Study of Triadic Relationships in Purchasing Orthopedic and Cardiac Implantable Medical Devices in the USA

Vafa Saboori Deilami*
Dominican University of California, San Rafael, California, USA

Anand S. Kunnathur
University of Toledo, Toledo, Ohio, USA

ChangSeob Yeo
Dominican University of California, San Rafael, California, USA

Recent legislations mandate hospitals to increase the efficiency of their operations and to reduce the cost of their services while maintaining the quality of care. Purchasing orthopedic and cardiac Implantable Medical Devices (IMDs) are among the top expenses of hospitals. Extant literature shows that the efficiency of hospitals in purchasing IMDs is low and needs significant improvement. However, this body of literature suffers from lack of studies that investigate the factors that lead to this poor performance. This paper reports the findings of an empirical study that looks into the root causes of this problem and proposes resolutions. Drawing on the theory of service triads, and based on the analysis of large scale dataset gathered at the national level in the United States, this paper puts forward several suggestions that serve as a guideline for hospital managers and clinicians who participate in the process of purchasing orthopedic and cardiac IMDs.

* Corresponding Author. E-mail address: vafa.saboori@dominican.edu

I. INTRODUCTION

The United States, in comparison to other developed economies, spends by far the highest percentage of its GDP on healthcare. (The Organisation for Economic Co-operation and Development, 2013). Although many factors contribute to this extravagant expenditure, one of the main causes is the cost of implantable medical devices (IMDs). These are devices that are imbedded in the human body through surgical procedures (ISO, 2016). Reports show a significant and sustained growth for the IMDs market, and the key devices in this market are cardiac and orthopedic IMDs (US Government Accountability Office, 2012; Transparency Market Research, 2013).

A characteristic specific to this market is the influence of physicians on the procurement decision made by hospitals. The preference of physicians for a certain manufacturer usually stems from their longstanding relationship, training, and trust.

Although this relationship is mainly professional in nature, there are some instances that state otherwise (Burns *et al.*, 2009). In 2010, Wall Street Journal reported that orthopedic surgeons in a US hospital received millions of dollars from a well-known IMD vendor. Those physicians were also conducting one of the highest number of surgeries that required IMDs manufactured by the same vendor (Carreyrou and McGinty, 2010).

The relationship between physician and vendor is one of the three relationships in the context of this study. The other two relationships form between hospital and vendor, as well as between hospital and physician. Operations management literature states that a service triad forms when three players, i.e. buyer, service provider, and customer start to interact with each other (van der Valk and van Weele, 2011). Drawing on this line of research this study argues that a service triad emerges with these three parties (hospital, physician, and vendor), and the three links between them. This study explores these three relationships, factors that affect them, how they interact with each other, and what are the antecedents of these three relationships.

The problems of purchasing implantable medical devices, has mainly been addressed from a dyadic point of view in the healthcare management literature (Burns and Muller, 2008; Dobrzykowski et al., 2014). However the extant dyadic perspective is not capable of fully explaining this phenomenon as the relationship between physician and hospital has become by far more complicated with the emergence of third parties who affect this relationship in several ways (Burns et al., 2009). Scholars (Burt, 2009; Simmel, 2010) argue that a third party can influence a dyadic relationship in different ways. The third party can unite the dyadic parties by either serving as their common adversary or their mediator. It can also benefit from the adversarial relationship between the dyadic parties (Burt, 2002). A third party can intensify the differences and negative aspects of the original relationship, or initiate them to gain benefits.

Over the past years many entities played the role of third party to induce and strengthen a divide between the hospital and its medical staff, in particular physicians. To name a few of these entities one can refer to managed care organizations, co-management companies, specialty hospital, ambulatory medical centers, and vendors of medical devices (Burns et al., 2009). Since this study focuses on the triadic relationship between hospital, physician, and vendors of IMDs, in this section we briefly explain the role of vendor as the third party. Cardiac and orthopedic implantable medical devices are traditionally considered physician preference items (PPIs) which are exempt from supply contracts and hospital procurement negotiations (Montgomery and Schneller, 2007; Burns and Muller, 2008). Therefore, vendors of such IMDs have directly dealt with cardiac and orthopedic surgeons. After hospital initiatives to reduce the cost of IMDs by reducing the number of vendors and limiting the maximum price, vendors retaliated by isolating hospitals and physicians through disintermediating the procurement department of hospitals and increasing their tie with the physician through improved medical service, and financial incentives (Burns et al., 2009).

As stated earlier, it is obvious that the dyadic relationship is not sufficient to explain this phenomenon, and in order to analyze this issue, researchers need to utilize theories that address triadic relationships. This study explores these problems from a triadic perspective and based on the results of an empirical study proposes solutions for hospitals to enhance their efficiency in purchasing orthopedic and cardiac implantable medical devices. This paper is

structured in the following way. The next section, briefly discusses the theories that explain the triadic relationships and service triads. Afterwards, this study provides a detailed discussion of the problems that arise in purchasing orthopedic and cardiac implantable medical devices, and drawing on the results of a recent empirical study, this study sets forward propositions that have been tested to be efficient in solving the mentioned problems. In conclusion, this study proposes managerial guidelines and avenues for future research.

II. THEORETICAL BACKGROUND

Study of triads has its roots in balance theory, social network theory, and agency theory (Choi and Wu, 2009). Balance theory (Simmel, 1950) explains the relational behavior of human beings in the social settings. Due to the convincing generalizability of this theory to the organizational setting (Madhavan, Gnyawali and He, 2004), it has been used to explain the relationships within and between organizations (Wuyts et al., 2004). With respect to triads, balance theory states that a triadic relationship should be in a balanced state, otherwise it will fall apart or transform to a triad in a balanced state (Wu, Choi and Rungtusanatham, 2010). Balance theory considers cooperative relationships as positive, and adversarial relationships as negative. A balanced state is a position in which either all three relationships are positive, or the product of the multiplication of the three relationships are positive, e.g. two negative relationships and one positive relationship (Choi and Wu, 2009). At the individual level, a cooperative or positive relationship is simply when two individuals like each other. At the organizational level, a positive relationship is when transactions are based on trust, absence of opportunism, open communication (Wu and Choi, 2005).

Social network theory (Borgatti and Li, 2009) refers to the parties in a service triad as "nodes", and the relationship between them as "ties". Therefore, a service triad is a social network comprised of three nodes and three ties. According to this theory, in any social network, ties are more important than nodes. Ties (relations) are a source of social capital through which nodes (interacting entities) could tap into resources that are not present in the absence of these relationships (Borgatti and Li, 2009; Li and Choi, 2009). Social network theory refers to the lack of relationship between two nodes as a "structural hole" (Burt, 2009). Scholars (Simmel, 1950; Burt, 2009) draw on the notion of "structural hole" to define "tertius gaudens" which is a third node that benefits from the presence of a "structural hole", i.e. absence of relationship between two other nodes. "Tertius gaudens" acts as a "bridge" (Li and Choi, 2009) or a gateway between the two other nodes who either have no relationship with each other or have an adversarial relationship, and enjoys the rents of this brokerage. This "bridge" position weakens as the two other parties, who have otherwise adversarial relationship, start to build a cooperative and positive relationship. This phenomenon is coined as "bridge decay" by operations management scholars (Burt, 2002; Li and Choi, 2009). If "tertius gaudens" does not take any corrective measure after the emergence of the symptoms of the "bridge decay", it will lose the "bridge" position altogether to another node. This situation, which is called "bridge transfer", revokes all the rents that "tertius gaudens" or "bridge" enjoys in the past. However, if the "tertius gaudens" involves itself in the newly built relationship between the two other nodes, it can sustain some of the benefits of the "bridge position". This strategy, which is called "permanent bridge decay" (Li and Choi, 2009) is not economically optimal, but is better than

losing everything to another party. This situation is illustrated in Figure 1.

Agency theory (Eisenhardt, 1989) conceptualizes the service triad through the common agency situation (Bernheim and Whinston, 1986), in which one agent transacts with two principals. First, each of these two agency relationships are prone to the agency problem which refers to misalignment of the goals of principal and agent, and difficulty of monitoring the behavior or performance of agent by principal. Second, in both of these relationships, the risk taking preference could be different between principal and agent. Therefore, agents might take actions that are not necessarily favorable to the principal. Third, since the agent is in a simultaneous relationship with two different principals, according to economic models, it will work in favor of the principal who offers better remunerations. Hence, one agency relationship gains more strength as the other becomes weak.

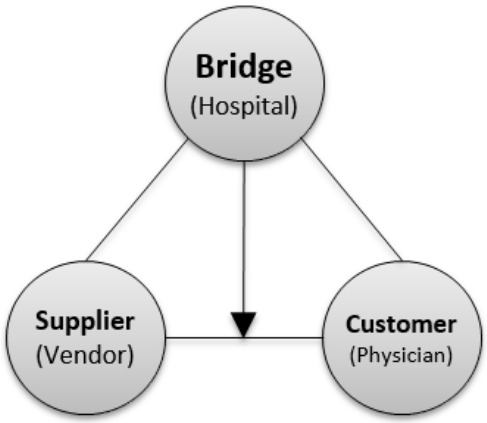

FIGURE 1. PERMANENT BRIDGE DECAY (LI AND CHOI, 2009)

III. CONCEPTUAL MODEL

As part of a broad study, this study proposes a conceptual model to investigate the relationships that emerge in IMD purchasing service triad. This framework also demonstrates the relationship between the mentioned relationships and efforts of hospital in reducing the total cost of ownership of IMDs as well as increasing the quality of them.

Broadly speaking, this model states that the relationship between hospital and physician has a positive effect on hospital's effort to standardize the process of purchasing IMDs and IMD services. This model conceptualizes the relationships between physician and hospital, and physician and vendor as principal-agent relationships. Physician is considered to be agent of hospital, as well as agent of vendor.

This model demonstrates that when the physician acts as the agent of hospital, their relationship positively affects the efforts of hospital in standardizing IMDs and achieving lower costs. On the contrary, this model demonstrates that when physician acts as the agent of vendor, this relationship negatively affects the efforts of hospital in standardizing IMDs and achieving lower costs and higher quality. The conceptual model is illustrated in Figure 2.

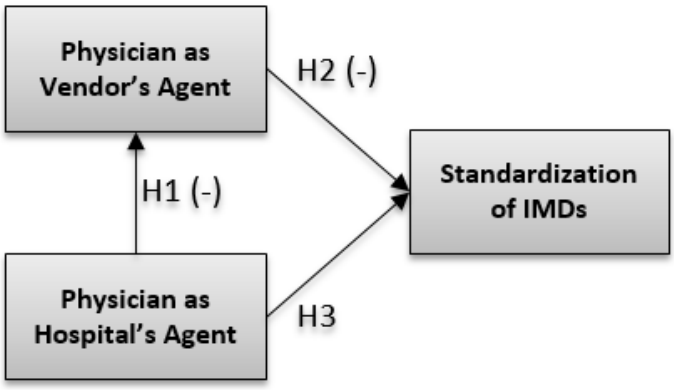

FIGURE 2. CONCEPTUAL MODEL

3.1. Hypothesis Development

When a hospital initiates a transaction with an orthopedic or cardiac IMD vendor, a service triad forms. In this service triad, the ideal position of the hospital, like any other buyer, is the "bridge" (Burt, 2002; Li and Choi, 2009) or "tertius gaudens" (Simmel, 1950) position. However, this condition is highly unlikely to happen, as physician and vendor are already in a strong and longstanding relationship. In other words, at its best, hospital is in a "bridge decay" (Burt, 2002) position, and at its worst hospital can be in a "bridge transfer" (Li and Choi, 2009) position with virtually no control over the purchasing of the IMDs. In this situation the hospital, i.e. buyer, needs to shift the situation into a "permanent bridge decay" condition (Li and Choi, 2009).

In order to do so, the hospital needs to do the following. First, the hospital should get involved in the relationship, i.e. tie (Borgatti and Li, 2009) between the physician (i.e. customer), and the vendor (i.e. service provider) to monitor this relationship and make sure that the service is being rendered in a way that is favorable to its stakeholders. Second, the hospital needs to maintain a close and strong relationship with the physician to encourage the physician to work in the best interest of the hospital (Forgione et al., 2005; Zhang, Lawrence and Anderson, 2014). Third, the hospital needs to sustain a cooperative and positive relationship with the vendor to ensure that vendor does not abuse its market power in manipulating purchasing processes. By doing all these three, the hospital will be in the position of "permanent bridge decay" (Li and Choi, 2009) which protects it from losing all its brokerage benefits.

In order to maintain a positive relationship with either physician or vendor, the hospital needs to use certain cooperation mechanisms (Wu and Choi, 2005; Rossetti and Choi, 2008; Wu, Choi and Rungtusanatham, 2010; van der Valk and van Iwaarden, 2011). Drawing on the literature in this field (Malone and Crowston, 1994; Simatupang, Wright and Sridharan, 2002; Gulati, Lawrence and Puranam, 2005; Gottschalg and Zollo, 2007; Gulati, Wohlgezogen and Zhelyazkov, 2012), this study states that a cooperative, i.e. positive relationship is comprised of two elements of action and incentive.

Drawing on the agency theory (Eisenhardt, 1989; Camerer and Knez, 1996), in a principal agent relationship, e.g. relationship between the physician and hospital, opportunism and self-interest drive

an agent to act in a way that guarantees its own profit rather than enhancing the mutual benefit. Therefore, the principal has to enforce incentive mechanisms (Gulati, Lawrence and Puranam, 2005) to align the goals of the agent with those of the principal. According to scholars (Gottschalg and Zollo, 2007; Gulati, Wohlgezogen and Zhelyazkov, 2012), mechanisms of incentive for cooperation motivate the "members of the organization" to act in the best interest of the organization, and encourages parties to follow the path that leads to the realization of mutual goals. Among others, common ownership of assets, monitoring, contracting, sanctions, and promise of future transactions, are examples of such mechanisms. Although incentives are great mechanisms for cooperation, they do not guarantee a cooperative relationship. Once parties agree to support a decision, they need tools to achieve this goal. These tools are mechanisms of action for cooperation (Malone and Crowston, 1994; Simatupang, Wright and Sridharan, 2002). These mechanisms harmonize actions of interacting parties, share knowledge and information between them, and provide feedback to the involved entities, to ensure that everybody is moving in the right direction to achieve the mutual objectives.

In purchasing orthopedic and cardiac IMDs, both hospitals and vendors try to court with physicians in order to win approval for their preference of IMDs. On the one hand, vendors use cooperation mechanisms to encourage physicians to use their products. On the other hand, hospitals use cooperation mechanisms to persuade physicians to choose the most economic implantable medical device (Burns et al., 2009).

Mechanisms that vendors use to enhance physician cooperation are incentives and actions that motivate physicians to approve and utilize their products. These mechanisms include but are not limited to financial remunerations that physicians receive from vendors in the form of speech honoraria, patent royalties, research grants, high quality training, and technical support. Likewise, the hospital uses certain mechanisms of cooperation to influence on the physician's preference for IMDs that are more economically optimal. These mechanisms are comprised of incentives and actions such as providing physicians with experienced nurses, allocating convenient operating room blocks to physicians, involving them in value analysis teams, and gain sharing programs for physicians (Wilson et al., 2008).

According to agency theory (Eisenhardt, 1989; Tosi, Katz and Gomez-Mejia, 1997) if the reward system of the agent is contingent upon the performance of the agent as evaluated by the principal, the agent's goals are more likely to be aligned with those of the principal.

This study characterizes the relationship between hospital and physician as a principal-agent relationship. As stated earlier, in this role physician acts as the agent of the hospital and is supposed to safeguard the interests of the hospital. This study defines the "Physician as Hospital's Agent" construct as "the extent to which, in the process of vendor selection and evaluation, physician has cost and quality concerns similar to those of hospital physician defends hospital stakes in these negotiations." Items used to build this latent construct are listed in

Appendix 1.

A physician in this service triad also has a principal-agent relationship with vendor. In this role the vendor expects physician to defend vendor's chips in price negotiations. There is a conflict between physician's agency role for vendor and hospital. This study argues that these two roles are conflicting. This study defines "Physician as Vendor's Agent" as "the extent to which, in IMD and IMD services purchasing process, physician promotes vendor." Items used to build this latent construct are listed in

Appendix 1.

Studies that expanded the agency theory (Eisenhardt, 1989) to multiple principals (Bernheim and Whinston, 1986) refer to a situation in which one agent is in relationship with two principals, as "common agency". In such a situation, since agent is expected to increase its benefit, it leans toward the principal that offers better remunerations. The stronger principal-agent relationship negatively affects the weaker principal-agent relationship. When multiple principals interact with a common agent, the richest relationship persists and the other vanishes (Bernheim and Whinston, 1986). Also, according to the balance theory (Simmel, 1950) and studies of triads built on this theory (Choi and Wu, 2009), when customer (physician) is well treated by buyer (hospital), customer (physician) becomes reluctant in its relationship with supplier (vendor). Therefore we hypothesize that:

> ***H1.*** *Agency role of physician for hospital is negatively associated with the agency role of physician for vendor.*

Based on prior studies in the procurement of physician preference items (Montgomery and Schneller, 2007) standardization of IMDs in this study is defined as "the extent to which hospital has standard processes for managing, controlling, and coordinating the purchasing process of orthopedic and cardiac implantable medical devices." Items used to build this latent construct are listed in

Appendix 1.

Several studies (Montgomery and Schneller, 2007; Burns et al., 2009; Streit et al., 2012; Transparency Market Research, 2013) referred to the fact that one of main barriers against standardization strategies of hospitals is the strong relationship between physicians and vendors. In other words, when physicians act as the agent of vendor, they defend the vendor's position and try to convince the hospital to pay higher prices and purchase implants from particular vendors. This situation is in opposition with the standardization strategies. Same studies show that when physicians' goals are aligned with those of the hospital, i.e. the physician acts as the hospital's agent, physicians defend hospital's stakes in purchasing implants. For instance they actively participate in value analysis teams (VAT) to speak on behalf of hospital and help to implement standardization strategies (Streit et al., 2013).

Moreover, according to the "common agency" model (Bernheim and Whinston, 1986) these two agency relationships are expected to work in contrary directions. The principal-agent relationship between physician and vendor has destructive effect on hospital initiatives for standardization, while the principal-agent relationship between physician and hospital has constructive effect on hospital initiatives for standardization. Therefore we hypothesize that:

> ***H2****. Agency role of physician for vendor is negatively associated with IMD standardization.*
>
> ***H3****. Agency role of physician for hospital is positively associated with IMD standardization.*

3.2. Instrument Development

In this study, a valid and reliable measurement instruments is developed for the constructs that have been used in the conceptual model. This process has been done in four distinct steps. These steps are item generation, pre-test and structured interviews, pilot study and Q-sort, and finally large-scale data analysis and instrument validation (Dillman 2000).

In the item generation step, measurement items for all the constructs are developed. This step is done via an extensive literature review. Next step is the pre-test and structured interviews. This is mainly performed to improve the content validity of the items. A systematic interview with academic experts and industry specialists was performed to ensure the desired level of content validity. Next, pilot study and Q-sort is performed to ensure the discriminant validity and convergent validity of the measurement instrument (Moore and Benbasat 1991). Finally, the large-scale data analysis is performed to evaluate the instrument reliability and validity.

Using the above instrument, this study conducted data collection through a large-scale survey. At this stage according to recommendations from clinical and academic experts, more demographic information has been included in the survey instrument to help identify hospitals for future researches. By using the collected data measures of reliability and validity were tested. The data gathered at this stage, were used to further validate the measurement instrument and test the proposed hypotheses.

To increase the response rate, scholars have a number of suggestions. For instance while designing the survey instrument "the questionnaire should have a simple, appealing appearance" (Erdos and Morgan 1970):128. Personalized engagement of researcher, is another technique that has been cited as a mechanism to increase the response rate (Erdos and Morgan 1970; Blankenship et al. 1998). This study uses several of these techniques to increase the response rate. In particular, a

group of research assistants, under supervision of a physician, who was fully aware of the research agenda and data collection procedure, made phone calls with potential respondents to encourage them for participation in this study. Afterwards an email containing the information about the research and a link to the online survey form was sent to each respondent, this also reduces the threat that questionnaire might be answered by someone other than the targeted respondent (Erdos and Morgan 1970). The actual instrument used in this study is included as Appendix 2.

3.3. Data Collection

This research has collected data from two major sources. First list is a contact list of over one thousand hospital operating room directors (ORD). Second list is a contact list of over one thousand chief financial officers (CFO) of hospitals. These two contact lists were acquired from LexisNexis Academic Database, which is a leading global provider of online information in different industries. LexisNexis is part of RELX Group and serves customers in more than 100 countries with more than 15,000 employees worldwide. This database is a reliable academic source that has been used by scholars in different disciplines including healthcare management (Wayne 2012).

Contact lists were purified from any duplicates and unusable data, and then the initial phone calls to invite respondents have been made. Following this step, data collection started. In this step emails were sent to respondents who showed interest in answering the questionnaire. This phase started in mid-December of 2014. Three weeks after the initial wave, reminder phone calls were made to respondents who did not provide any response. Afterwards, the second wave of emails was sent to them. This phase started in mid-January 2015. In total, surveys were sent to 1019 hospital officials. Final number of usable responses was 393, which yields the response rate of 38.57%. 167 of these responses were received from operating room directors, and 226 of them were received from chief financial officers. Summary of response rates is shown in **TABLE 1. RESPONSE RATE SUMMARY**Table 1.

TABLE 1. RESPONSE RATE SUMMARY

Respondents	CFO	ORD	Total
No. of Surveys Sent	633	386	1019
No. of usable responses	216	177	393
Response Rate	34.12%	45.85%	38.57%

In the sample acquired from the large scale survey (n=393), 54.96% of usable responses received from Chief Financial Officers of the hospital and 45.04% of usable responses were received from Operating Room Directors. Among respondents 226 (57.51%) of responses are about cardiac operating rooms and procedures, and 167 (42.49%) of responses are about orthopedic operating rooms and procedures. Questionnaires have been sent to all 50 states in The United States. Hospitals from 48 states participated in this survey. No responses were received from hospitals in Alaska and Delaware. As stated earlier, name, state, and zip code of respondent's affiliated hospitals are recorded. Summary of the sample characteristics is shown in Table 2.

TABLE 2. SAMPLE CHARACHTRISTICS (N=393)

Characteristics		Respondents
Hospital Ownership		
	For Profit	82 (20.87%)
	Not For Profit	242 (61.58%)
	public	69 (17.56%)
Teaching Status		
	Teaching	153 (38.93%)
	Non-Teaching	240 (61.07%)
Size		
	Small (<50)	92 (23.41%)
	Small to Medium (50-99)	50 (12.72%)
	Medium (100-199)	77 (19.59%)
	Medium to Large (200-400)	93 (23.66%)
	Large (>400)	81 (20.61%)
Location		
	Rural	99 (25.19%)
	Urban	294 (74.81%)
**Hospitals from 48 states participated in this survey*		

Non–response bias test (Armstrong and Overton, 1977; Malhotra and Grover, 1998) is conducted by utilizing a chi-square test (Meyer and Collier 2001). Authors kept a record of hospital executives who declined to answer. Therefore a list of respondents and non-respondents is available. These lists were matched with information from American Hospital Association to retrieve characteristics of respondents and non-respondents. Chi-Square and T-test has been conducted to evaluate the non-response bias. The results of these tests are shown in Table 3.

According to the results of Chi-Square and T-test for Non-response Bias, the difference between respondents and non-respondents is not significant for size (number of beds), ownership (For Profit, Not For Profit, Public), location (Urban, Rural), and teaching status (Teaching, Non-Teaching) of the hospitals.

TABLE 3- NON-RESPONSE BIAS TEST

Variable	T-Value	DF	P-value
Size (Number of Beds)	1.012	694	0.31
Variable	Pearson $\chi 2$	DF	P-value
Teaching Status	0.457	2	0.796
Ownership (For Prof, Not For Prof, Public)	1.83	4	0.772
Location (Urban, Rural)	5.497	1	0.064

All constructs in this study are built using the reflective model approach (Jarvis et al. 2003; Tabachnick and Fidell 2007). In the reflective model, the direction of causality (association) is from construct to item (Jarvis et al. 2003). This means that any change in the construct conceptualization, will impact the measurement items, however dropping measurement items does not impact the conceptual definition of the construct (Petter et al. 2007). Therefore measurement items are supposed to be correlated, and for the same reason measurement errors are taken into account at the items level (Jarvis et al. 2003).

In order to further validate the instrument, this study performs exploratory factor analysis (Hair et al. 2006). In this step, factor selection is performed for each construct. Extraction is based on Eigenvalues greater than one. Eigenvalues are a special set of values connected with a linear system of equations. These values sometimes are called characteristic roots, characteristic values, proper values, or latent roots (Hair et al. 2006). In order to obtain simple and interpretable factors, Varimax rotation method with Kaiser Normalization is used in the factor analysis. Rotation is a method used to further analyze the initial exploratory factor analysis to make the pattern of loading clearer (Hair et al. 2006). In this phase, items that have factor loadings less than the acceptable threshold of 0.5 (Hair et al. 2006) have been dropped. After dropping the items with low loadings, based on the exploratory factor analysis, this study conducts a confirmatory factor analysis to test the validity and reliability of constructs and in general the measurement model. In this phase factor loading coefficient or λ, average variance extracted or AVE, along with indices of model fit are calculated.

The estimated loadings of all items on the latent constructs are significant at the $P<0.01$ level. The square roots of AVE values of all constructs are fairly close to, or above the 0.70 threshold. This indicates a very good convergent validity of the overall model. Indices of fit provide strong support for model fit. These indices are shown in Table 4.

TABLE 4. MODEL FIT INDICES

Model Fit Indices	
RMR=0.0412	GFI = 0.822
NFI = 0.898	CFI = 0.989
AGFI = 0.812	RMSEA = 0.046

In order to test for discriminant validity, statisticians propose the method of comparing the square root of AVE for each construct to the correlation coefficients between that construct and all other constructs. If the square root of AVE is greater than the correlation coefficients, this shows proof for discriminant validity (Chin 1998). This study compares the square root of AVE values with correlation values for each construct to test for discriminate validity. All of the AVE root values are higher than the relevant correlation values. Therefore, the discriminant validity of the overall

measurement model is considered to be established. For details please see Table 5.

TABLE 5. CORRELATION MATRIX WITH AVE ROOT VALUES

	PVA	PHA	STD
PVA	0.76		
PHA	-0.64	0.72	
STD	-0.6	0.56	0.63

3.4. Structural Model Analysis and Results

This study utilizes the measurement model that includes all reflective constructs. As stated earlier, factor analytic models deal with how the observed variables are related to their underlying latent variables. They basically are concerned with the regression path from factor to the observed variable. Since these models are focused on the relationship between latent factors and their observed items, they are called measurement model. This study has covered the measurement model analysis and results in the previous chapter (Byrne 2013b).

Combining a measurement model with a structural model gives the researcher a model called "full latent variable model". This model can deal with the regression between the latent variables. Therefore such a model is the right device for testing the hypothesized relationships among latent factors. In other words, a structural model along with a measurement model could represent the relationships between latent construct and their observed factors, as well as the relationship between the latent variables. A complete latent variable model that represents causal associations in only one direction is also called a "recursive model" (Byrne 2013b). The model developed in this study is a recursive model. Structural equation modeling analysis performed on the structural model using EQS software (Byrne 2013b). The values of path coefficients for each hypothesized relationship and their significance level, along with the model fit indices are shown in Table 6.

TABLE 6. RESULTS OF THE STRUCTURAL MODEL ANALYSIS

Hypothesized Relationship	Standardized Coefficient (β)	t-Value	Std. Error	Sig.	Support	Model Fit Indices	
PHA-PVA (Neg.)	-0.476	-10.58	0.045	<.001	Strong	RMR = 0.010	NFI = 0.982
PVA-STD (Neg.)	-0.654	-17.68	0.037	<.001	Strong	GFI = 0.838	CFI = 0.953

PHA-STD	0.356	10.17	0.035	<.001	Strong	AGFI = 0.825	RMSEA = 0.033

Harmon's single factor approach is used to evaluate the level of common method variance (CMV) (Podsakoff et al. 2003). In this method only one factor is extracted from all the survey items via exploratory or confirmatory factor analysis. If the total explained variance is less than 25%, one can argue that CMV is not an issue in this research (Podsakoff et al. 2003). In order to perform Harmon's single factor test, one factor has been created and all items were forced to load on this factor. According to the results this general factor only accounts for 3.024% of the total variance which is well below the threshold of 0.25 (Podsakoff et al. 2003).

This study also controls the results for the responses that have received from different groups of respondents. In order to perform this test, this study controls if the results will show any difference when responses from cardiac versus orthopedic group are used. Likewise, this study controls if there is any difference in the results when responses of the operating room directors are used versus when the responses from chief financial officers. The results of the control tests show that all path loadings remain significant, and all hypotheses are supported with the same directions. In other words, these tests show that the analysis of the proposed relationships yield the same results when controlled for the different groups of respondents.

IV. DISCUSSION

H1 is strongly supported, and the path coefficient is statistically significant (β= -0.476, t-value=-10.58, p<.001). In other words, results of this study show that for a physician, higher levels of agency for hospital are associated with lower levels of agency for vendor. This is a very important result in the context of the triadic relationship between hospital, physician, and vendor. First, it highlights the centrality of physicians in purchasing decisions about IMDS (Egol et al., 2014). Traditionally, the profession of medicine has been characterized with autonomy, accountability, self-regulation, and not being subject of evaluation by others (Freidson, 1988). This traditional view has been revised and scholars (Light and Aasland, 2003) suggest that as the external bodies have access to information about physicians' practice, the autonomy of physicians is superseded by their accountability. However, in many cases, physicians still have the final call. For instance, scholars point out that in the case of physician preference items, although hospitals try to become more exact in monitoring and influencing the process of procurement, the physician still have a good influence on hospitals decisions (Schneller and Wilson, 2009). These results also show that a dual agency issue (Adams, 2014) exist in the service triad studied by this research. Dual agency, also called dual loyalty or mixed agency, in medicine (Carr, 2004) arises when a physician acts as the agent of two principals. In this study these two principals are hospital and vendor. In short, this is a moral challenge that physicians face in situations that involve competing and conflicting interests. Specifically, when physician plays a higher role as the agent of hospital in purchasing of IMDs, he/she is more inclined toward defending the hospital stakes than those of vendor. Although physician has the opportunity to build a dual agency relationship with both vendor and

hospital, with increase in one role, the other will decrease.

H2 is strongly supported, and the path coefficient is statistically significant (β= -0.654, t-value= -17.68, p<.001). When physician plays a higher agency role for vendors, they have a close cooperative relationship with vendor and therefore they are more familiar with the state of the art technology of IMDs, the dynamics of the industry, and future trends in the market. Therefore there will be a great information asymmetry between physician and hospital. This puts physician in a superior position in making procurement decisions. Physician, as agent of vendor, holds the upper hand, and could hinder the efforts of hospital in implementing standardization strategies. It is well worth mentioning that the relationship between physician and vendor has not been thoroughly studied (Schneller and Wilson, 2009). Therefore it is possible that the role of vendors and their representatives is inaccurately valued in the conceptual works in the literature and anecdotal works (Pope, 2002). In other words, trust, sharing information, training, and reliability that characterize a cooperative relationship between physician and vendor, which in turn leads to physician agency for vendor, in fact works as a double edge sword. Although it may increase the quality of care, it also has a negative effect on hospital procurement strategies for physician preference items (PPI). Scholars (Schneller and Wilson 2009) argue that in certain strategies for purchasing PPIs, supplier (vendor) and their representative are an integral part of the decision making body. Therefore hospitals should screen the relationship of vendor with physician, as it has detrimental effects on hospital initiatives to make more efficient decisions.

H3 is strongly supported by the results of statistical analysis (β=0.356, t-value=4.322, p<.001). These statistical results confirm the proposition of this study. This study hypothesize that there is a positive association between the agency role of physician for hospital and the standardization of the process of purchasing IMDs. This empirically proves the conceptual arguments of prior studies (Burns et al. 2009; Montgomery and Schneller 2007; Transparency Market Research 2013; Streit et al. 2012) that posit when physician's goals are aligned with hospital, i.e. physician acts as agent of hospital, they protect hospital chips and will be the voice of hospital in negotiations for purchasing IMDs.

4.1. Implications for Managers and Clinicians

Hospital executives, e.g. procurement managers, are the first group of administrators who can benefit from the findings of this study. They can use the findings of this study to develop strategies to manage the triadic relationship between hospital, physician, and vendors of cardiac and orthopedic IMDs. Hospital executives can benefit from strategies that this study proposes, to control the relationship between the vendor and physician in order to sustain the intermediary "bridge" position of the hospital in purchasing IMDs. They can also use the results of this study in order to secure a strong and positive relationship with the orthopedic and cardiac physicians which, according to the suggestions of this study, is associated with standardization strategies. Moreover, hospital executives can benefit from the findings of this study to carefully vet the standardization strategies that they are intended to implement or have implemented to ensure the success of these strategies in purchasing orthopedic and cardiac IMDs.

Clinicians are the second group that could benefit from the results of this study. The term "clinicians" here includes orthopedic and cardiac surgeons, as well as

other physicians and medical practitioners who in any way are involved in procedures that deal with orthopedic or cardiac IMDs. Since this research sheds light on the nature of different relationships between hospital, physician, and vendor, it helps clinicians to evaluate the significance of their decisions with regard to the cardiac and orthopedic IMDs. Clinicians are deemed to undervalue the effects of their preference on the performance of the hospital (Streit et al., 2012). Extant studies show that when clinicians have a clear picture of the consequences of their preferences, they would be a great source of support for hospital initiatives to reduce the cost and increase the quality of cardiac and orthopedic IMDs (Burns et al., 2009; Streit et al., 2012). Findings of this study enables clinicians to appreciate how their preference for certain device or vendor would affect the performance of the hospital, which in turn will hurt their benefits. This knowledge will help them to cooperate with the hospital, and use their medical expertise in order to better implement standardization strategies and help hospital procurement executives to make optimal and informed decisions in purchasing cardiac and implantable medical devices.

Finally, manufacturers and vendors of cardiac and orthopedic IMDs can also benefit from the findings of this study. Results of this study reveal that the conventional method of doing business in this field is becoming obsolete. Buyers, e.g. hospitals, and their payers, e.g. Centers for Medicare and Medicaid services are more vigilant about their relationships with physicians (Sismondo, 2013). Hospitals cannot afford the inefficient expenditures on the cardiac and IMDs, and decide to put more emphasis on monitoring physicians and cooperating with them through mechanisms listed in this study. Furthermore, as the current trends show, physicians are becoming employees of hospitals and healthcare systems, instead of being private practitioners (O'Malley, Bond and Berenson, 2011). Therefore they tend to be have rather more cooperative relationships with hospitals. Government mandates (Wilson, 2014) put manufacturers under pressure to reveal their financial relationships with physicians. These are reasons that explain why vendors who have a good relationship with physician do not necessarily have a guaranteed buyer for their devices. Moreover, as the results of this study show, the above mentioned trends contribute to the success of implementation of standardization strategies in purchasing orthopedic and cardiac IMDs. Hence, vendors are required to either abide by the lower prices dictated by hospitals or face removal from the confirmed vendor list (Montgomery and Schneller, 2007; Wilson et al., 2008). Vendors need to rethink their sales strategies and shift towards building a cooperative relationship with hospitals.

4.2. Limitations and Future Research

The data were gathered for this empirical research, which form the basis for the identified results, through a large scale single respondent survey. Such data by nature cannot explain the relationships that it shows between variables (Kerlinger and Lee, 2000). Furthermore, since the data is gathered from one respondent in each hospital, it limits this study from providing accurate justification of the dynamics at a triadic level (Venkatraman and Grant, 1986). This opens an avenue of future research. Since all the hospitals in this research are identified, gathering data from all three nodes of a given triad for each hospital is possible. Another limitation of the research that this study is based on, is the fact that data gathering happened in a short period of time. In other words, one can state that this research uses cross sectional data. This opens another avenue for future research: namely,

collecting data about the cause and consequence variables at different times and then run the statistical analysis to test for the longitudinal effect of the antecedents on the final consequence, i.e. hospital performance. Another limitation of this study is its reliance on primary data. This is also a great opportunity for future research. Especially since the hospitals in this research are identified, and as there are great resources for secondary data available about hospitals, it is feasible to collect secondary data about them, match them with primary data from this research or future researches, and then perform the statistical analysis.

V. CONCLUSION

This paper reports the findings of an empirical study that inspects the service triad that forms between hospital, physician, and vendor when hospitals start the process of purchasing cardiac and orthopedic implantable medical devices. Drawing on the results of the mentioned research, this paper explains the dynamics of such a service triad and could be used by hospital executives, clinicians, and manufacturers of cardiac and orthopedic IMDs.

In particular this study shows that both hospitals and vendors of IMDs are in a competition to shift the preference of physicians towards the IMDs that are more favorable to them. In order to do so, hospitals and vendors of cardiac and orthopedic IMDs use mechanisms that are proven to be effective in influencing the final decisions of physicians in adopting IMDs. Moreover, this paper proposes that hospitals that build a strong relationship with physicians, are more likely to gain better prices through standardization. The reason behind this fact is that such strong relationship reduces the propensity of the physicians to have a relationship with a vendor, and increases the tendency of physicians to build a cooperative relationship with the hospital. After a detailed discussion on standardization of cardiac and orthopedic IMDs, this paper proposes that a positive relationship between hospital and physician increases the rate of success for implementation of standardization strategies for IMDs. Likewise, this study posits that the cooperative relationship between vendor and physician will reduce the success rate of such standardization efforts.

This paper draws on the results on an empirical study that has been performed on data gathered from hospitals all across the United States. This paper is among the first works that is focused on the triadic relationship between practitioners, i.e. hospital executives, clinicians, and cardiac and orthopedic IMD manufacturers. Recommendations of this paper are valuable for hospital executives as they can implement the cooperation and monitoring mechanisms to achieve higher performance through standardization of cardiac and orthopedic IMDs. Clinicians benefit from the propositions of this study as it will make it clear for them that their preferences have a significant impact on the performance of the hospital, and eventually their own benefit. Finally, manufacturers of cardiac and orthopedic IMDs benefit from the propositions of this study. Recommendations of this paper show that a new trend has started in the healthcare industry which puts great emphasis on efficiency. Hospitals are trying new methods to reduce cost of IMDs, and more physicians are becoming hospital employees. These facts and findings, all show to the manufacturers of IMDs that their conventional method of building a cooperative relationship with physician and trying to circumvent the hospital in selling IMDs is becoming harder and will eventually will become impossible.

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Appendix 1. Measurement Items for Latent Constructs

Measurement Items for Construct: Physician as Vendor's Agent

- Physicians advocate products and services that vendor provides.
- Physicians have longstanding tenure with the vendor that they promote.
- Physicians force hospital to purchase IMDs at prices dictated by vendor.
- Physicians speak on behalf of vendor in purchasing process.
- Physicians threaten hospital to take their business elsewhere if hospital purchases IMDs and IMD services from another vendor.
- Physicians rather drop their hospital privilege than abiding by hospital's decision to purchase IMDs and IMD services from another vendor.
- Physician has significant leverage in trying to influence hospital decisions over which vendor to use.
- Physician's professional identity and interest overlaps with that of vendor.

Measurement Items for Construct: Physician as Hospital's Agent

- Physician's professional identity and interest overlaps with that of hospital.
- In value analysis meetings, physicians use their professional knowledge to help hospital.
- Physicians share their professional experience with hospital in regards to IMDs and IMD procedures.
- Physicians have harmonious objectives with hospital in balancing the cost and quality of IMDs and IMD services.
- Physicians trust hospital in decisions about balancing the cost and quality of IMDs and IMD services.
- Physician approve of hospital"s efforts to cut costs of implantable medical devices and their related services.
- Physicians believe to be in the same boat with hospital, and they both are being paid less for implant surgery.
- Physicians follow deliberations by value analysis team (VAT) of the hospital to make decision to use a given product or work with a given vendor.
- Physicians accept decisions of materials managers or O.R. managers to use a given IMD or work with a given vendor.

Measurement Items for Construct: Standardization of IMDs

- Hospital manages, controls, and coordinates the process of purchasing IMDs through negotiation with vendor and physician.
- Hospital restricts the number of approved vendors from which the cardiac IMDs are purchased.
- Hospital restricts the number of approved vendors from which the orthopedic IMDs are purchased.
- Hospital is restricts the price paid for particular types of cardiac IMDs.
- Hospital restricts the price paid for particular types of orthopedic IMDs.

Appendix 2. Instrument

Purpose: You are invited to participate in the research project entitled, Hospital Purchasing for Cardiac and Orthopedic Implantable Medical Devices. The purpose of this study is explore the mechanisms that hospital could use to efficiently purchase implantable medical devices. You will be asked to complete a questionnaire in which you will answer questions about purchasing implantable medical devices in your hospital. Your participation will take about 15 minutes.

Potential Risks: There are minimal risks to participation in this study, including loss of confidentiality. Answering this survey does not cause any risk to you.

Potential Benefits: The only direct benefit to you if you participate in this research may be that you will learn about how business researches are run and may learn more about purchasing implantable medical devices. Others may benefit by learning about the results of this research.

Confidentiality: The researchers will make every effort to prevent anyone who is not on the research team from knowing that you provided this information, or what that information is. The data generated through this survey will be kept anonymous (without any information that could identify the respondents). Although we will make every effort to protect your confidentiality, there is a low risk that this might be breached.

Voluntary Participation: Your refusal to participate in this study will involve no penalty or loss of benefits to which you are otherwise entitled. In addition, you may discontinue participation at any time without any penalty or loss of benefits.

By clicking on to the next page and beginning the survey, you are stating that you have read and accept the information above and are giving your consent to participate in this research. You are also confirming that you are 18 years old or over.

Instructions

Respondent: "Director of the Operating Rooms" and/or "Chief Financial Officer"

This survey will take about 15 minutes of your time

Please identify a critical orthopedic and a cardiac implantable medical device (IMD) that you are familiar with. A critical IMD may reflect any of the following features:

- The largest cost component of the surgery,
- The most medically important device in the surgery,
- The purchased IMD on which you spend most of your time
- The most difficult IMD to obtain, volatile price, the longest lead-time, etc.

Of the available suppliers for this critical IMD, identify one who is the primary supplier of these IMDs. Of the available physicians who perform procedures using these IMDs, identify two who are most important to the hospital (one for each specialty). This survey focuses on identifying factors that characterize the relationship between you (hospital), your physician, and your vendor. Please respond to all statements and questions in reference to your vendor and physician. Following statements are about relationships, and dynamics among you (hospital), (a) your physician, and (b) your vendor.

Thank you again for participating in this survey.

General Question

A) What is your position in hospital?

- Operating Room Director
- Chief Financial Officer
- Other:

B) Hospital Name:

C) Hospital Zip Code:

D) Hospital State:

C) Which OR (Cardiac or Orthopedic) procedures are you considering while responding to this survey?

- Cardiac
- Orthopedic
- Both

Please answer all questions on the following scale, unless instructed otherwise.

- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

Physician as Vendor's Agent

Q-1. Physicians advocate products and services that vendor provides.
Q-2. Physicians have longstanding tenure with the vendor that they promote.
Q-3. Physicians force hospital to purchase IMDs at prices dictated by vendor.
Q-4. Physicians speak on behalf of vendor in purchasing process.
Q-5. Physicians threaten hospital to take their business elsewhere if hospital purchases IMDs and IMD services from another vendor.
Q-6. Physicians rather drop their hospital privilege than abiding by hospital's decision to purchase IMDs and IMD services from another vendor.
Q-7. Physician has significant leverage in trying to influence hospital decisions over which vendor to use. (Dropped after EFA)
Q-8. Physician's professional identity and interest overlaps with that of vendor. (Dropped after EFA)

Physician as Hospital's Agent

Q-9. Physician's professional identity and interest overlaps with that of hospital.
Q-10. In value analysis meetings, physicians use their professional knowledge to help hospital.
Q-11. Physicians share their professional experience with hospital in regards to IMDs and IMD procedures.
Q-12. Physicians have harmonious objectives with hospital in balancing the cost and quality of IMDs and IMD services.
Q-13. Physicians trust hospital in decisions about balancing the cost and quality of IMDs and IMD services.
Q-14. Physician approve of hospital's efforts to cut costs of implantable medical devices and their related services.
Q-15. Physicians believe to be in the same boat with hospital, and they both are being paid less for implant surgery.
Q-16. Physicians follow deliberations by value analysis team (VAT) of the hospital to make decision to use a given product or work with a given vendor. (Dropped after EFA)
Q-17. Physicians accept decisions of materials managers or O.R. managers to use a given IMD or work with a given vendor. (Dropped after EFA)

Standardization of IMDs

Q-18. Hospital actively controls the process of purchasing IMDs through negotiation with vendor and physician.
Q-19. Hospital restricts the number of approved vendors from which the cardiac IMDs are purchased.
Q-20. Hospital restricts the number of approved vendors from which the orthopedic IMDs are purchased.
Q-21. Hospital is restricts the price paid for particular types of cardiac IMDs.
Q-22. Hospital restricts the price paid for particular types of orthopedic IMDs.

Hospital Size

Q-23. Hospital Size is

- Small
- Medium
- Large

Hospital Type

Q-24. This hospital's type is

- For Profit
- Not for Profit
- Public
- Teaching Public
- Teaching Not for Profit

Hospital Location

Q-25. Hospital is located in a ---------- area.

- Rural
- Urban

Statistical Control Questions

The following questions are used for purposes of statistical control only. These questions are very important in statistically validating this research. Your answers will not be released under any circumstances.

Q-26. On many occasions, I gave up doing something because I thought it is out of my ability.
Q-27. There have been very few times when I felt like rebelling against people in authority even though I knew they were right.
Q-28. No matter whom I'm talking to, I'm always a good listener.
Q-29. I don't find it particularly difficult to get along with loud mouthed, obnoxious people.
Q-30. I have never deliberately said something that hurt someone's feelings.
Q-31. I usually admit to my mistakes.

Thank you very much for participating in this research.