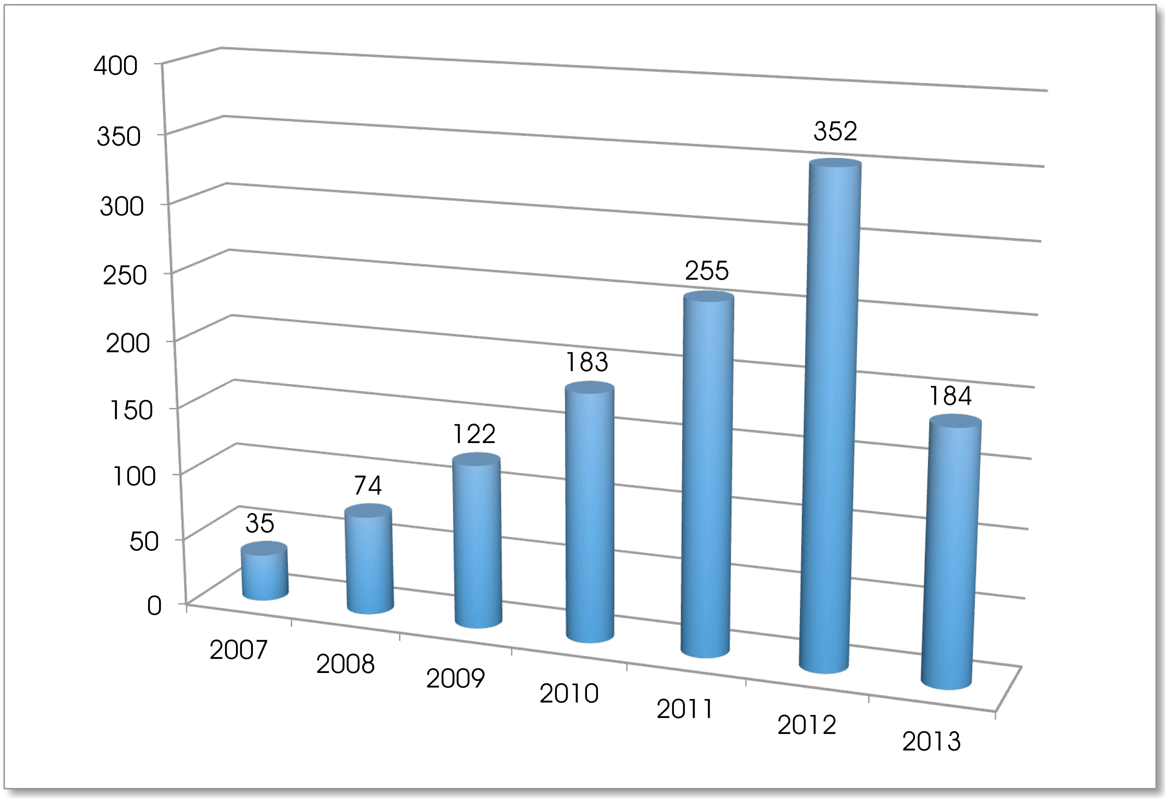

Figure 10 Period II: Repeat Systems Sales

(Intuitive Surgical, Quarterly Earning Calls, 2007 – 2013)

In October 2007, the vice-president of business development and strategic planning for Intuitive Surgical shared, "Repeat systems sales included the Cleveland Clinic, Northwestern University Hospital, the Lahey Clinic and Hackensack Medical Center. The sale to Hackensack represented their fifth da Vinci system" (Seeking Alpha, Q307 ISRG Earning Call, 2007:4). In April 2008 he shared, "… customer like St. Joes in Atlanta. This quarter they brought another system, that was a repeat customer, in fact they would have bought their fifth system" (Seeking Alpha, Q108

ISRG Earning Call, 2008:9). Consider the statements of Lonnie Smith, Chairman and CEO of Intuitive Surgical in 2008, when she said, “I think the confirmation of the value-add of the system is really reflected in repeat purchases. And those that have bought and had found success and then buy a second system that's a confirmation of their satisfaction with their purchase and willingness to do it again” (Seeking Alpha, Q108 ISRG Earning Call, 2008:9). By 2009, more hospitals were buying into the long-term viability of RSPs. In fact, in Q3 2009, over 40% of system sales were to existing robotic customers including “a sixth system to Methodist Medical Center in Houston, a fifth system to Ohio State University Medical Center” (Seeking Alpha, Q309 ISRG Earning Call, 2009:5). As the evidence suggests, the long-term program relational value of RSPs improved to high during this period.

The transactional value, compared to the prior period, decreased as the cost of a robotic acquisition went up. At the beginning of the first period, the average sales price for a da Vinci system was $925,000 (Intuitive Surgical, Q105 Quarterly Report, 2005) (See Figure 11: Average Sales Price).

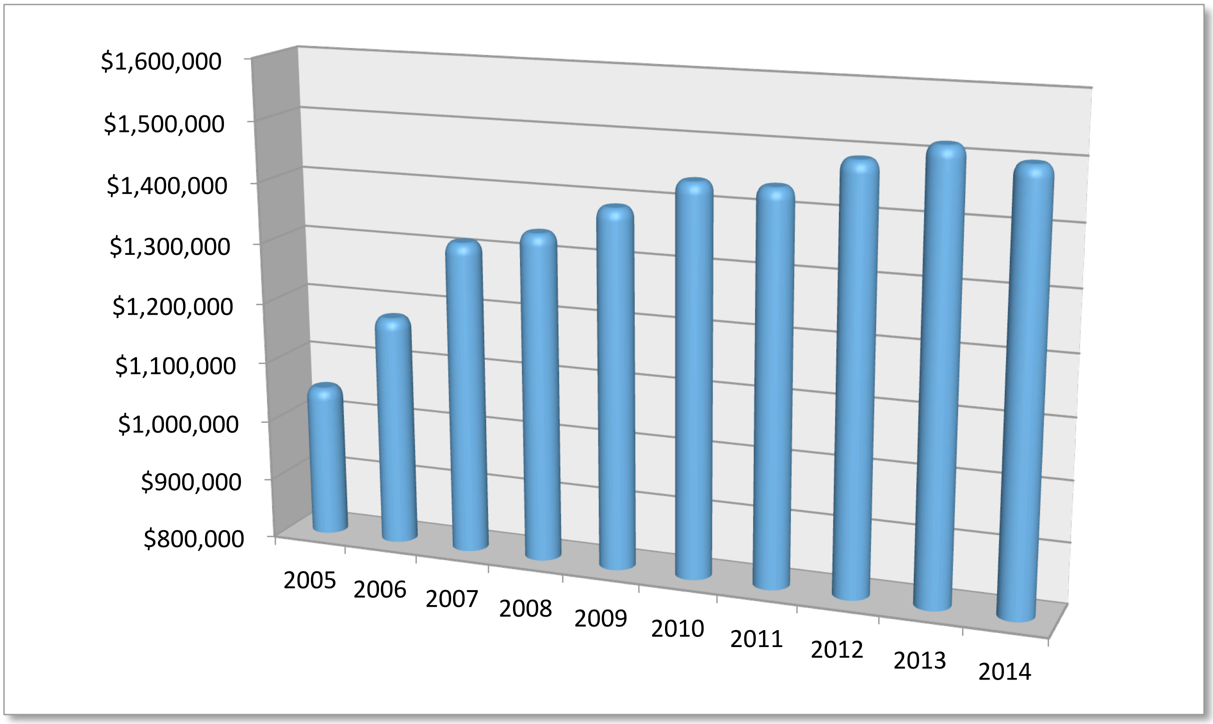

Figure 11 Average Sales Price

By March 2009, in the aftershocks of the 2008 financial crisis, the *da Vinci*® Surgical System was at its highest recorded average sales price to date, $1,430,000 (Seeking Alpha, Q209 ISRG Earning Call, 2009). These price points continued to increase throughout the period supported by market adoption, market acceptance, and iterative robotic system product launches. By the end of the period, transactional value for hospitals had decreased. Overall the financial value of robotic surgery for hospitals had slightly decreased (See Table 29: Financial Value Assessment).

Table 29 Financial Value Assessment

FINANCIAL CRITERIA	PERIOD I	PERIOD II
Core Benefit	Low/Moderate	Moderate
Add-on Benefit	Moderate	High
Relational Benefit	Low	High
Transactional Benefit	Moderate	Moderate/Low
OVERALL ASSESSMENT	**LOW/MODERATE**	**MODERATE/HIGH**

III.2.3.3 Strategic Value.

During this period, the strategic core benefit of attracting physicians and patients increased from low to high. In 2005, Ohio State University recruited Dr. Vip Patel "to direct its robotics and minimally invasive urological surgery program." (AACI Update, 2005:1). Dr. Sudhir Srivastava attracted patients from all over the United States to Odessa, Texas for robotic heart surgeries (Imbesi, 2007). After performing over 800 robotic cardiac procedures and becoming the highest volume robotic cardiac surgeon in the United States, Dr. Srivastava was recruited from Alliance Hospital to the University of Chicago Medical Center in 2007 to become director of robotic and minimally invasive cardiac surgery (Imbesi, 2007). The following year, Florida Hospital announced, "Dr. Vip Patel has accepted the position of Medical Director of the newly established Global Robotics Institute (GRI)" (Florida Hospital Media Relations, 2008:1). Not only did Florida Hospital recruit one of the highest volume surgeons in the world, with approximately 2,000 cases performed, but they lauded that Dr. Patel "leads one of the world's most experienced robotic surgery teams, which will now join him in Central Florida" (Florida Hospital Media Relations, 2008:1). Dr. Patel's entire team was recruited. In November 2009, Florida Hospital published the following press release:

"Florida Hospital Celebration Health Welcomes Dr. Arnold Advincula

Gynecological Robotic Surgery Specialist First In World To Perform Robotic Myomectomy"

(Florida Hospital Media Relations, 2009:1).

Clearly, investments in robotic surgery had demonstrated a high level of ability to recruit surgeons and patients.

During this period, hospital systems achieved new market leadership positions through the creation of unique value. Odessa, Texas became one of the primary robotic surgery training centers entertaining over 150 doctors from around the world interested in robotic heart surgery (Imbesi, 2007). Saint Josephs of Atlanta initially purchased the da Vinci robot in 2002 and became the first in the world to purchase the da Vinci in pursuit of becoming "A World Leader in Robotic Surgery" (Health Care 2017: Envisioning Our Future 2006:13) At the same time, Florida Hospital grew from acquiring a robotic surgery system in 2004 to establishing the Global Robotic Institute (Florida Hospital Media Relations, 2008). The strategic add-on benefit of creating unique value remained moderate during this period.

The relational aspect of robotic surgery strengthened during this period. To more physicians, an investment in robotic surgery represented an investment in the hospital surgeon relationship. This is best illustrated through physician recruitment related to robotic surgery, the increased number of procedures performed, and the increase in clinical studies performed in relation to robotic surgery. As generation X and millennials became the dominant surgeon population, the existence of a RSP equated with being a high-tech hospital (Maccracken, Pickens and Wells, 2009). Overall, the relational value of having a RSP during this period was moderate.

Lastly, strategic transactional value is related to the short-term strategic benefits of a RSP, which is best demonstrated through marketing. The marketing value of robotic surgery during the period increased dramatically. Dr. Saliba, senior vice-president of marketing and planning for Florida Hospital, discussed the impact of marketing their RSP on the web (Saliba, 2009). The mix of Florida Hospital's direct, interactive, and physician robotic surgery marketing campaign led to higher surgery volume trends than expected for every month of the following year, as well as shifts in market share from 5.9% in 2007 to 36.4% in 2008, measured from January – June (Saliba, 2009). Alternatively, there were opinions that much of the growth in robotic surgery was attributed to marketing rather than clinical benefits. Consider the following: "Between 2001 and 2008, robotically assisted minimally invasive prostate surgery jumped from 1% of all procedures to up to 60%, largely because of direct-to-consumer marketing…" (Fauber, 2009:1). The high transactional value of robotic surgery in support of strategic marketing efforts was not challenged, though the appropriateness of such marketing was questioned, which carried into the next period. Overall, the strategic value of robotic surgery for the period increased from low/moderate to high. See Table 30: Strategic Value Assessment.

Table 30 Strategic Value Assessment

STRATEGIC CRITERIA	PERIOD I	PERIOD II
Core Benefit	Low	High
Add-on Benefit	Moderate	Moderate
Relational Benefit	Low	High
Transactional Benefit	Moderate	High
OVERALL ASSESSMENT	**LOW/MODERATE**	**HIGH**

III.2.3.4 Overall Customer Value.

During this period, acceptance was the predominant theme driving robotic surgery customer value from low/moderate to moderate/high due to increases in hospital robotic surgery experience. This acknowledgment of robotic surgery was clearly evident at surgical meetings. According to one corporate synopsis of a urology annual meeting,

> "The agenda at this year's AUA Conference held in Chicago was a Da Vinci testimonial in and of itself. Presentations, clinical abstracts, live surgeries, postgraduate robotic courses, and booth presentations dominated this year's conference. The mass global appeal of da Vinci-based procedures within the specialty of urology is truly material. During the 4-day conference, we registered over 1000 urologists at our booth, representing nearly 40 countries" (Intuitive Surgical, Q2 Quarterly Report, 2009:6).

Independent of whether the increase in experience was clinically justified or not, it was happening; and as it did, hospital executives were forced to make tough decisions. Consider the following blog post from Paul Levy, former President and CEO of Beth Israel Deaconess Medical Center,

> "Notwithstanding the lack of evidence of enhanced clinical efficacy, I have been advised the following by one of our leading doctors: 'Due to market forces beyond any of our control, the unfortunate reality is that without a da Vinci robot, BIDMC prostatectomy volume would likely plummet by 2010 and BIDMC would consequently quickly become a non-entity in regional prostate cancer care. This would have dire consequences for

BIDMC clinical urology, radiology, radiation oncology, medical oncology, as well as for research in translational oncology. It is unlikely that [we can] fully gauge the breadth and depth of collateral damage that absence of a da Vinci robot would bring to our medical center'" (Levy, 2007).

Despite the bantering between robotic proponents and antagonists regarding clinical and financial value, the market forces behind the strategic value of robotic surgery were undisputed. As one physician put it, "I guarantee you that robotic surgery is going to become the standard…all hospitals will have it in the next 10 years because patients want the best, and so hospitals will either have it or lose patients" (Georgia Trend, 2008:1). See Table 31: Customer Value Overall Assessment.

Table 31 Costumer Value Overall Assessment

ROBOTIC SURGERY CUSTOMER VALUE	PERIOD I	PERIOD II
Clinical Value	Moderate	High
Financial Value	Low/Moderate	Moderate/High
Strategic Value	Low/Moderate	High
OVERALL ASSESSMENT	**LOW/MODERATE**	**MODERATE/HIGH**

III.2.3.5 Hospital Value Predicted vs. Hospital Value Assessed.

From 2005-2009 the robotic surgery industry transition from a relatively weak industry structure from the previous period to a strong industry structure. Once again, contrary to the prediction based on industry structure hospital RSP value increased in all facets during this period. This was largely driven by three dominant themes: 1) Holistic increases in clinical value or perceived clinical value, 2) Greatly enhanced financial relational and add-on benefits and 3)

Improved strategic core and relational benefits. Clinically, this period saw the extension of the benefit to robotic prostatectomy becoming the number one surgical treatment for prostate cancer and the extension of those benefits to additional procedures like nephrectomies and hysterectomies. Hospitals' ability to create unique value, specific to robotic surgery, increased during the period as physicians gained more robotic surgery experience. The perception of financial add-on benefits, hospitals ability to create unique financial value through RSP, increased significantly in comparison to the previous period. This perception was apparent in the number of hospitals (over 240) that elected to re-invest in robotic surgery systems during the period. Contrary to prediction, the change in industry structure improved the strategic value of a RSP. As industry barriers and competitiveness increased for the manufacturer, the strategic value for hospitals became more valuable as well. Industry collective messaging in the importance of converting open surgery to MIS provided a strategic core benefit to new and existing RSPs. Traditional surgical techniques were paling in comparison to robotic surgery's ability to create unique value and new market leaders. See Table 32 Period II: Integrated Industry Structure and Customer Value.

Table 32 Period II: Industry Structure and Customer Value

2005-2009	ROBOTIC SURGERY CUSTOMER VALUE (HOSPITAL VIEWPOINT)		
	Clinical	Financial	Strategic
Overall Industry Structure Assessment (Very Strong)	C – Present A – Present R – Present T – Slightly Present	C – Barely Present A – Slightly Present R – Barely Present T – Barely Present	C – Slightly Present A – Slightly Present R – Slightly Present T – Slightly Present

III.3 Period III: The Establishment of Robotic Surgery (2010 -2014)

III.3.1 Period Synopsis

III.3.1.1 Key Events.

The third period saw the establishment of robotic surgery as a permanent offering of modern healthcare. By the end of 2010, hysterectomy replaced prostatectomy as the highest volume robotic procedure performed. This period saw the introduction of key complementary products to enhance the surgeon robotic surgery experience, such as training simulators, advanced imaging, stapling/vessel sealing products, and single-site technology. Until this period, the focus of robotic surgery was converting open surgery to MIS; however, during this period there was an unprecedented increase in robotic usage in non-complex procedures. See Table 33: Procedural Approvals. In the face of advancements, this period was also fraught with national criticism regarding aggressive marketing, FDA warnings, voluntary recalls, lawsuits, and insistent competitive substitutes. The period was mixed with dramatic success, ranging from the largest increase in total system sales from one year to the next (Intuitive Surgical, 2010) to the disappointment exemplified in the first total system decrease in industry sales (Intuitive Surgical, 2013).

Table 33 Procedural Approvals

PROCEDURE	FDA APPROVAL
PERIOD I	
General Laparoscopic	July 2000
Non-cardiac thoracoscopic	March 2001
Prostatectomy	May 2001
Cardiotomy/Mitral valve repair	November 2002
Totally Endoscopic Atrial Septal Defect	January 2003
Cardiac revascularization	July 2004
PERIOD II	
Urologic Surgery Approval	March 2005
Gynecology	April 2005
Pediatric Surgery	June 2005
Transoral Otolaryngolgoy	December 2009
PERIOD III	
Single-Site Laparoscopic Cholecystectomy	December 2011
Single-Site Benign Hysterectomy	February 2013

During this period, TransEnterix entered into the robotic surgery market. Like Titan Medical, the FDA has yet to approve its robotic surgery system. Consequently, there are no competitive robotic systems in the market, maintaining Intuitive Surgical's position as market leader, with its da Vinci System remaining the sole robotic surgery system approved for broad application. During this period laparoscopic substitutes to robotic surgery, primarily manufactured by Ethicon Endo-Surgery and Covidien, Inc, became increasingly competitive.

The buyers for the period remained hospitals, while the suppliers remained largely undisclosed with some exceptions.(Table 34: Industry Participants).

Table 34 Industry Participants

	PERIOD I	PERIOD II	PERIOD III
New Entrants	None	Titan Medical	Titan Medical & TransEnterix
Industry Competitors	Intuitive Surgical and Computer Motion	Intuitive Surgical	Intuitive Surgical
Substitutes	EES and Tyco, etc.	EES and Tyco, etc.	EES and Tyco, etc.
Buyers	Hospitals and Surgeons	Hospitals and Surgeons	Hospitals and Surgeons
Suppliers	Olympus, Panasonic, etc.	EES, Gyrus, etc.	Mimic, etc.

III.3.2 5-Forces

III.3.2.1 Threat of new entrants.

At the beginning of the period economy of scale benefits were clearly present. "The increase in gross margin compared to the prior year reflect increased system ASPs [Average Sales Prices], material cost reductions and absorption of fixed costs over a larger revenue base" (Seeking Alpha, 2010:5). Demand-side benefits of scale continued to be a deterrent as well, with an installation base of over 3,000 systems, average sales pricing of $1.52 million, and cumulative procedural numbers approaching 2 million in this period (Intuitive Surgical, Investor Presentation, Q2 2014 and Intuitive Surgical, Annual Reports, 2010-2013). Government policy may have become more of a deterrent during the period, as the leading manufacturer experienced an FDA investigation (The Advisory Board Company, 2013) and subsequent FDA Warning

Letter (Intuitive Surgical, Annual Report, 2013). The increased regulatory environment on surgical robotics may actually serve as a deterrent for new entrants, due to the increased intrusion and regulatory expense. As in the previous period, research and development costs continued to increase, peaking at $170 million in 2012 (Intuitive Surgical, Annual Report, 2012). Switching costs continued to increase due to resources invested into implementation, operations, inventories, and on-going service obligations. Additionally, by this period, hundreds of hospitals performed over 1,000 robotic procedures (Google Search, 2014). Access to distribution continued to increase significantly as clinical and capital sales increased over 70% from 2009 to 2013 (Intuitive Surgical, Annual Reports, 2009 & 2013). Incumbency advantages independent of size increased dramatically in this period, in comparison to last period, beginning with an increase in patents and patents pending from 840 in 2009 to 1800 by the end of 2010 (Intuitive Surgical, Annual Reports, 2009 & 2010). This intellectual property position advanced to 3,000 U.S. and foreign patents by October 2014 (Intuitive Surgical, Investor Presentation, Q3 2014). Lastly, the ability of the leading manufacturer to retaliate also increased during this period, with cash reserves approaching $3 billion in 2012 (Intuitive Surgical, Annual Report, 2012). Overall, the barriers to entry for new entrants increased during this period. (Table 35: Threat to New Entrants Assessment).

Table 35 Threat to New Entrants Assessment

THREAT OF NEW ENTRANTS CRITERIA	PERIOD I	PERIOD II	PERIOD III
Economies of Scale	Non-Deterrent	Deterrent	Deterrent
Demand-side Benefits of Scale	Non-Deterrent	Deterrent	Deterrent
Government Policy	Non-Deterrent	Non-Deterrent	Deterrent
Capital Requirement	Deterrent	Deterrent	Deterrent
Switching Costs	Non-Deterrent	Deterrent	Deterrent
Access to Distribution	Non-Deterrent	Deterrent	Deterrent
Incumbency Advantages Independent of Size	Non-Deterrent	Deterrent	Deterrent
Expected Retaliation	Non-Deterrent	Deterrent	Deterrent
OVERALL ASSESSMENT	**LOW BARRIERS TO ENTRY**	**HIGH BARRIERS TO ENTRY**	**HIGH BARRIERS TO ENTRY**

III.3.2.2 Industry Rivalry.

Once again there was no industry rivalry during the period, due to the lack of FDA approved systems in the market other than the da Vinci® Surgical Systems. In addition to Titan Medical, Inc., TransEnterix began their development of a surgical robot in 2012 (TransEnterix, 2014). Given the lack of a competitive robotic system in the market, there is no competitive balance in the industry, and industry growth rates continued to climb during the period (Figure 8: Industry Revenue Growth). Despite the high fixed cost, “Lower system production volume resulted in a higher amount of fixed manufacturing costs being expensed…” there was little downward pricing pressure (Intuitive Surgical, Q2 Quarterly Report, 2014:2). Once again, there was no pressure to cut price due to fixed or marginal costs, product differentiation, or the lack of competitive diversity. The strategic stakes for the incumbent remained high, because there was no market for the surgical system outside of healthcare. Overall, the threat of industry rivalry or competitiveness during the period was exceptionally low (See Table 36: Intensity of Rivalry Assessment).

Table 36 Intensity of Rivalry Assessment

INTENSITY OF RIVALRY CRITERIA	PERIOD I	PERIOD II	PERIOD III
Competitive Balance	Equal competitors	Sole competitor	Sole competitor
Industry Growth	Slow sales growth	High Sales Growth	Slowed new customer
Fixed/Marginal Costs	Limited pressure to cut	No pressure to cut	No pressure to cut price
Differentiation	Little differentiation	Sole competitor	Sole competitor
Overcapacity	Not apparent	Not apparent	Not apparent
Competitive Diversity	Signaling clear, but	No signaling	No signaling
Strategic Stakes	High	High	High
Exit Barriers	Moderate	Low	N/A
OVERALL ASSESSMENT	**HIGHLY COMPETITIVE**	**NOT COMPETITIVE**	**NOT COMPETITIVE**

III.3.2.3 Threat from Substitutes.

Robotic manufacturers began with a vision of not only converting open cases to MIS, but converting MIS to robotic surgery as well. This was evident in 2000, when one robotic manufacturer stated, “We believe that our technology has the potential to change surgical procedures in three basic ways…Convert Open Procedures to Intuitive Surgery…Facilitate Difficult MIS Operations…. Simplify Existing, High-Volume MIS Procedures” (Intuitive Surgical, Annual Report, 2002:9). It is interesting how closely these objectives are affiliated with the three periods. From 1999-2004, robotic surgery positioned open surgery as the most competitive substitute. As a result, “It was reported that in 2009 more than 85% of men undergoing RP had robotic surgery” (Makarov, James, Desai, Penson, & Gross, 2011). From

2005-2009, robotic surgery positioned open surgery and difficult MIS operations as the competitive substitute.

In the last period, robotic surgery positioned high volume MIS procedures as the most competitive substitute. This was evident in several ways. First, the only two robotic procedures approved this period by the FDA were single-site laparoscopic cholecystectomy and single-site benign hysterectomy (Intuitive Surgical, Annual Report, 2013).In the U.S. approximately 830,000 cholecystectomies were performed annually, with 90 percent of those completed laparoscopically (Afdhal and Vollmer, 2014). While the CDC reports approximately 600,000 hysterectomies performed each year (Center of Disease and Control, 2014), 41% of hysterectomies were being performed through MIS in 2005 (Intuitive Surgical, Q2 Investor Presentation, 2014). Intuitive Surgical acknowledges this shift in substitute positioning, claiming, "Our less complex segment has increased from approximately 40% to 60% of U.S. procedures between 2011 and 2013" (Intuitive Surgical, Annual Report, 2013:18). This trend has been further promoted in corporate presentations regarding serving two segments beginning in 2014 (Intuitive Surgical, Q1 Investor Presentation, 2014). The clinical benefits of converting open cases to MIS, despite cost increase, are frequently accepted. The clinical benefits of converting complex laparoscopic cases to robotic, despite cost increase are often tolerated. However, the third period trend of converting MIS to robotic cases was met with severe resistance, beginning with the price-performance trade-off.

To review, price-performance trade-off is related to the relative value provide by an alternative. In this case, it is represented by the relative value of laparoscopy for a non-complex procedure in comparison to robotic surgery. Many industry manufacturers, surgeons, and pundits weighed in on the debate. One of the primary manufacturers of laparoscopic surgery instruments, Ethicon Endo-Surgery, funded a study producing an article titled, "Comparing Robot-Assisted with Conventional Laparoscopic Hysterectomy: Impact on Cost and Clinical Outcomes" (Pasic et al., 2010:1). Authored by leading laparoscopic surgeons, the study concluded, "Our findings reveal little clinical differences in perioperative and postoperative events. This, coupled with the increased per-case cost of the robot, suggests that further investigation is warranted when considering this technology for routine laparoscopic hysterectomies" (Pasic et al., 2010:8). Other surgeons, not sponsored by equipment manufacturers, also voiced their opinion regarding the relative value of robotics in comparison to laparoscopy. Consider the following statement by the President of the American Congress of Obstetricians and Gynecologists: "Robotic surgery is not the only or the best minimally invasive approach for hysterectomy. Nor is it the most cost-efficient" (American College of Obstetricians and Gynecologists, 2013:1). Another leading gynecological physician group, the American Association of Gynecologic Laparoscopists (AAGL), added "Robotic-assisted laparoscopic surgery should not replace conventional laparoscopic or vaginal procedures for women who could otherwise undergo conventional laparoscopic or vaginal surgery for benign gynecologic diseases" (Worldwide, AAGL Advancing Minimally Invasive Gynecology 2013:8). With regards to mainstream media outlets, the Wall Street Journal published six articles during the period covering robotic surgery with the following titles:

- "Study Cautions on Robotic Surgery" (Beck, February 2013)
- "Robot's Safety Under Review" (Burton, November 2013)
- "The Pros and Cons of Robotic Surgery" (Pinkerton, November 2013)
- "Robotic Surgery? Benefit Unclear" (Walker, July 2014)
- "Robot Surgery Has Flaws, Study Says" (Beck, October 2014).
- "Robotic Surgery Brings Higher Costs, More Complications, Study Shows" (Beck, 2014)

The competitive position from substitution stakeholders can be best summarized by the statement, “Patients should be advised that robotic hysterectomy is best used for unusual and complex clinical conditions in which improved outcomes over standard minimally invasive approaches have been demonstrated” (American College of Obstetricians and Gynecologists, 2013:2).

The cost of hospitals switching to robotic surgery is equally relevant. Unfortunately, comparing the cost of robotic surgery to substitute surgical techniques is a convoluted endeavor. The industry lacks standardization in clinical cost comparison. Consider this examination of over 20 cost comparisons (See Table 37: Robotic Procedural Cost Comparison), varying by procedure, physician experience, patient comorbidities, patient body habitus, comparing operating room costs, purely instrument costs, total cost of hospital stay, inclusion of fixed costs (such as acquisition cost), etc.

Table 37 Robotic Procedural Cost Comparison

ROBOTIC COST	SUBSTITUTE COST	PROCEDURE	SOURCES
OPEN TO ROBOTICS			
$14,538	$13,894	MVR	Kam, J. K., Cooray, S. D., Kam, J. K., Smith, J. A. and Almeida, A. A. (2010).
$32,144	$31,838	MVR	Suri, R. M., Thompson, J. E., Burkhart, H. M., Huebner, M., Borah, B. J., Li, Z. and Schaff, H. V. (2013).
AU$18,503	AU$17,879	MVR	Seco, M., Cao, C., Modi, P., Bannon, P. G., Wilson, M. K., Vallely, M. P. and Yan, T. D. (2013).
$10,178	$11,370	Sacrocolpopexy	Worldwide, AAGL Advancing Minimally Invasive Gynecology 2013
$6752	$4437	Prostatectomy	Bolenz, C., Gupta, A., Hotze, T., Ho, R., Cadeddu, J. A., Roehrborn, C. G., & Lotan, Y. (2010).
$17,582	$13,605	Prostatectomy	Hall, R. M., Linklater, N., and Coughlin, G. (2013).
$10,804	$9,693	Prostatectomy	Yu, H. Y., Hevelone, N. D., Lipsitz, S. R., Kowalczyk, K. J. and Hu, J. C. (2012).
COMPLEX LAPAROSCOPIC TO ROBOTICS			
$13,894	$11,153	Nephrectomy	Yu, H. Y., Hevelone, N. D., Lipsitz, S. R., Kowalczyk, K. J. and Hu, J. C. (2012).
$56,000	$34,500	Myomectomy	Worldwide, AAGL Advancing Minimally Invasive Gynecology 2013
$30,084	$13,400	Myomectomy	Worldwide, AAGL Advancing Minimally Invasive Gynecology 2013
$2724	$2,295	Sacrocolpopexy	Worldwide, AAGL Advancing Minimally Invasive Gynecology 2013
$8,508	$7353	Sacrocolpopexy	Worldwide, AAGL Advancing Minimally Invasive Gynecology 2013
NON-COMPLEX LAPAROSCOPIC TO ROBOTIC			
$5410	$2861	Hysterectomy	Worldwide, AAGL Advancing Minimally Invasive Gynecology 2013
$2000 >		Hysterectomy	Weissman, J. S., & Zinner, M. (2013).
$3,500>		Hysterectomy	Shukla, P. J., Scherr, D. S., & Milsom, J. W. (2010).
4,066(pounds)	2,150(pounds)	Hysterectomy	Sarlos, D., Kots, L., Stevanovic, N., & Schaer, G. (2010).
$7,426	$4,922	Ovary Removal	(Beck, 2014)
$7,444	$4,133	Cyst Removal	(Beck, 2014)
$2,189>		Hysterectomy	Wright, Ananth, Lewin, Burke, Lu, Neugut & Hershman, (2013).

Interestingly, despite the comparative landscape there were some overarching themes. Generally, robotic surgery procedures cost more than their substitute surgical technique. This statement was less likely in cases where the procedure was a conversion from an open technique to a robotic technique. With the exception of myomectomy, the cost difference between the conversions from complex laparoscopy to robotic was less costly than the conversion from non-complex laparoscopy to robotic. Although this case comparison is limited, it demonstrates that there are many variables to be considered when evaluating switching costs. However, regarding substitutes, the relative value of robotic surgery appears to have decreased as the surgical focus has shifted from open or complex laparoscopic surgery to converting non-complex laparoscopic surgery to robotics. By the end of this period, substitutes present a moderate threat to robotic surgery (See Table 38: Pressure from Substitutes Assessment).

Table 38 Pressure from Substitutes Assessment

PRESSURE FROM SUBSTITUTES CRITERIA	PERIOD I	PERIOD II	PERIOD III
Price-performance Trade-off	Open to MIS comparison	Primarily, open to MIS comparison Limited robotic to MIS comparison	Primarily, robotic to MIS comparison
Buyer's Cost of Switching to Substitute	Switching to robotic surgery is expensive	Switching to substitute after robotic purchase is prohibitive	Switching to robotic surgery is expensive, but switching to substitute after robotic purchase is prohibitive
OVERALL ASSESSMENT	**LOW/MODERATE**	**MODERATE**	**MODERATE/HIGH**

III.3.2.4 Buyer Bargaining Power.

The ability of buyers to negotiate favorable terms decreased during this period. The hospital industry was still largely fragmented, although "hospital mergers and acquisitions increased 10 percent in the first quarter of 2014 compared with the same time frame last year" (Daly, 2014:1). Like the previous period, there was only one robotic surgery unit on the market. Hospitals remained the exclusive purchaser, which, along with the trend in consolidation, benefited hospitals and surgeons. However, backwards integration remained highly unlikely. The switching cost for buyers remained non-existent given the monopolistic robotic manufacturer environment. Buyer margins became increasingly tight given contractions in reimbursement and robotic cost averaging $1980 per procedure, while fluctuating as high as $3200 per procedure (Intuitive Surgical, Investor Presentation, Q3 2014). The service line increased in importance as robotic surgery became a critical component of urology and gynecology surgical offerings. Lastly, hospital access to information to improve ability to negotiate terms remained largely unchanged during the period. As a monopoly, the industry manufacturer could largely influence when and how industry information was disclosed. Overall, buyer bargaining power was very low for hospitals throughout the period (See Table 39: Buyer Bargaining Power Assessment).

Table 39 Buyer Bargaining Power Assessment

BUYER BARGAINING POWER CRITERIA	PERIOD I	PERIOD II	PERIOD III
Buyer Concentration	Disproportionate impact on revenue	Fragmented	Fragmented
Service Differentiation	Zeus or da Vinci	Single Manufacturer	Single Manufacturer
Industry Purchases	Hospitals exclusive purchaser	Hospitals exclusive purchaser	Hospitals exclusive purchaser
Backward Integration	University study programs	Less Likely	Less Likely
Switching Costs	Few; inception of robotics	High	High
Buyer Margins	Low Margins	Low Margins	Low Margins
Service Importance	Not important service line	Important	Important
Full Information	Customers As Informed (Technologist)	Customers Less Informed	Customers Less Informed
OVERALL ASSESSMENT	**HIGH BUYER POWER**	**LOW BUYER POWER**	**LOW BUYER POWER**

III.3.2.5 Supplier Bargaining Power.

As in previous periods, there was limited information disclosed regarding supplier agreements. There was no evidence to suggest that supplier concentration changed during the period. It also appeared that supplier dependency remained unchanged. In 2009 it was reported, "Some of the components necessary for the assembly of ISRG's products are currently provided by sole sourced suppliers or single-sourced suppliers" (Scilley and Sissleman, 2009:7). The narratives regarding suppliers switching cost, differentiation, and substitutes remained largely the same during the period as well. "While ISRG believes that alternative suppliers exist and could be identified for sole-sourced components, the cost of the disruption or termination of the supply of components could cause a significant increase in the costs of these components, which could negatively affect operating results" (Scilley and Sissleman, 2009). One might estimate the *da Vinci*® Surgical System to have thousands of components and possibly hundreds of suppliers.

Consider the impact of supplier power on one key supplier, Mimic Technology, co-developer and supplier of the simulation software used in the da Vinci Skills Simulator (Intuitive Surgical, Website 2014). Currently, there are only a few simulator companies that focus primarily on robotic surgery simulation, like Mimic Technologies and Simulated Surgical Systems. Although the area is concentrated, Intuitive Surgical is currently working with Mimic Technologies but could choose to work with Simulated Surgical Systems or a software developer to create a platform specific to the da Vinci Skills Simulator. The simulator suppliers are more dependent on the leading manufacturer of robotic surgery systems than vice versa. There are switching costs and differences between the simulator systems; but the costs are not exorbitant, and the differences are not extreme. The likelihood of this supplier or others forward integrating into the production of robotic surgery systems is unlikely. In fact, it is more likely that a key supplier may be acquired; consider Luna Innovations (Intuitive Surgical, Q1 Quarterly Report, 2014). Overall, supplier bargaining power during the period remained low/moderate (See Table 40: Supplier Bargaining Power Assessment).

Table 40 Supplier Bargaining Power Assessment

SUPPLIER BARGAINING POWER CRITERIA	PERIOD I	PERIOD II	PERIOD III
Concentration	Very Concentrated	Less Concentrated	Less Concentrated
Dependency	High	Moderate	Low
Switching Costs	High	Moderate	Low
Differentiation	Moderate	Moderate	Moderate
Substitutes	Few	Few	Few
Forward Integration	Possible	Unlikely	Unlikely
OVERALL ASSESSMENT	**HIGH SUPPLIER POWER**	**LOW/MODERATE SUPPLIER POWER**	**LOW/MODERATE SUPPLIER POWER**

III.3.2.6 Overall Industry Structure (5-Forces).

In comparison to the previous period, the industry structure remained largely unchanged. The robotic manufacturer faced a limited threat of new entrants due to high industry barriers to entry. Downward pricing pressures were absent from industry rivals given the monopolistic characteristics of the industry. The bargaining power for hospitals remained anemic, and supplier power remained low to moderate at best. However, the threat of substitution changed given the focus of surgeons, hospitals, and non-robotic manufacturers regarding alternatives to robotic surgery. The threat of substitutes therefore increased in this period from moderate to moderate/high. Overall, the robotic surgery manufacturer's market power for this period was very strong. See Table 41: 5-Forces Overall Assessment.

Table 41 5-Forces Overall Assessment

PORTER 5-FORCES	PERIOD I	PERIOD II	PERIOD III
Threat of New Entrants	Low Barriers to Entry	High Barriers to Entry	High Barriers to Entry
Intensity of Rivalry	Highly Competitive	Not Competitive	Not Competitive
Pressure from Substitutes	Low/Moderate	Moderate	Moderate/High
Buyer Bargaining Power	High	Low	Low
Supplier Bargaining Power	High	Low/Moderate	Low/Moderate
OVERALL ASSESSMENT	**WEAK INDUSTRY STRUCTURE**	**VERY STRONG INDUSTRY STRUCTURE**	**VERY STRONG INDUSTRY STRUCTURE**

III.3.2.7 Predicted Role of Industry Structure on Customer Value.

The maintenance of a very strong industry structure from period II to Period III for robotic surgery manufacturers during this period should result in hospitals experiencing declines of value within their robotic surgery programs. As shown below, the diminished value is realized and consistent with expected behavior from Porter's 5-Forces model.

III.3.3 Customer Value

III.3.3.1 Clinical Value.

By this period, the core benefits of robotic surgery were fairly well accepted. In a September 2011 article titled "Status Of Robotic Assistance—A Less Traumatic And More Accurate Minimally Invasive Surgery," the authors found "The most promising procedures are those in which the robot enables a laparoscopic approach where open surgery is usually required" (Kenngott, Fischer, Nickel, Rom, Rassweiler and Müller-Stich, 2012:1). Still, the acceptance of the core benefits of robotic surgery, in converting open procedures to MIS, was not without dissent. The American Association of Gynecologic Laparoscopists (AAGL) expressed "the lack of direct access to the patient to be a significant disadvantage compared with conventional laparoscopy" (Worldwide, AAGL Advancing Minimally Invasive Gynecology 2013:3). As discussed earlier, the Wall Street Journal published several articles during the period questioning the benefits of robotic surgery, even in comparison to traditional open procedures (Walker, 2014). Nonetheless, with over 7,000 peer review articles and over 1,000 comparative studies in circulation by the end of the period (Intuitive Surgical, Q111 Investor Presentation, 2014), the da Vinci system was found to have moderate and high levels of evidentiary support for its core clinical value proposition (O'Toole, Bouazza-Marouf, Kerr, Gooroochurn, & Vloeberghs, 2010). High is defined as "Randomized controlled clinical trial or systematic review" and moderate is defined as "upgraded observational study or downgraded randomized trial or systematic review" (O'Toole, Bouazza-Marouf, Kerr, Gooroochurn, & Vloeberghs, 2010:301). Although the core benefits were still strong, especially for converting open procedures to MIS, the evidence of value relative to converting non-complex laparoscopic procedures to robotic was less compelling. Overall, the clinical core benefits this period slipped slightly to moderately high.

Equally significant were the unique benefits of robotic surgery. These add-on benefits became more important this period as comparisons between robotic surgery and laparoscopy became more prevalent. This is especially evident when exploring complex MIS. For instance, in the beginning of the period a subsequent study by Payne and others found "Women with large uteri may successfully undergo robotically assisted hysterectomy with low morbidity, low blood loss, and minimal risk of conversion to laparotomy" (Payne, Dauterive, Pitter, Giep H., Giep B., Grogg & Hubert 2010).

The interest in the da Vinci Single-Site™ is another example of add-on benefits. In May 2008, Covidien introduced the Covidien SILS(TM) Procedure Kit to be used in Single-Incision Laparoscopic Surgery and other laparoscopic procedures (Covidien, News Release, 2008). In 2011, the da Vinci Single-Site™ was introduced to enable surgeons to remove the gallbladder or uterus through a small navel incision, often times providing the patient with improved cosmesis (Intuitive Surgical, Single-Site Website, 2014). The focus of this device is converting non-complex procedures performed laparoscopically into robotically assisted procedures. In the summer of 2012 a comparative study between the single-site robotic approach and the single-incision laparoscopic approach for cholecystectomy was released. The study found that the robotic approach was safe, easy to learn, and faster than its laparoscopic counterpart (Spinoglio, Lenti, Maglione, Lucido, Priora, Bianchi & Quarati, 2012). By the end of 2013, over 800 customers had ordered Single-Site™ (Intuitive Surgical, Annual Report, 2013) to pursue the single-site robotic approach. In this period, the patient value equation (Patient Value = Efficacy / Invasiveness) extended beyond the traditional consideration of open and complex MIS procedures to the consideration of exchanging laparoscopic for robotic approaches. Consider the following descriptive statement added to the annual report to describe patient value: "When the patient value of a da Vinci procedure is deemed higher than alternate treatment options, patients may seek out hospitals that offer that specific da Vinci procedure…" (Intuitive Surgical, Annual Report, 2012:23). The word 'deemed' highlights the importance of perceived value, which is at the heart of the contention between the reality of robotics and the positions of alternative minimally invasive advocates. *Deemed* does not equal *clinically proven*. Nonetheless, this period saw the introduction of products and instrumentation to create differentiators between robotic approaches and the laparoscopic contemporaries. These products demonstrated benefits that were unique to the robotic approach, which proved once again to deliver high levels of add-on benefits.

Regarding, long-term relational benefits evident through patient satisfaction, the period was mixed. A study by Dr. Samadi, who has conducted over 5,500 robotic prostatectomies, concluded that 1-year post treatment nearly 90% of his patients are satisfied with their prostate cancer decision (Collingwood, McBride, Leapman, Hobbs, Kwon, Stensland & Samadi, 2014). An alternative study conducted by Dr. Pitter found "that patient experience was better for each of the major minimally invasive approaches than for abdominal hysterectomy. However, robotic-assisted hysterectomy was the only modality that independently predicted greater satisfaction and willingness to recommend and have the same procedure again" (Pitter, Simmonds, Seshadri-Kreaden & Hubert, 2014:1). Conversely, a March 2013 report on robotic surgery discussed the following:

> “However, a CNBC Investigations Inc. review, which included numerous interviews with surgeons, lawyers, ex-employees and patients, and an extensive review of internal documents, multiple studies, lawsuits and depositions of current employees, shows:
>
> - A sharp rise in lawsuits and complaints about injuries, complications and even deaths following da Vinci procedures. At least 10 have been filed over the past two years, most of them in 2012; many more complaints, plaintiffs’ attorneys says, are headed toward mediation.
> - Surgeons can use the robot to operate on patients after several steps, including at least an hour of online training, four hours watching two full-length procedures online, seven hours operating on a pig and as few as two surgeries, overseen by a more seasoned robotic surgeon. The number of supervised cases can vary by hospital.
> - A high-pressure sales culture driven by quarterly "quotas" on surgical procedures has led sales people to lean on surgeons to do more robotic surgeries, according to interviews with former salespeople and internal emails” (Greenberg, 2013:2)

The robotic manufacturer faced a litany of lawsuits during the period, one alleging vaginal cuff dehiscence, an opening of the vagina allowing the intestines to fall out (McDonald v. Intuitive Surgical, Inc., 2014). Another lawsuit, Tiblier v. Intuitive Surgical, Inc. (2014), alleges that the plaintiff suffered a bladder tear due to micro-cracks in the monopolar scissors, which were subsequently recalled (FDA, website, 2014). During the period, Intuitive Surgical or corporate representatives were named defendants in over 60 legal proceedings (Intuitive Surgical Federal Litigation Fillings, 2014). Given the mix of patient satisfaction, legal claims, and recalls, the overall long-term relational clinical benefits were assessed as moderate for the period.

As discussed previously, there were over 7,000 peer reviewed published clinical trials, 523,000 procedures, and 3,100 installed robots by the end of 2014 (Intuitive Surgical, Q3 Investor Presentation, 2014). Robotic surgery became well established in gynecology and urology while growing in other surgical specialties, but utilization rates flattened around 180 cases per robot per year, with year over year improvement utilization flattening between 2012 and 2014. See Figure 9: Mean Utilization Rates. This utilization rate equals about 3.5 cases per robot per week. In multiple publications surgeons discussed performing 1-2 cases per day or 5-10 cases per week (Franasiak, Craven, Mosaly & Gehrig, 2014). Despite the increase in market adoption, operational benefits appeared to stall. Consequently, transactional benefits remained moderate. Overall, there were slight reductions in clinical value in core and relational benefits, resulting in a moderate assessment for the period (See Table 42: Clinical Value Assessment).

Table 42 Clinical Value Assessment

CLINICAL CRITERIA	PERIOD I	PERIOD II	PERIOD III
Core Benefit	Moderately High	High	Moderate/High
Add-on Benefit	Moderately High	High	High
Relational Benefit	Moderate	High	Moderate
Transactional Benefit	Low	Moderate	Moderate
OVERALL ASSESSMENT	**MODERATE**	**HIGH**	**MODERATE**

III.3.3.2 Financial Value.

During the period, there were multiple studies that reflected procedural cost parity or advantages between robotic surgery and traditional open surgery, demonstrating core financial benefits (See Table 43). The core benefits of robotic surgery are best reflected in benefits or perceived benefits in converting open procedures to MIS. These cases saw core financial advantages related to mitral valve repairs (Kam, 2010; Suri et al., 2013; Seco et al., 2013), prostatectomy (Bolenz et al., 2010; Yu et al., 2012; Hall et al., 2013), and sacrocolopexy (Worldwide, AAGL, 2013). The mounting evidence in support of cost equivalency or slight cost increases for converting open cases to robotic cases during the period supported an assessment of moderate core financial benefit.

Unlike core benefits, the add-on financial benefit for robotic cases decreased this period as the proportion of non-complex to complex robotic procedures performed increased. In October 2014, a group of “researchers from Columbia University found that the technology costs significantly more and has a higher rate of complications than regular minimally invasive surgery for removing ovaries and ovarian cysts” (Beck, 2014:1). Central to add-on benefits is the ability to create ‘unique value’; pundits for laparoscopy claim that the advent of robotic surgery for non-complex procedures adds cost but does not add unique financial value, evidenced by increasing revenue. Much of the financial strain of robotic surgery is related to the following corporate statement: “Our less complex segment has increased from approximately 40% of U.S. procedures in 2011 to approximately 60% of U.S. procedures in 2013” (Intuitive Surgical, Q114 Quarterly Reports, 2014:36). Between 2011 and 2013, approximately 648,000 procedures, consisting primarily of benign gynecology and cholecystectomies, were performed. Cases like single-site cholecystectomies do offer unique value, but with diminishing reimbursements, elevated costs (adding $500 - $2500 per case), and mitigated clinical benefits in comparison to their laparoscopic alternatives (Barbash, & Glied, 2010). Overall, the financial add-on benefit slipped to moderate, as procedural trends switched from complex to non-complex.

This shift in robotic procedural mix impacted the financial relational benefits and long-term profitability for RSPs. On the revenue side, complex procedures like oncology and cardiovascular procedures, which have higher reimbursements, have given way to less complex procedures, which reimburse less, leading to less revenue per robotic case performed. Alternatively, robotic costs have continued to rise. The average service cost per system increased from $139,000 per year (Intuitive Surgical, Annual Report, 2009) to $145,000 per year (Intuitive Surgical, Annual Report, 2014). Lastly, the average cost of instruments per case increased from $1,888 per case (Intuitive Surgical, Annual Report, 2009) to $1,980 per case (Intuitive Surgical, Annual Report, 2014). Overall, the recurring cost per robotic system increased from approximately $402,000 in 2009 to $482,000 in 2013. These costs, in conjunction with diminishing reimbursements, decreased the long-term relational benefit of RSPs from high, in the previous period, to moderate.

The short-term, transactional benefits relative to acquisition costs increased during the period as well. The average sale price increased from $1.39 million, at the beginning of the period, to $1.52 million, in 2013 (Intuitive Surgical, Annual Report, 2009 and 2013). Several proponents quoted significantly higher pricing; the Wall Street Journal published a range of "$1.5 million-to-$2.2 million" (Beck, 2013:1). The Journal of Minimally Invasive Surgery reported a range "between $1.6 million and $2.5 million for each unit" (Worldwide, 2013:7) and *Trustee* reported $1.7 to 2.2 million (Montagnolo, 2011). In either case, the acquisition costs have increased over time, resulting in the lowest transactional benefits to date. Overall, the financial value during this period slipped from moderate/high in the previous period to moderate (See Table 43: Financial Value Assessment).

Table 43 Financial Value Assessments

FINANCIAL CRITERIA	PERIOD I	PERIOD II	PERIOD III
Core Benefit	Low/Moderate	Moderate	Moderate
Add-on Benefit	Moderate	High	Moderate
Relational Benefit	Low	High	Moderate
Transactional Benefit	Moderate	Moderate/Low	Low
OVERALL ASSESSMENT	**LOW/MODERATE**	**MODERATE/HIGH**	**MODERATE**

III.3.3.3 Strategic Value.

The core strategic benefit for a RSP is the ability to recruit patients and physicians to the hospital. Evidence suggests that this benefit waned towards the end of the period. In 2013, for the first time, year-over-year procedural growth did not exceed the procedural volume growth of the previous year (See Figure 12: Year Over Year Procedural Growth), which resulted in lower than projected instrument and system sales.

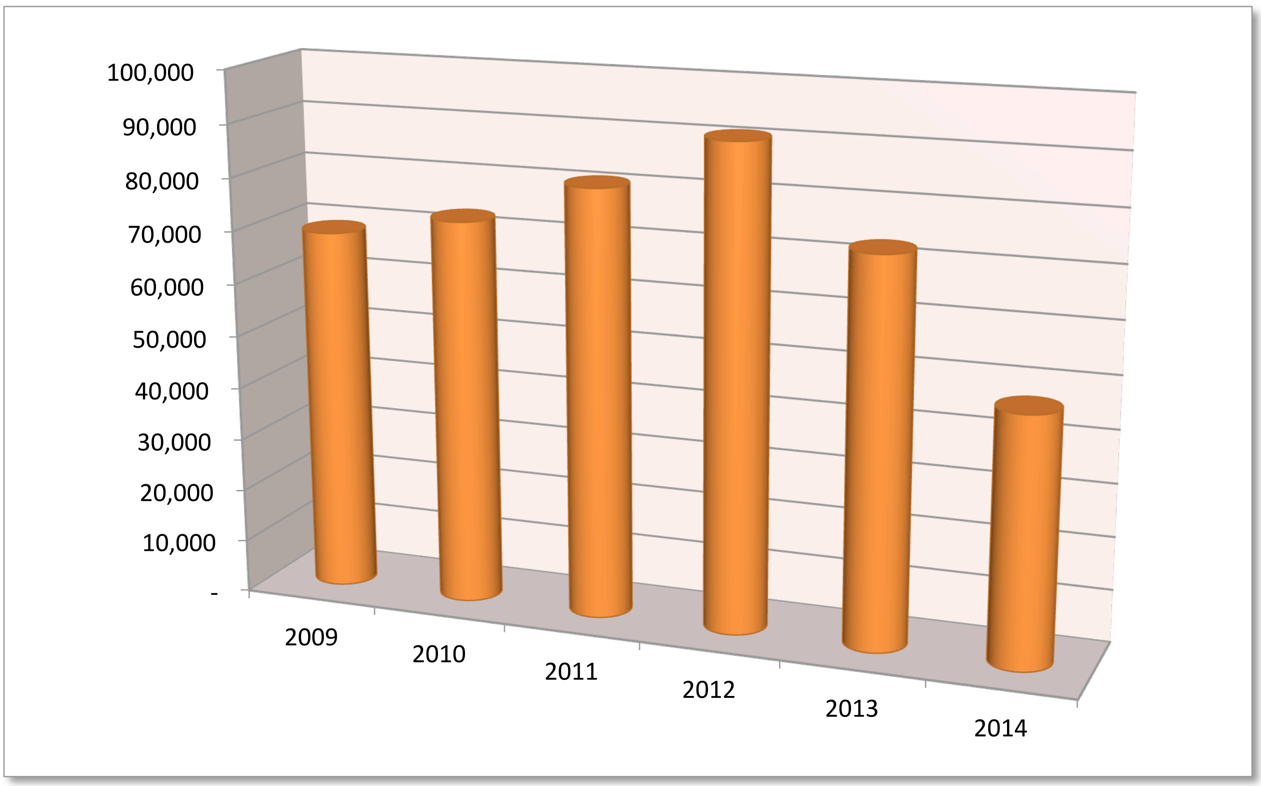

Figure 12 Year over Year Procedural Growth

Poor Q2 results precipitated the poor procedural performance, which was explained by the manufacturer as follows:

> "There appear to be a couple of underlying causes for slower than expected U.S. benign dVH growth… Overall admissions for benign gynecology appear to be under pressure in the first half of 2013. Since we are a significant share of hysterectomy our growth rate in dVH is sensitive to these admissions. Second, our MCS notification and negative press occurred in the quarter, it may have pressured growth in utilization, although estimating their impact on procedure volume is difficult. Given that the average da Vinci system is used for hundreds of procedures per year, a change in da Vinci patient admissions can free capacity on existing systems and pressure new system sales. This appears to be the case this quarter" (Seeking Alpha, Q213 ISRG Earnings Call, 2013:2).

The ability of robotic surgery to recruit new patients was somewhat in question given the poor procedural numbers in 2013. Following the first quarter of 2014, the manufacturer announced, "Gynecology procedures fell slightly year-over-year, driven by a contraction of procedures in the United States" (Seeking Alpha, Q114 ISRG Earnings Call, 2014:2). Physician demand was still strong for da Vinci; however, the shift in the substitution landscape impacted the strategic value of the system. Patients clamored less for robotic options in treating conditions where minimally invasive alternatives were available. As a result, core strategic benefits decreased to moderate for this period.

The strategic add-on benefits continued to increase during the period. This was largely due to emphasis on the role of an 'experienced robotic surgeon.' A 2010 New England Journal of Medicine article suggested, "Surgeons must perform 150 to 250 procedures to become adept in their use" (Barbash and Glied, 2010:1). Regarding robotic assisted laparoscopic prostatectomy, one author suggested, "the learning curve started to plateau after 1000-1500 cases"

(Sooriakumaran, John, Wiklund, Lee, Nilsson & Tewari, 2011:1). The Wall Street Journal reported, “Some surgeons with extensive robotic experience say it takes at least 200 surgeries to become proficient at the da Vinci and reduce the risks of surgical complications. That's difficult for surgeons at smaller hospitals to achieve” (Carreyrou, 2010:5). This focus on experienced surgeons allowed for the fortification of new market positions based upon robotic surgery experience. As new procedures such as single-site cholecystectomy and hysterectomy were approved, hospitals continued to invest deeply in robotics to pursue these positions of market leadership. Consequently, the add-on strategic benefits remained high during this period.

Surgeon satisfaction during this period remained strong from 2010 - 2013, as evidenced by the amount of surgeons performing robotic procedures and implementing new robotic surgery programs. The vast majority of opposition toward robotic surgery cites the expense (McLaughlin, J., 2013). This is important to note, given that the technical value proposition of robotic surgery references enhanced vision, control, and instrument dexterity (Intuitive Surgical, 2002 and Computer Motion, 2002). There is little to no opposition regarding these tenets of robotic surgery; more often than not, critiques reference expense and/or surgeon training (Rabin, 2013). However, one trend that could be indicative of waning physician satisfaction is decreasing procedure growth year over year (See Figure 12: Year Over Year Procedural Growth). In early 2014, robotic hysterectomy volume, the highest volume robotic procedure, reduced dramatically (Seeking Alpha, Q114 ISRG Earning Call, 2014). Overall, surgeons appear to still be optimistic and satisfied by the benefits afforded by a robotic surgery program, leading to continued high but declining relational benefit assessment.

Regarding the transactional benefits of robotic surgery, there were two key publications that came out during the period worth exploring. Both studies examined the marketing value of robotic surgery, which aligns with transactional benefits in the sense that one can market the purchase of the technology immediately. In 2011, the authors examined the websites of 400 U.S. hospitals touting robotic surgery programs. They found 37% presented robotic surgery on their homepage, 73% used stock images, and 86% made statements of clinical superiority regarding robotic surgery (Jin, Ibrahim, Newman, Makarov, Pronovost, & Makary, 2011). The inclusion of robotic surgery in such a prominent way illustrates the strategic transactional benefit of robotic surgery. The second study, conducted in 2014, researched "The Impact of Marketing Language on Patient Preference for Robot-Assisted Surgery" (Dixon, Grant, & Urbach, 2015). The study found that the marketing frame of robotic surgery versus alternative techniques, like laparoscopy, was likely to induce patients to select robotic surgery independent of evidence based-outcomes (Dixon, Grant, & Urbach, 2015). Both studies are suggestive of the high strategic transactional benefits of robotic surgery (See Table 44: Strategic Value Assessment).

Table 44 Strategic Value Assessment

STRATEGIC CRITERIA	PERIOD I	PERIOD II	PERIOD III
Core Benefit	Low	High	Moderate
Add-on Benefit	Moderate	Moderate	High
Relational Benefit	Low	High	High
Transactional Benefit	Moderate	High	High
OVERALL ASSESSMENT	**LOW/MODERATE**	**HIGH**	**HIGH**

III.3.3.4 Overall Customer Value.

This period saw the expansion of robotic surgery to robotic hysterectomy. During the period, robotic hysterectomy eclipsed robotic prostatectomy to become the highest volume robotic procedure and expanded the robotic installation base by almost 1800 units. The success of robotic surgery during this period was largely driven by a return to a 2001 commitment to "Simply Existing, High-Volume MIS Procedures" (Intuitive Surgical, Annual Report, 2001:6). Although this commitment did not resurface in plain text on annual reports during the period, the inclusion of hysterectomy and single site procedures serve as concrete examples of the thematic trend, which dominated the period. This focus on non-complex procedures supported the beneficial elements discussed above, but it also facilitated negative press, competitive reactions from surgical substitution providers and manufacturers, as well as an increase in litigation. The empowering of substitutions diminished the relative value of robotic surgery during the period. As an example, one author described the use of the robotic system to remove a gallbladder as, "A bit like killing a fly with nuclear weapons" (Levy, 2014:1). During the period, the reduction in clinical and financial value was driven by the increased application of robotics for less complex surgical procedures. Although this trend increased procedural volume and system sales, it reduced the overall customer value of robotic surgery program from moderately high to simply moderate (See Table 45: Customer Value Overall Assessment).

Table 45 Costumer Value Overall-Assessment

ROBOTIC SURGERY CUSTOMER VALUE	PERIOD I	PERIOD II	PERIOD III
Clinical Value	Moderate	High	Moderate
Financial Value	Low/Moderate	Moderate/High	Low/Moderate
Strategic Value	Low/Moderate	High	High
OVERALL ASSESSMENT	**LOW/MODERATE**	**MODERATE/HIGH**	**MODERATE**

Hospital Value Predicted vs. Hospital Value Assessed.

From 2010-2014, the robotic surgery industry remained strong. As predicted, the RSP value decreased from Period II to Period III. This diminished value can be attributed to the robotic surgery manufacturer's strategic moves consistent with conventional wisdom relative to an industry leader operating with strong market power. During this period, the manufacturers increased focused on larger procedural markets in order to drive capital and recurring instrument revenue. These procedural markets were largely characterized by less complex procedures, which resulted in relatively lower clinical value in comparison to surgical alternatives to robotics. Financially, this shift in manufacturer direction resulted in lower financial value for hospitals as less complex procedures were typically characterized by lower reimbursement rates. This period, similar to the second period, was characterized by strong industry structure. Interestingly, hospital strategic value remained largely intact during the period. (See Table 46 Period III: Integrated Industry Structure and Customer Value).

Table 46 Industry Structure and Customer Value

2010 - 2014	ROBOTIC SURGERY CUSTOMER VALUE (HOSPITAL VIEWPOINT)		
	Clinical	Financial	Strategic
Overall Industry Structure Assessment (Very Strong)	C – Present A – Present R – Present T – Slightly Present	C – Not Present A – Slightly Present R – Barely Present T – Barely Present	C – Slightly Present A – Slightly Present R – Slightly Present T – Slightly Present

IV IMPLICATIONS OF INDUSTRY STRUCTURE ON CUSTOMER VALUE

IV.1 Discussion

The purpose of this research was to explore how hospitals can apply an integrated understanding of industry structure and customer value to improve a RSP. This qualitative longitudinal industry study was conducted by examining over 200 public sources, including corporate reports, company and industry websites, published clinical studies, analyst evaluations, hospital press releases, mainstream media reports, university studies, and government reports regarding robotic surgery during the period of 1999 through 2014. This exploration was conducted using 5-forces to evaluate industry structure, predicting the role of the industry structure on customer value, using the CFS-CART framework to appraise RSP value, followed by an exploration into the interactions between the industry analysis and customer value specific to the hospital. The research produced four critical findings.

IV.1.1 5-Forces Findings.

The first finding is that in the face of increasing industry structure, identification of favorable forces may create opportunities to preserve and/or increase overall customer value. Porter suggested that the 5-forces model reveals implications regarding industry and firm (Porter, 2008). Regarding the robotic surgery manufacturing industry, I found that the increase in industry structure from Period I to Period II was associated with gross profits of $88 million in 2004 (Intuitive Surgical, Annual Report, 2004), $751 million in 2009 (Intuitive Surgical, Annual Report, 2009), and $1.5 billion in 2013 (Intuitive Surgical, Annual Report, 2013). Porter also proposed that 5-forces “guide managers toward fruitful possibilities for strategic action,” which includes efforts to alter industry structure in a way that favors a firm (Porter, 2008:27). This was evident in Intuitive Surgical’s decision to merge toward the end of Period I, which benefited the manufacturer by reducing industry rivalry and mitigating buyer bargaining power. This effect was further evidenced by the rapid extension of the da Vinci robotic surgery installation base across the second period, from 286 in 2004 to 2,966 in 2013, as well as increased annual R&D spending from $17 million in 2004 to $167 million in 2013, which erected substantial barriers of entry. Over the course of the examined period the industry structure for robotic manufacturers strengthened most dramatically between periods I and II, with a slight decrease in robotic manufacturer market power in period III.

Through this exploration I discovered pressure from substitutes, unlike the broader market forces, increased across all three periods. Consequently, since pressure from substitutes has an inverse relationship with regard to industry structure, pressure from substitutes was the only market force that negatively impacted robotic manufacturer market power (See Figure 13: Industry Structure by Force).

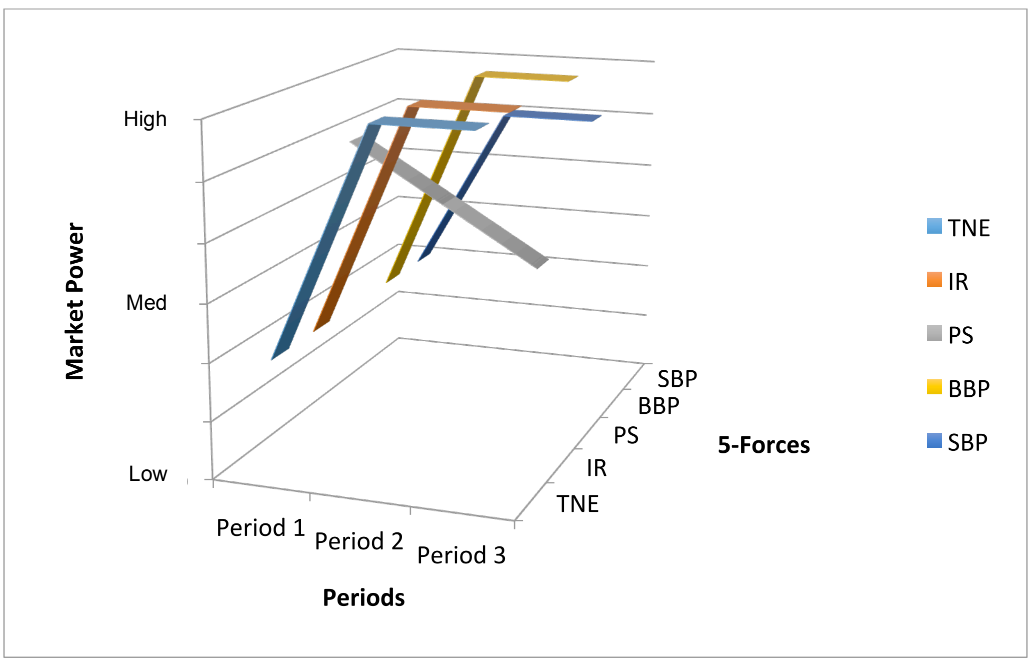

Figure 13 Industry Structure by Forces

The identification of this inverse relationship and increasing market power is essential for hospitals to increase customer value within their RSPs. As defined earlier, substitutions are represented by alternative MIS techniques which offer similar benefits to robotic surgery (i.e. laparoscopy). Throughout the three periods, as procedural applications of robotic usage have become less complex (Intuitive Surgical, Annual Report, 2013:18), the relative values of robotic surgery in comparison to alternative techniques has decreased.

IV.1.1.1 Customer Value Findings.

The second critical finding is that exploring customer value related to RSPs, both through the lens of CART benefits and in the sub-context of CFS values (CFS-CART Framework), aids in the identification of market power influences on customer value. Although the research literature regarding customer value is extensive, research specific to customer value related to capital-intensive medical innovations is sparse. The work of Menon, Homburg and Beutin, combined with the insights of Grönroos, provides the basis of a framework that considers direct benefits in conjunction with indirect benefits. Additional works (Barney, 1991; Magretta, 2013; Mintzberg, H., Ahlstrand B., and Lampel J., 2005; Porter, 1998; Prahalad and Hamel, 1990; and Vandenbosch, 2002) further suggest the importance of the inclusion of 'unique value' in any evaluation of customer value. Beginning in 2000, in an examination of the literature on robotic surgery, language associated with 'clinical' benefits and 'cost' concerns were limited to clinical and financial value. My findings indicate a third value proposition, strategic value, which is drawn from Mintzberg (2005). The inclusion of these constructs enabled the evaluation of customer value based on clinical, financial, and strategic value. This method of valuation enables the formation of collective and individual insights specific to capital-intensive medical innovations.

For instance, the overall customer value of RSPs, based on CART benefits, increased from Period I to II, but subsided from Period II to III (See Figure 14: Customer Value).

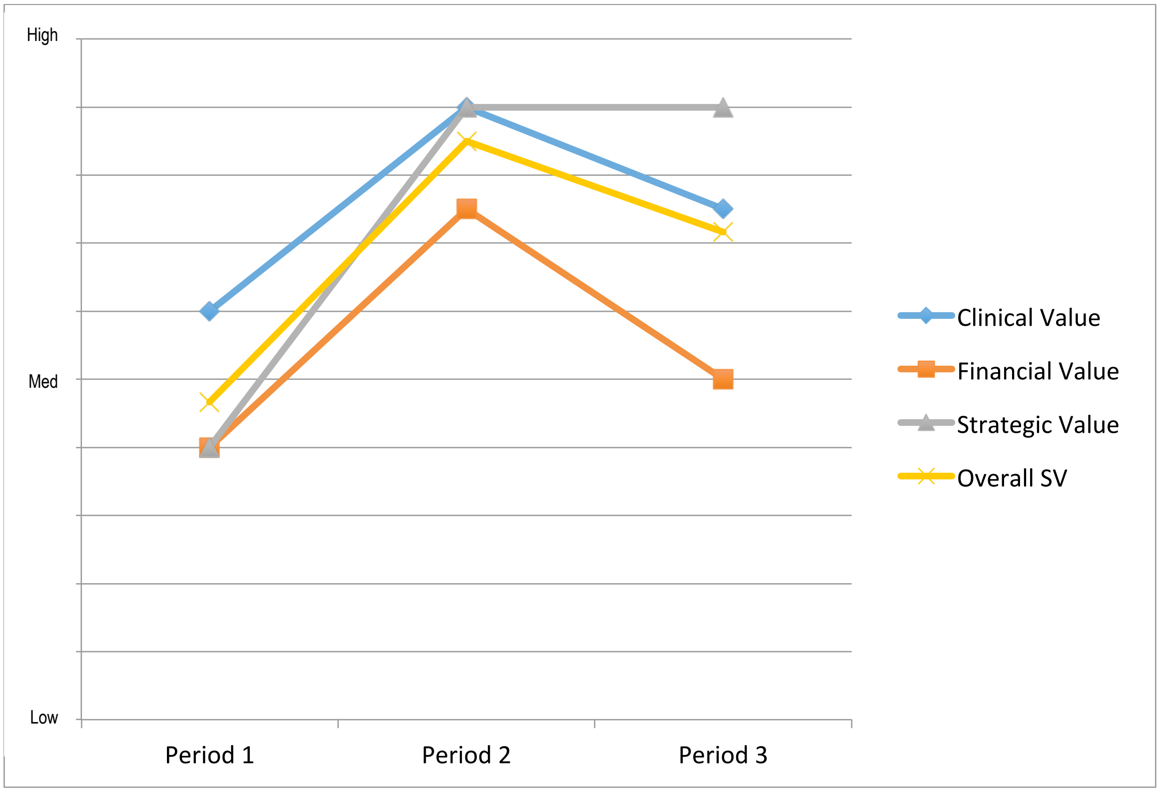

Figure 14 Customer Value

Examining each value separately reveals an elevated assessment of strategic value since 2005. Clinical and financial value both abated, with financial value being the more depressed of the two. These insights are helpful in understanding the further promulgation of robotic surgery, while robotic opponents bemoaned the lack of value of robotic surgery in Period II and III based upon the lack of clinical evidence and higher cost of service delivery (Levy, 2007; Pasic et al., 2010; Beck, 2013; Weissman and Zinner, 2013). Regarding value in health care Michael Porter shared, “Value in health care is the health outcome per dollar of cost expended” (Porter, 2006). Figure 14 demonstrates that Porter’s limited focus on two value components of capital-intensive medical innovations, while neglecting the strategic value which proved to be the most dominant over the past two periods. In a healthcare environment characterized by physician shortages, consolidations, and increased competitiveness, strategic value has become pre-eminent. An assessment of value simply based on clinical and financial attributes, while consistent with calls for comparative effectiveness and value-based medicine, fails to consider the strategic nature of capital-intensive medical innovation investments. As the procedural complexity of robotic surgery programs has decreased, the relative clinical value has diminished, and the relative financial value has dropped sharply.

Examining a matrix view of CFS value uncovers the influence of direct benefits in contrast to indirect benefits on CFS value (See Figure 15: CFS Value Matrix). Consider the implications of the void illustrated below where high levels of indirect benefits are not experienced absent high levels of direct benefits.

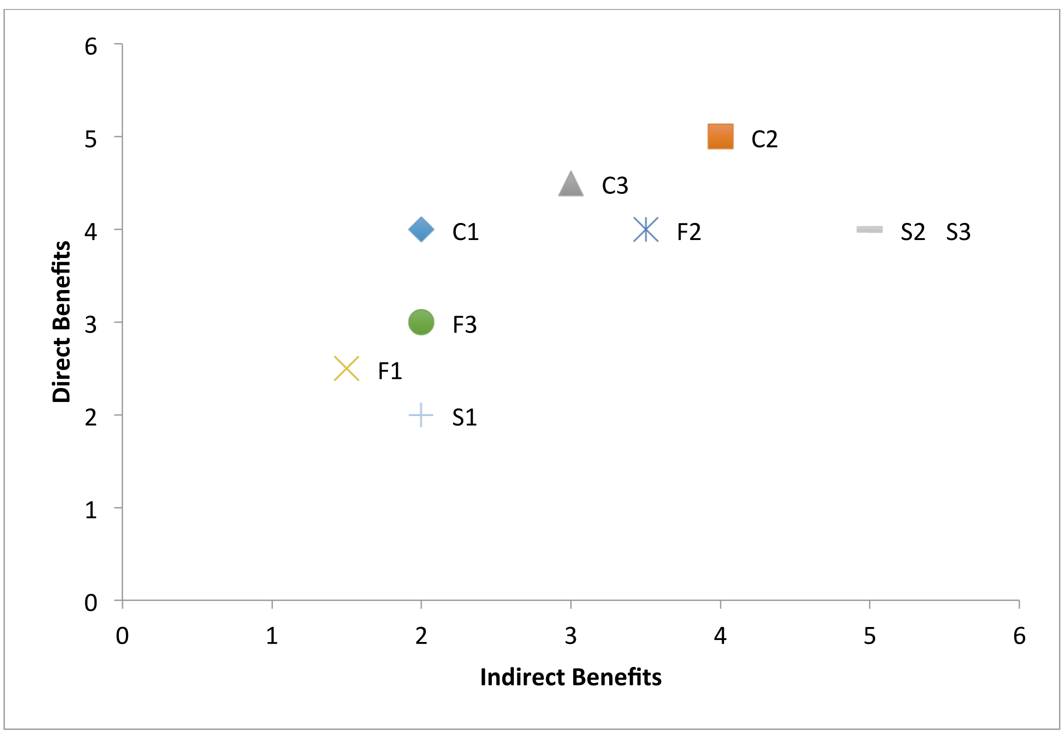

Figure 15 CFS Value Matrix

In the first period, short-term clinical value was unclear and long-term financial and strategic was speculative. Comparatively, Period I strategic value remains in the upper right, while clinical value has fallen off slightly relative to diminishing procedural complexity. Financial value was at its highest when robotic procedural applications were more consistent with converting cases to MIS (Core Clinical Benefits) (Seeking Alpha, Quarter 3, 2008), while surgeons were discovering unique value of robotic surgery in comparison to laparoscopy (Add-on Clinical Benefits) (Payne and Dauterive, 2008). This change in surgical trends contributed to perceived long-term financial benefits (Relational Benefits) (Morgan et al., 2005).

IV.1.1.2 Hospital Value Predicted vs. Hospital Value Assessed Findings.

Another critical finding is the limited predictability of industry structure on hospital RSP value. Many believed that hospitals' unrealized value in RSP was due to manufacturer market power, however during the first two periods industry structure predictive nature was limited. Based on theory relative to competitiveness and profit maximization, first period industry structure would suggests that hospitals could experience disproportionate gains in value during the first period and disproportionate losses in value during the second period. (See Table 47: RSP Value Predicted vs. Value Assessed).

Table 47 Value Predicted vs. Value Assessed

	PERIOD I	PERIOD II	PERIOD III
Industry Structure Assessment	Weak	Strong	Strong
RSP Value Predicted	High	Decreased	Decreased
RSP Value Assessed	Low	Increased	Decreased

The difference between prediction and assessment during the first two periods, in comparison to, the third period could be attributed to characteristic of technology adoption. Proponents of technology adoption suggest that innovators and early adopters are characterized as technology enthusiasts or buyers motivated by "their own intuition and vision" (Moore, 2002:12). Whereas the early majority market is driven by "a strong sense of practicality" (Moore, 2002:13). During the first period, hospitals purchasing robotic surgery units were primarily innovators and the industry was largely unstable. Consequently, the predictive value of industry structure based on innovators and early adopters would not necessarily be the same for later adopters in Period II. Comparatively, the third period suggest that the industry was more mature and stable, and industry structure assessment becomes a better predictor of RSP value.

IV.1.1.3 Integrated Approach Findings

The remaining critical finding is that the degree of market presence of CFS value sub-constructs appears to be uniquely influenced by an integrated view of 5-Forces and CART benefits, leading to clusters of value. Although there is extensive research on industry structure and customer value, there is little research between the two. However, as illustrated in Table 1, there have been several research efforts that have explored industry structure within other frameworks. In one article, Nohria and Garcia-Pont (1991) suggest a theoretical framework to explain the network of strategic linkages in light of a global industry structure. The purpose of my study was to explore and ultimately propose a theoretical construct to understand the integrated role of industry structure and customer value specific to RSPs in order to enhance these programs. The CFS Value Matrix, Figure 15, equipped us with an aggregated view of direct benefits in comparison to indirect benefits. For a view based on individual CART benefits, the assessments were coalesced into a 2x2 matrix (See Table 48: CART Model).

Table 48 CART Model

BENEFITS	RELATIONAL	TRANSACTIONAL
Add-On	A-R	A-T
Core	C-R	C-T

The graphic depiction of each quadrant allowed for additional insights. Consider Figure 16: CART Quadrant Benefits; these models illustrate a clinical and strategic value cluster across all periods and varying degrees of industry structure. The clusters emphasize the long-term or relational benefits of RSPs, with clinical relational slightly higher than strategic relational benefits. The A-R benefits contribute to higher financial value than C-T benefits and represent the tightest clustering of CFS values in comparison to all other quadrants.

Figure 16 CART Quadrant Benefits

Figure 16: CART Quadrant Benefits illustrates longitudinal growth in transactional clinical benefits from Period I to Period III; this can be understood as staff procedural competency, training models (computer simulation), and surgeon experience improved over the research period. This increase in relational clinical benefits occurred despite the increased market power of robotic manufacturers, which suggests that clinical value may increase in value despite diminished market power for hospitals. Once again, the add-on benefits model demonstrated a tighter cluster than its core benefits counterpart. However, the consolidation of benefits is not as tight as the A-R benefits, which reemphasizes the importance of long-term benefits for RSPs. The last major finding is the dramatic decrease in transactional financial benefits between Period I and subsequent periods, which appears to be closely aligned with the change in industry structure.

IV.2 Contributions

IV.2.1 Contribution to Theory on Porter's 5-Forces and Customer Value.

These findings yielded several theoretical contributions to industry analysis in the application of 5-Forces. First, traditionally the 5-Forces model is applied to an industry with the firm or organization in mind. Porter appropriately encourages the contemplation of 5-forces with regard to firms evaluating industry structure for market implications to 1) Position the company, 2) Exploit industry change, 3) Shape industry structure, and/or 4) Define the industry (Porter, 2008). However, Porter's recommendations fall short by not recommending the consideration of 5-forces by industry customers as a means of identifying opportunities to increase customer value. By doing so, I discovered the ability to further facilitate the use of laparoscopy to exceed industry utilization rates (Figure 9), reduce program costs, and improve upon robotic surgery program profitability. This theoretical extension of 5-Forces spreads beyond RSPs to other capital-intensive medical innovations, resulting in broader applications.

Second, 5-Forces is generally applied as a solitary framework "relating a company to its environment" (Porter, 1980:3) or as a tool for evaluating the structural power of an industry (Powell, 1996). Our findings build on the research of Grundy (2006) by utilizing 5-forces to conduct a longitudinal study to explore varying levels of industry strength across a research period and to consider the market implications of such periodic variance. This application contributed to the identification of pressure from substitutes as a means to improve RSP profitability and overall value.

A third theoretical contribution to 5-Forces is the integrated use of 5-Forces in conjunction with a customer value framework to identify market power influences on value. This is an extension of Grundy's (2006) suggestion of interrelating 5-forces with other frameworks to provide operating managers with meaningful insight. In the case of RSPs, the integrated application of 5-Forces and a customer value framework allows practitioners to isolate consistent streams of value, like clinical value, through varying industry structures. It also enables administrators to concentrate cost savings efforts into forces like buyer bargaining power, related to creation of unique value. For example, a high volume surgeon's participation in regulatory approval for a new medical technology may allow for reduced pricing, despite high manufacturer market power. This integrated application contributes to a limited pool of research on 5-Forces and customer value and to an even smaller collection of research specific to RSPs.

IV.2.2 Contributions to Theory on Customer Value.

In accordance with comparative effectiveness research, the preponderance of clinical research on robotic surgery focuses on clinical and financial concerns (Weissman and Zinner,

2013) without a lens for strategy. The research introduced the CFS-CART framework, which enables hospital administrators to evaluate clinical and financial concerns within the same context as strategic considerations. Moreover, this model allows for the evaluation of primary and secondary effects of capital-intensive medical innovations as well as indirect benefits to evaluate long and short-term value implications. The framework facilitates the aggregation and disaggregation of CFS value to explore the longitudinal effects on value. Regarding RSPs, this information allows hospital executives to recognize industry fluctuations in CFS constructs and recognize harmful trends in order to take corrective actions. For instance, the investment in a RSP primarily for financial gain may fall short of expectations. On the other hand, despite mainstream media divergent accounts, the clinical value of robotic surgery exceeded expectations over the course of this study. Such a view may reinforce clinical efforts to sustain robotic surgery as a capital-intensive medical innovation.

In addition, the CFS Value Matrix serves as a complementary framework that illustrates collective direct benefit in comparison to collective relational and add-on benefits. This tool is useful for clinical managers seeking to identify value voids and short/long-term program benefits. In comparison, the CART Model allows hospital administrators to focus their efforts on the quadrant that is most receptive to value pursuits. For example, administrators interested in maximizing clinical value may look to emphasize relational benefits as opposed to transactional ones. In contrast, hospital administrators that are more dependent on quick returns related to RSPs may be better served by pursuing strategic value over clinical or financial.

Lastly, this research contributes to the existing literature dedicated to customer value in capital-intensive medical innovations, and more broadly, to literature specific to the healthcare industry. As previously discussed, there has been little research regarding customer value in relation to robotic surgery or capital-intensive medical innovations. Most research that includes customer value focuses on patients (Seeking Alpha, Q4 ISRG Earning Call, 2008; Collingwood, McBride, Leapman, Hobbs, Kwon, Stensland and Samadi, 2014; Pitter, Simmonds, Seshadri-Kreaden and Hubert, 2014). This research diverged from existing norms by researching value specific to hospitals.

IV.2.3 Contributions to Practice.

This research presents contributions that enable hospitals to better understand RSPs within the context of industry structure, in order to improve the value of their RSPs. For instance, the findings suggest hospital leadership would do well to employ laparoscopy in conjunction with robotic initiatives. Pressure from substitutes was the only diverging market force, as such laparoscopy allows administrators to safeguard the use of robotics for more complex procedures with improved clinical, financial, and strategic value. Secondarily, hospitals would improve value by crafting a deliberate, strategic approach to their program. Throughout the period, RSPs have demonstrated a consistent ability to attract physicians and patients, create new market leadership positions, satisfy surgeons, and improve marketing. Moreover, the continued presence of strategic value, throughout all periods, directly equates to value realization. The findings suggest that hospitals should independently design an objective, customized strategy to incorporate this value.

In addition, hospitals should look to incorporate direct benefits above indirect benefits. Throughout the entire study, moderate to high levels of indirect benefits were not evident without equivalent levels of direct benefits. Moderate to high levels of direct benefits did occur, however, absent moderate indirect benefits. Another practical contribution of the research is the consistency of RSP clinical value, throughout the study, even as the proportion of robotic procedures decreased in complexity during Period III (Intuitive Surgical, Annual Report, 2013). As procedural complexity decreased, so did clinical value; this is not to say, however, that robotic surgery does not offer value in less complex cases. It simply illustrates that perceived and experienced clinical value has always been present or slightly present throughout the study, even with varying industry structures.

The next practical contribution, in contrast, suggests that financial value has been less present, and has grown more elusive, in RSPs. This does not mean that RSPs are without real or perceived financial value; rather, it is an indication that this particular value has become less clear. In practical application, hospitals might include a structure to capture cost to better illuminate financial trends and incorporate methodologies to assuage costs. Additionally, transactional clinical benefits have grown period over period. This is the only benefit that has experienced consistent increase. Hospitals can be encouraged that as program experience grows, clinical benefits increase in presence. Lastly, hospital executives could extend the application of these models to improve the synergy between capital purchases and organizational strategic plans.

IV.3 Conclusion

This research has demonstrated that hospitals can apply an integrated understanding of industry structure and customer value to improve a RSP by:

- Examining 5-forces from the point of view of a customer.
- Identifying favorable forces to preserve and/or increase overall customer value.
- Using the CFS-CART Framework to identify market power influences on customer value.
- Applying an integrated view of 5-Forces and CART benefits to clusters of value.
- Longitudinally applying 5-forces to evaluate value under varying levels of industry structure.

- Studying individual and collective constructs to better understand the underlying influences on overall value.

IV.3.1 Limitations.

While encouraging in its findings and their implications for hospital executives facing difficult decisions relative to robotic surgery programs, this examination was not without limitations. This research was limited by the lack of access to interview industry stakeholders. This qualitative analysis was conducted exclusively using only public data sources. There were scarce public disclosures regarding robotic manufacturers' agreements with their suppliers. The use of interviews could have been beneficial in gaining current perspectives from industry participants, while mitigating potential researcher biases. The data was also less subject to retrospective biases, since the accounts were taken during or shortly after the period examined. The examination and coding of hundreds of public documents allowed for multiple, time sensitive perspectives. Additionally, the inclusion of interviews would not necessarily overcome the limitations related to access of supplier-manufacturer contractual agreements to explore supplier power. Despite its limitations, this exploration offered theoretical and practical applications which may help hospital administrators prepare for the future of robotic surgery and other capital-intensive medical innovations.

IV.3.2 Future Research.

After evaluating the past 15 years of robotic surgery, consider the opportunity to think prospectively. The robotic surgery market is estimated to grow to $20 billion by 2020 (Seeking Alpha, 2015). The current period, 2015 - 2020, will likely include a shifting industry structure that will continue to favor robotic manufacturers. Several new robotic surgery manufacturers may enter the market. The existing manufacturers will have to strategically resolve how to compete against direct competition and persisting substitute surgical techniques. New robots from existing and emergent manufacturers might be released to treat varying levels of procedural complexities. Traditional surgery will likely continue to diminish, but the challenges of the Affordable Care Act and governmental healthcare efforts will influence hospital approaches to capital-intensive medical innovations. Robotic surgery systems will become more prevalent, as the unit of measurement for adoption will shift from hospitals to operating rooms. It will become more incumbent upon hospital executives to design robotic implementation and management plans specific to their organizational needs if they are to be clinically, financially, and strategically successful. Researchers during this period may want to include the following to assist hospitals in the continued improvement of clinical, financial and strategic outcomes:

- The role of leadership development in accessing latent value in RSPs
- The role of governmental policies and regulations on robotic technologies.
- An examination of hospital executive perspectives on the role of supplier power on customer lifetime value.
- The use of training mechanisms to reduce robotic operational costs.

This study represents an empirical analysis of industry structure and customer value in robotic surgery. Some proponents may find the introduction of an integrative model for measuring customer value in robotic surgery applicable to other capital-intensive medical innovations or disruptive technologies at large.

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APPENDIX

APPENDIX 1: INDUSTRY STRUCTURE DEFINITIONS

FORCES AND SUB-FORCES	EXEMPLARS
THREAT OF NEW ENTRY	
Economies of Scale	Production costs, sales volumes, and employee resources
Demand-side Benefits of Scale	Installation base, pricing, procedural volumes, and clinical publications
Government Policy	FDA & Foreign equivalent regulatory statements and information
Capital Requirement	Research and development funding and accumulated debt
Switching Costs	Implementation costs, recurring costs, estimates of customer inventory levels, on-going service obligations, physician learning curve
Access to Distribution	Number of sales and marketing personnel
Incumbency Advantages Independent of Size	Number of patents and procedural experience (by volume)
Expected Retaliation	Cash available and history of legal action
INTENSITY OF RIVALRY: CURRENT COMPETITORS	
Competitive Balance	Revenue, market cap, sales, employee base, and accumulated deficit
Industry Growth	Overall industry growth rate
Fixed/Marginal Costs	Total assets as a measure to evaluate fixed and storage costs.
Differentiation	Product characteristics
Overcapacity	Production levels and evidence of price-cutting
Competitive Diversity	Compared corporate goals, objectives, and strategies t
Strategic Stakes	Corporate statements
Exit Barriers	Estimation of assets, inventories, and accumulated debt
SUBSTITUTIONS	
Price-performance Trade-off	Clinical comparison data
Buyer's Cost of Switching to Substitute	Capital cost, instrument cost, and procedural cost data
BUYER BARGAINING POWER	
Buyer Concentration	Data regarding hospital purchasing groups and the hospital industry
Service Differentiation	Product characteristics
Industry Purchases	Capital cost, procedural cost, and recurring operating cost
Backward Integration	Competitive activity and narrative information
Switching Costs	Instrument and system cost information
Buyer Margins	Hospital industry data and narratives
Service Importance	Clinical data and narrative information
Full Information	Industry disclosure
SUPPLIER BARGAINING POWER	
Concentration	Industry disclosure specific to the robotic surgery manufacturers
Dependency	Industry knowledge specific to the robotic surgery products and the importance of those products based upon product contributions
Switching Costs	Manufacturer statements regarding alternative suppliers
Differentiation	Manufacturer statements regarding customized parts and services
Substitutes	Manufacturer statements regarding supplier alternatives solutions
Forward Integration	Supplier core competencies, demonstrated capabilities, and corporate statements

APPENDIX 2: CUSTOMER VALUE DEFINITIONS

CUSTOMER VALUE	DEFINITIONS	EXAMPLES
CC (Clinical Core Benefits)	Medical benefits or perceived medical benefits of converting open procedures to MIS	Patient benefits of MIS
CA (Clinical Add-on Benefits)	Medical benefits or perceived benefits of creating unique value present	Patient benefits specific to robotics
CR (Clinical Relational benefits)	Medical benefits or perceived long-term or interpersonal benefits between surgeons and patients	Patient Satisfaction
CT (Clinical transactional benefits)	Medical benefits or perceived short-term or operational benefits	Favorable procedural times
FC (Financial Core Benefits)	Financial benefits or perceived benefits of converting open procedures to MIS	Lower treatment costs
FA (Financial Add-on Benefits)	Financial benefits or perceived benefits of creating unique value	Incremental revenue
FR (Financial Relational benefits)	Financial benefits or perceived long-term or interpersonal benefits between program stakeholders	Program profitability
FT (Financial transactional benefits)	Financial benefits or perceived short-term acquisition and/or operational costs	Robotic costs
SC (Strategic Core Benefits)	Strategic benefits or perceived benefits of converting open procedures to MIS	Attracting physicians and patients
SA (Strategic Add-on Benefits)	Strategic benefits or perceived benefits of creating unique value	New market leadership positions
SR (Strategic Relational benefits)	Strategic benefits or perceived long-term or interpersonal benefits	Surgeon satisfaction
ST (Strategic transactional benefits)	Strategic benefits or perceived short-term or operational benefits	Marketing

APPENDIX 3: GLOSSARY

CART – Core, Add-on, Relational, and Transactional

CFS – Clinical, Financial and Strategic

MIS – minimally invasive surgery

RSP – robotic surgery program

FIGURE 17: DA VINCI STANDARD ROBOTIC SYSTEM

(Robotic Surgery, 2008)

Figure 18: Zeus Robotic System (Computer Motion)

(Wikilogia Med, 2012)

(Focosi, 2014)

FIGURE 19: CITATIONS

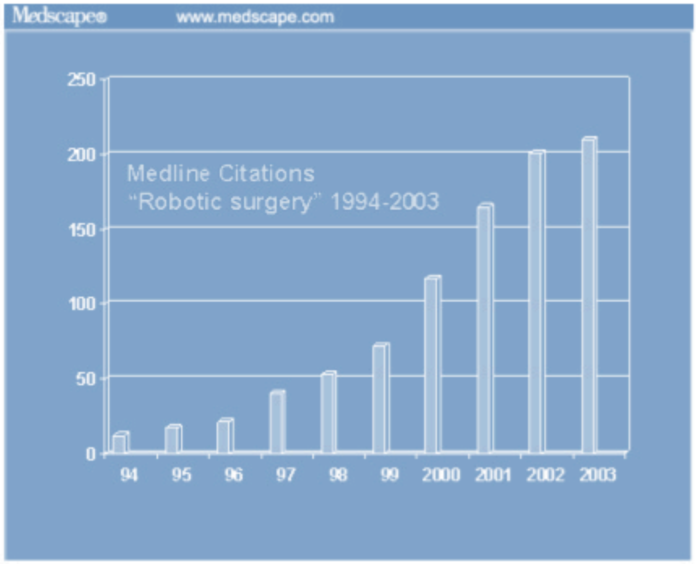
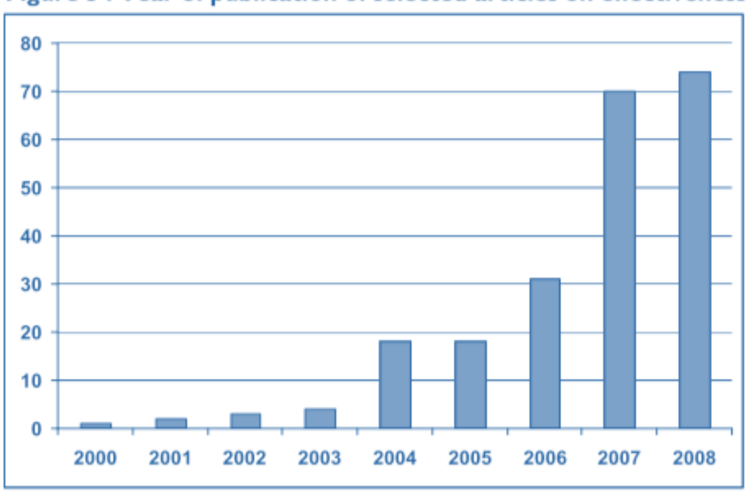


Figure 1. MEDLINE citations retrieved with search term "robotic surgery" from 1994 through 2003.

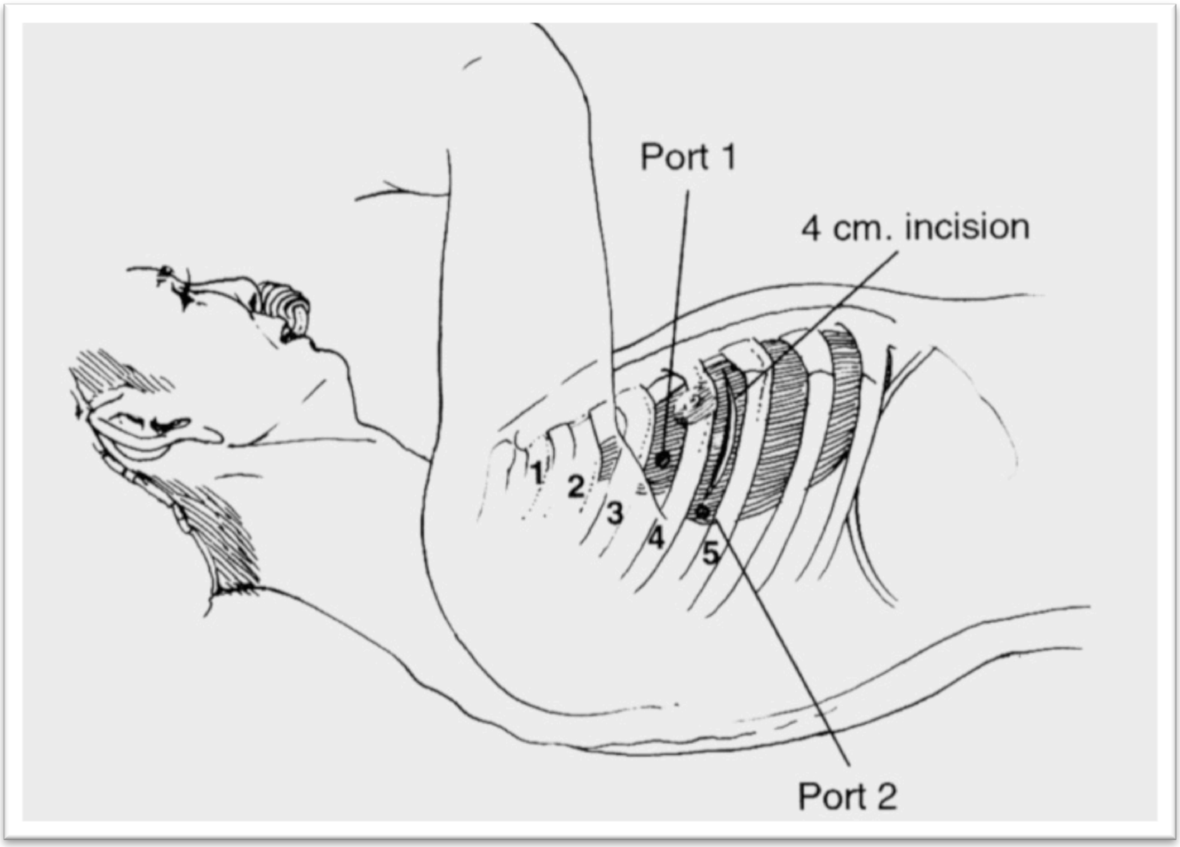
Figure 3 : Year of publication of selected articles on effectiveness and safety



For 2008 this includes publications up to the last literature search performed mid October 2008.

(Belgian Health Knowledge Center, 2009)

FIGURE 20: MITRAL VALVE PORT-SITE ROBOTIC APPROACH



(Chitwood, W. J., Kypson, A. P., and Nifong, L. W. 2003)

FIGURE 21: MARKETING ROBOTIC SURGERY

(HCA Healthcare, 2003)

BIOGRAPHICAL SKETCH

Berkley Baker is the managing partner/CEO of OpX Consulting and a Facilitator for the Center for Leadership Studies. He received his MBA from Emory University. His current research interests include industry structure and the robotic surgery industry.