Implant vendors and hospitals: Competing influences over product choice by orthopedic surgeons

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Background: Vendors of hip and knee implants court orthopedic surgeons to adopt their products. Hospitals, which have to pay for these products, now court the same surgeons to help reduce the number of vendors and contain implant costs.
Purposes: This study measures the surgeon's perceived alignment of interests with both vendors and hospitals and gauges surgeons' exposure and receptivity to hospital cost-containment efforts.
Methodology/Approach: We surveyed all practicing orthopedists performing 12 or more implant procedures annually in Pennsylvania. The survey identified the surgeon's preferred vendor, tenure with that vendor, use of the vendor during residency training, receipt of financial payments from the vendor, alignment of interests with both vendor and hospital stakeholders, and exposure and receptivity to hospital cost-containment efforts.
Findings: Surgeons have long-standing relationships with implant vendors, but only a small proportion receive financial payments. Surgeons align most closely with the vendor's sales representative and least closely with the hospital's purchasing manager. Paradoxically, surgeons support hospital efforts to limit the number of vendors but report that their own choice of vendor is not constrained. The major drivers of surgeons' alignment and stance toward cost containment are their tenure with and receipt of financial payments from the vendor.
Practice Implications: Hospitals face a competitive disadvantage in capturing the attention of orthopedists, compared with implant vendors. The vendors' advantage stems from historical, financial, and service benefits offered to surgeons. Hospital executives now seek to offer comparable benefits to surgeons.

United States expenditures on medical devices comprised $80 billion in 2007 and constitute one of the fastest growing components of hospital costs. Orthopedic implants represent a substantial proportion of these device expenditures and are expected to rise 9.8% annually to $23 billion by 2012

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(Freedonia Group, 2008). Demand for hip and knee implants, the largest sector of orthopedic devices, is expected to grow rapidly because of an aging population and increasingly active lifestyles, which expand the number of persons having injured and deteriorating joints.

A major contributing factor in rising device expenditures is implant prices, which have risen steadily since the 1990s (Advisory Board, 2004). By contrast, Medicare reimbursements to hospitals and orthopedic surgeons for implant procedures have not kept pace. The profitability of orthopedics as a hospital service line has consequently declined, prompting hospitals and their materials managers to court orthopedic surgeons to participate in several cost-containment initiatives: standardize implant choice using a smaller number of vendors and thereby negotiate lower implant prices (formulary model), persuade vendors to agree to price ceilings (payment cap model), and engage physicians in gain-sharing programs (collaboration model; Montgomery & Schneller, 2007; Ventola, 2008). Standing in the way of these hospital efforts are long-standing relationships that vendors have with orthopedists and their ongoing effort to get orthopedists to adopt newer generations of products. More recent vendor efforts involving financial payments have raised serious concerns over conflicts of interest and incurred federal fines (Department of Justice, 2007).

Orthopedists are thus caught in a tug-of-war between vendors and hospitals for their loyalty. Like other triadic relationships (e.g., love triangles), this situation is quite unstable. The situation is obviously more complex than this, involving additional stakeholders such as patients aroused by direct-to-consumer (DTC) advertising, hospital-based value analysis teams (VATs) and new-technology committees (NTCs) which review products, and the Centers for Medicare and Medicaid Services which is planning a new demonstration program ("Acute Care Episode") to pay hospitals and their orthopedic surgeons one bundled payment for implant procedures.

The technological innovation and sales goals of vendors are in direct conflict with the cost-containment goals of the hospital. Given the historically close ties between the vendors and their sales representatives on the one hand and the orthopedic surgeons on the other, as well as the sizeable financial resources at their disposal, vendors are theorized to have the edge in this contest. Conversely, hospital efforts to develop collaborative models with surgical specialists are more recent and less well developed (Scott, 1982). This article tests this general hypothesis using recent survey data collected from orthopedic surgeons in Pennsylvania. This article addresses two research questions: (1) To what degree do orthopedists report that their interests align with implant vendors and their sales representatives compared with their alignment with hospitals and their materials managers? (2a) Do orthopedists experience hospital constraints on their choice of implants or influences over their decision making? (2b) If so, do orthopedists favorably evaluate these hospital efforts to reduce their choice of vendors, influence their choice of implants, and engage them in cost containment? Answers to these questions suggest which suitor has the advantage.

We first develop a theoretical model for the triadic relationships described earlier. We next review the limited literature on physician choice of medical devices (e.g., orthopedic implants) and hospital efforts to constrain this choice. Such medical devices are referred to as *physician preference items* (PPIs) due to strong vendor and technology preferences among clinicians and the weight played by these preferences in hospital-purchasing decisions (Montgomery & Schneller, 2007). This literature suggests the hypotheses to be tested here. We next describe the data used to test these hypotheses, the survey from which they are taken, and the methods used to analyze them. The following section presents the univariate and multivariate results. We discuss the findings and their implications in the final section.

Vendors Versus Hospitals in Courting Physicians

The Triadic Relationship Between Hospitals, Physicians, and Vendors

Triadic relationships have long been studied in the sociological literature (Burt, 1992; Simmel, 1902). Simmel (1902) argued that a third party affects an existing dyadic relationship by playing one of three roles: (1) The new party can serve to unify the original dyadic parties by acting as an arbitrator or a common enemy; (2) the new party can derive some personal advantage from conflict between the original dyadic parties; and (3) the third party can exploit differences and/or instigate conflict between the original dyadic parties to serve its own purposes.

Hospital–Physician relationships have been studied for several decades (see Burns & Muller, 2008, for a recent review). Such dyadic exchanges have become more complicated in the 1990s and 2000s with the emergence of several third parties (Burns, Nash, & Wholey, 2007). Managed care organizations (MCOs) played the first role and served as the common enemy that united hospitals and physicians to form integrated delivery networks. With the demise of closed-panel MCO networks and the rise of consumerism in the late 1990s, patients played the second role as a third party that passively caused division between hospitals and physicians by virtue of being courted by both for their

ambulatory care business. Physician-practice management companies (PPMCs), single-specialty hospitals, ambulatory surgery centers, and medical-device vendors played the third role by actively dividing hospitals from their medical staffs and enticing them away using financial incentives.

Vendors, for example, have traditionally sold medical devices directly to specialists as PPIs that were exempt from bulk supply contracts negotiated by group-purchasing organizations (GPOs; Burns & Lee, 2008; Montgomery & Schneller, 2007). By the 2000s, however, hospitals recognized their rapidly growing spending on PPIs and attempted to control it by reducing the number of vendors their physicians used in exchange for lower prices. In response to this threat, device vendors sought to divide hospitals and physicians by deliberately bypassing materials managers and developing even closer relationships with physicians (e.g., through increased service offered by sales representatives and financial incentives).

Strength of Vendor Preference

Two academic field investigations documented the centrality of physicians in this triad and their dominance in decisions regarding medical devices (cf. DeGraaff & Pauly, 2002; Schneller & Smeltzer, 2006). These findings were replicated in Wall Street and vendor surveys of clinicians which demonstrated that surgeon preferences heavily outweigh those of materials managers, operating room (OR) nurse managers, and hospital administrators (Harris Interactive, 2003; Nudell, 2006). Although materials managers represent the face of hospital efforts to constrain choice of vendor, both academic and industry studies find that materials managers satisfy the surgeons' requests in part because of physician opposition to constrained choice (Burns & Lee, 2008; Nudell, 2006). Materials managers also have less education and clinical expertise compared with those of surgeons regarding medical devices and thus typically defer to (rather than challenge) surgeons' judgment and preferences. It is only in recent years that some materials managers have sought to persuade orthopedists to switch vendors. The short history of such attempts contrasts sharply with the longer association between orthopedists and the vendors they utilize.

Industry studies suggest that physicians not only dominate the decision making, but also their product decisions are typically not driven by cost (Hsu & Wise, 2004; Nudell, 2006). Research documents the important role of the sales representatives and their service levels for driving adoption of heart devices (e.g., implantable cardioverter defibrillators) by interventional cardiologists (Kruger, 2005). Industry sources likewise reported that the top drivers of orthopedists' choices of their current implant are product technology and service considerations rather than cost, value to the hospital, or patient requests (Scannell & Bedell, 2008a, 2008c). Further complicating this picture is the fact that DTC advertising is becoming an increasingly common tactic employed by implant vendors. Nevertheless, surgeons believe that DTC advertising has exerted a negative impact on their patient relationships and may consequently resist its influence (Bozic et al., 2007; Kruger, 2005).

Furthermore, orthopedic surgeons seem to protect their decision-making prerogatives and, thus, "do not take a relaxed view" of hospital efforts to constrain their choice of implants (Scannell & Bedell, 2008c). According to these analysts, the Number 1 barrier to cost control is surgeons' unwillingness to have any constraints imposed on their decision making. Other barriers include price-increasing technological improvements and surgeons' threats to move their patients to another hospital if pressured or constrained (Miksic, Reicin, Yik, & Roman, 2005). Although surgeons do form long-standing relationships with their hospitals, they are not employees of the hospital, have operating privileges at multiple hospitals, are more likely than are nonsurgical specialists to divide their admissions over multiple hospitals (divided loyalty), and express greater dissatisfaction with the hospital (Burns & Muller, 2008). The hospital, as well as its materials manager, may thus be at a competitive disadvantage relative to the vendors.

Complicating this picture is the fact that surgeons' preferences for given vendors and/or their products are long-standing, extending as far back as the surgeon's residency training. The market shares for the six major vendors of orthopedic implants have been quite stable ("sticky") over time. Industry experts suggest that surgeons change their preferences very slowly; indeed, they stick with their vendor and sales representative for 5 to 15 years (Miksic et al., 2005; Scannell & Bedell, 2008b).

Orthopedists are reluctant to switch vendors due to both efficiency and safety reasons (e.g., speed and proficiency in using a familiar technology platform). This explains surgeons' loyalty toward their vendor's technology and the sales representatives who train them on this technology in the OR. Surgeons may also be less likely to switch vendors from whom they receive financial payments (e.g., for consulting or product development). Such financial arrangements do not seem to be widespread according to both industry and academic studies, however (Burns, Lee, Bradlow, & Antonacci, 2007; Miksic et al., 2005).

On the basis of these findings, we propose the following hypotheses:

> *Hypothesis 1:* Orthopedic surgeons are likely to express higher alignment of interests with implant vendors and their sales representatives and lower alignment with hospitals and their materials managers.

Hypothesis 2: Orthopedic surgeons' alignment of interests with vendors and their sales representatives is likely to be fostered by:

a. the length of tenure between the vendor and the surgeon,
b. use of that vendor during the surgeon's residency training, and
c. the surgeon's receipt of payments from the vendor.

Hospital Efforts to Constrain Physician Preference

Scott (1965) originally described hospitals as autonomous professional organizations in which management delegates to professionals the responsibility for defining and implementing goals, setting performance standards, and ensuring that standards are maintained. In a later essay, he predicted that the conflict between macroconcerns and microconcerns would lead hospitals to become conjoint professional organizations in which managers and professionals coexist in a state of interdependent and mutual influence (Scott, 1982). Harris (1978) also predicted that internal allocation problems within the hospital would lead to changes in its internal organization as the gap narrows between a hospital's medical staff and administration. Such developments may help hospitals to align more closely with their surgeons and overcome the challenges posed by third parties such as implant manufacturers.

Hospitals place a high priority on reining in costs for orthopedic implants (Nudell, 2006) and have pursued several cost-containment strategies (Advisory Board, 2004; Montgomery & Schneller, 2007; Schneller & Smeltzer, 2006). Unfortunately, there are very few national data on the prevalence or effectiveness of these strategies. One industry survey of 80 hospital purchasing managers found that the most prevalent strategies are (in order) having capitation/price ceilings, limiting the number of vendors, competitive bidding, information sharing across hospitals, demand matching, and gain sharing (Matson & Whitt, 2005). Two industry surveys of orthopedists have also estimated the prevalence of these strategies. One survey of 65 orthopedic surgeons found that the most prevalent strategies are (in order) limiting the number of vendors, having capitation/price ceilings, GPO contracting, and gain sharing (Miksic et al., 2005). A more recent industry survey of 100 orthopedists found that the most prevalent strategies are (in order) limiting the number of vendors, price discounting based on volume purchasing, having price ceilings, sole-source contracting, GPO contracting, and consigning (Scannell & Bedell, 2008c).

Although not as prevalent as some other strategies, gain sharing has increased in recognition. In gain-sharing programs, the hospital works with physicians to reduce total service line costs and then splits the savings (gains) with them. Restrictions by the Office of the Inspector General (OIG) have historically limited the spread of such programs. Recent academic evidence suggests that these programs have succeeded primarily in negotiating lower device prices with vendors, ostensibly through joint hospital–physician bargaining (Ketcham & Furukawa, 2008). Another popular strategy has been to employ VATs and NTCs to review all new technologies that physicians and vendors wish to bring inside the hospital. Recent unpublished data from a national survey of hospitals suggest that one half to three quarters of hospitals have adopted VATs and NTCs (Burns, 2007).

How effective are these hospital efforts? There is only a bit of indirect evidence. One industry survey of 100 hospitals ranked these strategies in perceived importance as follows: having improved negotiation with vendors, demand matching, limiting the number of vendors, information sharing with other hospitals, GPO contracting, and gain sharing (Nudell, 2006).

In contrast to vendors and their sales representatives, hospitals seem to have much weaker leverage over surgeons and their product preferences. Roughly one third of hospitals responding to an industry survey have no strategies in place to manage orthopedic implant choices, according to recent survey data (Scannell & Bedell, 2008c). Moreover, hospitals may lack systems for cost accounting and point-of-care data capture that can track which devices are used by which surgeons. This results from the fact that hospitals may not buy and inventory implants ahead of time but instead rely on the sales representative to bring the implant into the OR just in time for the procedure (DeGraaff & Pauly, 2002). Even when strategies are pursued, however, their effectiveness depends on physician receptivity. For example, 83% of orthopedic surgeons responding to an industry survey said that their hospitals employed a strategy to reduce the number of orthopedic implant vendors used, but only 35% viewed this standardization strategy as feasible (Miksic et al., 2005). Indeed, many analysts reported that efforts undertaken by hospitals and their GPOs to standardize the number of vendors have met with physician resistance. As a consequence, many hospitals have switched to a capitation strategy whereby they allow physicians free choice among vendors but require vendors to offer their products at or under a set price ceiling.

Although the costs of implants are certainly significant, the costs of implants do not comprise the total cost of a procedure. Procedure costs also vary based on the amount of OR time, a variety of team processes, organizational learning, and clinical leadership (Guthrie, Froneberger, & Terry, 2005; Pisano, Bohmer, & Edmondson, 2001). Hospitals must consider all of these

input and throughput costs to identify the most appropriate lever for change.

In summary, orthopedic surgeons seem to protect their prerogative to choose implant products and vendors. They are not supportive of efforts to dictate implant choice by hospitals or other external influences, such as patients, VATs, and NTCs (Bozic et al., 2007; Scannell & Bedell, 2008c). Although these influences may be fundamentally different, their effects seem similar in the eyes of surgeons in that they represent attempts to restrict product choice. Thus, surgeons are likely to oppose these efforts but to differing degrees depending on the source. This is likely to be particularly true when surgeons have formed long-standing relationships with vendors or receive financial payments from vendors because these surgeons tend to have even stronger personal preferences for certain vendors than do surgeons without these incentives.

On the basis of these findings, we propose the following additional hypotheses:

Hypothesis 3: Orthopedic surgeons are not likely to:

a. face strong constraints imposed on their choice of implants by hospital efforts to reduce implant costs;
b. face strong influence over their decision making by patients, VATs, and NTCs; and
c. view positively any hospital efforts to standardize implant vendors.

Hypothesis 4: Physician perceptions of (a) hospital constraints or (b) external influences are likely to be negatively associated with

a. the length of tenure between the vendor and the surgeon,
b. use of that vendor during the surgeon's residency training, and
c. the surgeon's receipt of payments from the vendor.

Data and Methods

Pennsylvania Survey

The data presented here are taken from a survey of orthopedists in Pennsylvania. We identified the population of all surgeons performing hip and knee implant procedures in hospitals in 2004 (N = 2,421) using the discharge database maintained by the Pennsylvania Health Care Cost Containment Council (PHC4). A sizeable number of surgeons (N = 1,869) performed fewer than 12 procedures during that year (less than 1 per month on average). We excluded the low-volume surgeons from our sample and the survey administration for several related reasons. They were less likely to have familiarity with the implant vendor and its products; they were less likely to be subject to and aware of the hospital's cost-containment efforts with respect to PPIs; and they were less salient in the eyes of both vendors and hospitals and thus less likely to be courted by either suitor. We excluded an additional 60 surgeons for whom we did not have full names or could not locate mailing addresses. After these exclusions, we had a final sample of 492 orthopedists.

The survey was developed in consultation with several stakeholders: executives at orthopedic implant vendors, high-volume orthopedic surgeons, and materials managers at several hospitals. An earlier version of the survey was pilot tested with 25 orthopedic surgeons at a hospital in another state specializing in orthopedic implants. Results from this survey were used to refine the instrument before the statewide survey implementation during summer 2006 (see Appendix A). After two mailings, we received responses from 201 surgeons, representing a response rate of 40.8%.

The survey gathered data on all of the dependent variables. First, the survey asked surgeons to rate the alignment of their interests with four major stakeholders: the implant vendor, the vendor's sales representative, the hospital, and the hospital's materials management director in charge of implant procurement. Surgeons indicated the extent to which their interests overlapped with each stakeholder on an 8-point scale ranging from *far apart* to *near total or complete overlap*. The same scale has previously been used in empirical studies of physician alignment of interests with hospitals and was found to correlate strongly with multi-item measures of organizational commitment and loyalty (Burns et al., 2001; Dukerich, Golden, & Shortell, 2002).

Second, the survey asked surgeons to evaluate the efforts undertaken by their "primary" hospital (defined as the hospital at which they performed most of their hip and knee implant procedures) to contain orthopedic implant costs. These efforts spanned three broad areas: hospital efforts to constrain the physician's choice of implant vendors, outside efforts by patients and hospital committees to influence the physician's choice of implants, and physicians' willingness to support hospital efforts to standardize implant vendors. Surgeons evaluated these efforts on multiple items using a 5-point Likert scale (ranging from *strongly disagree* to *strongly agree*).

The survey also gathered information on all of the independent variables needed to test the hypotheses. Surgeons were asked to identify their primary vendor of orthopedic implants, the number of years they had been using that vendor's implants, whether they had used that vendor's products during their residency training, and whether they received payments from the vendor for any of three activities (consulting, product development royalties, and professional talks).

The survey also asked surgeons to name the primary hospital that they used. For most surgeons, we were able to validate these responses using the PHC4 discharge data. For nonrespondents and respondents that did not name a primary hospital, we imputed the hospital's identity using the discharge data where they performed the most hip and knee implants. We subsequently matched up these responses with hospitals in the American Hospital Association's annual survey to measure an array of descriptive characteristics of the hospitals in which the surgeons practiced. These characteristics served as one set of control variables in our models. They included two measures of hospital size (volume of inpatient beds and outpatient surgeries), hospital membership in a multihospital system (1 = yes), academic medical center (1 = yes), binary indicators (1 = yes) for investor and public ownership (with nonprofit ownership as the excluded contrast), and the Herfindahl–Hirschman Index for local market competition among hospitals.

A second set of control variables was constructed from the PHC4 discharge database. These data allowed us to measure the level of the orthopedist's surgical activity at the primary hospital, the number of hospitals utilized by the surgeon, the surgeon's loyalty to the primary hospital (defined as the percentage of all implant procedures performed there), and the hospital's dependence on that surgeon (defined as the percentage of total hospital implant volume accounted for by that surgeon).

Analysis of Survey Nonresponse

Following the survey research literature, we employed multiple methods to assess and handle any potential nonresponse bias in the survey findings. First, we used supplemental matched data to compare responders and nonresponders on characteristics that might affect the dependent measures. One set of nonresponse analyses compared survey responders and nonresponders in terms of the hospitals they utilized. We found no significant differences in terms of hospital bed size (345 vs. 326, $p < .37$), surgical volumes (14,321 vs. 14,414, $p < .92$), academic medical center teaching status (10.9% vs. 7.2%, $p < .15$), Herfindahl–Hirschman Index (1,560 vs. 1,464, $p < .50$), and hospital ownership ($\chi^2 = 2.82$, $p < .25$) and only one marginally significant difference in terms of system membership (54.7% vs. 46.4%, $p < .07$).

Another set of nonresponse analyses compared responders and nonresponders in terms of the number of hospitals that surgeons utilized, their implant procedure volumes for hips and knees, the share of their total hip and knee implant volume at the primary hospital, and the share of the hospital's total implant volume accounted for by that surgeon. As revealed by t tests, most of these differences were significant or marginally significant. Compared with the nonresponders, the responders utilized significantly fewer hospitals (1.6 vs. 1.8, $p < .07$) and had higher hip implant volumes (34.7 vs. 27.5 procedures, $p < .10$), significantly higher knee volumes (66.4 vs. 53.2 procedures, $p < .05$), higher shares of their volume at the primary hospital (20.7% vs. 18.7%, $p < .25$), and significantly higher shares of the hospital's total implant volume (17.2% vs. 14.1%, $p < .02$). Because these variables are likely to influence the dependent measures and the model results, we statistically controlled for the differential response in our multivariate models. Following Kalton (1983) and Tomaskovic-Devey, Leiter, and Thompson (1994), we weighted the data to conform to known population distributions to estimate population means. We estimated a logistic regression model to predict survey response using the surgeon's utilization and volume characteristics, computed the inverse mills ratio to measure the odds of survey nonresponse, and then used it as an additional covariate in the estimation of our multivariate models.

As a final test of nonresponse bias, we conducted a wave analysis (Hikmet & Chen, 2003; Rogelberg & Stanton, 2007) to compare the responders with those of the first and second administrations of the survey. There were no significant differences on any of the variables in Table 1. Although the lack of any difference here does not conclusively indicate an absence of any sampling bias, it does provide additional evidence that such bias does not exist.

Statistical Techniques

We employed principal factor analysis to reduce the large number of hospital variables and physician survey items to derive a smaller number of underlying dimensions. This increased the parsimony of the multivariate models and reduced potential problems of multicollinearity. Factors were subjected to orthogonal (varimax) rotation methods; those factors with eigenvalues of 1.0 or greater were retained. Factor coefficients were used as weights to construct summary scales from the items loading on that factor (see Appendix B).

Among the hospital and physician variables, we constructed a factor for hospital size from the number of beds and total surgical operations. Academic status is measured by a binary indicator of whether the hospital is an academic medical center (1 = yes) and three binary items from the physician survey denoting the surgeon's involvement in teaching fellows and residents, writing journal publications, and speaking at extramural meetings. Physician volume is measured by the number of hip and knee implants performed by that surgeon during 2006. Physician splitter is measured by the number of hospitals utilized by the physician and the inverse

Table 1

Independent variables

Variable	N	M	SD
Number of beds	201	343.15	233.68
Number of surgical operations	201	14,285.22	9,986.78
Factor: size	201	11,127.86	7,738.41
Academic medical center (% yes)	201	10.94	31.30
Surgeon's involvement in teaching (% yes)	201	46.27	49.98
Surgeon's involvement in writing journal publications (% yes)	201	18.41	38.85
Surgeon's involvement in speaking at extramural meetings (% yes)	201	42.79	49.60
Factor: academic status	201	64.98	69.87
Number of hip implants	201	34.72	49.78
Number of knee implants	201	66.42	75.05
Factor: physician volume	201	88.98	95.09
Number of years physician has used current hip implant vendor	192	11.05	6.72
Number of years physician has used current knee implant vendor	196	11.42	6.84
Number of years physician has been in practice	201	17.40	8.58
Factor: vendor tenure	188	10.15	5.13
Number of hospitals utilized by physician	201	1.61	0.77
Proportion of physician's implant volume at primary hospital	201	87.82	19.85
Factor: physician splitter	201	1.59	0.84
Receipt of consulting fees from vendor (% yes)	199	11.56	32.05
Receipt of honoraria for talks from vendor (% yes)	199	11.56	32.05
Factor: vendor payments	199	19.42	49.00
Number of hip implant vendors utilized by physician	197	1.48	0.81
Proportion of hip implant cases performed using primary vendor	192	93.46	12.09
Factor: vendor splitter-hips	191	5.64	8.22
Number of knee implant vendors utilized by physician	199	1.35	0.71
Proportion of knee implant cases performed using primary vendor	196	96.38	8.53
Factor: vendor splitter-knees	196	1.55	1.53
Hospital system member (% yes)	201	54.45	49.92
Herfindahl–Hirschman Index	201	1,554.60	1,647.58
Physician used primary vendor during residency (% yes)	168	45.24	49.32
Proportion of orthopedics practice in spine	197	4.19	11.87
Investor-owned hospital (% yes)	201	3.96	19.55
Local government-owned hospital (% yes)	201	1.98	13.97

proportion of the physician's hip and knee volume at the primary hospital (1 − volume percentage). We constructed a measure of vendor tenure from three items: the number of years the surgeon has used the current vendor of hip implants, the number of years the surgeon has used the current vendor of knee implants, and the number of years the surgeon has been in practice. The surgeon's receipt of vendor payments is measured by two binary indicators (1 = yes) indicating the receipt of consulting fees and honoraria for professional talks; the third survey item indicating receipt of product royalties did not load on the factor. We also constructed two factors to reflect the degree to which the surgeon splits his or her preferences among several implant vendors. Vendor splitter-hips is measured by the number of hip implant vendors utilized and the inverse proportion of hip cases performed using the primary hip implant vendor; vendor splitter-knees is likewise measured by the number of knee implant vendors used and the inverse proportion of knee cases performed using the primary knee implant vendor. Because empirical analyses revealed that neither of these splitter measures had any effect on the dependent variables, we omitted them from further discussion.

Some of our dependent variables were also constructed from the factor analyses. The degree to which the surgeon perceived that he or she faced constrained vendor choice of implants was measured by five items: "My hospital has reduced the number of implant vendors," "my hospital is restricting access to vendors of innovative products and technologies," "my hospital requires me to utilize implant products from only one or two vendors," "I am losing leverage in trying to influence hospital decisions over which vendor to use," and "my hospital allows me to select the implant vendor of choice" (reverse coded). The degree of outside influence over the physician's choice of implant was measured by three items: "patient requests for specific

products influence my decision to use a given product or work with a given vendor," "deliberations by hospital value analysis or new technology committees influence my decision to use a given product or work with a given vendor," and "decisions by materials managers or operating room managers influence my decision to use a given product or work with a given vendor." Physicians' willingness to support standardization of implant vendors was measured by two items: "I approve of my hospital's efforts to cut costs by standardizing implant vendors," and "I would rather drop my hospital privileges than comply with my hospital's request to standardize on fewer implant vendors" (reverse coded).

Our multivariate models employ a Heckman sample selection model to mitigate potential sampling bias observed among the surgeons who responded to our survey. The first stage of our model controls for response bias as a function of hip and knee implant volume, the number of hospitals that our surgeons practice in, and a dummy variable indicating whether each surgeon's primary hospital is an academic medical center. The second stage of our model tests the factors that are associated with surgeons' alignment of interests with different stakeholders and their evaluations of hospital cost-containment efforts. Due to multicollinearity among several variables, we estimated several different specifications of our second-stage model. The model specification that excluded academic status but included all other variables produced the most consistently robust results and is the one reported here. Following Dukerich et al. (2002), we also estimated the second-stage model, with the alignment measures included as additional predictors of the physician's evaluation of hospital efforts. This is the model reported.

Results

Univariate Statistics

Table 1 presents the univariate statistics on our independent variables. The average orthopedist in Pennsylvania performs nearly 35 hip implant and 66 knee implant procedures annually. These surgeons have been with their implant vendor for 10 years and utilized that vendor's products in most (93%–96%) of their implant procedures. Surgeons are nearly as loyal to their primary hospital, where they perform the majority (88%) of these procedures. Roughly 12% of orthopedists receive payments from their vendors for consulting and talks. This percentage resembles the proportions found in prior studies of orthopedists and general surgeons (Burns, Lee, et al., 2007; Miksic et al., 2005).

Table 2 presents the descriptive statistics on our dependent variables which serve to test Hypotheses 1 and 3. We first measured how much the surgeon's professional identity and interest align with each of four stakeholders. In partial support of Hypothesis 1,

Table 2

Dependent variables

Variable	*N*	*M*	*SD*
Physician's perceived alignment of interests with hospital	198	4.14	1.86
Physician's perceived alignment of interests with materials manager	196	2.65	1.73
Physician's perceived alignment of interests with vendor	198	3.99	1.89
Physician's perceived alignment of interests with sales representative	198	4.48	1.92
Hospital has reduced number of implant vendors	198	2.27	1.23
Hospital restricts access to vendors of innovative products	201	2.57	1.13
Hospital requires use of implants from only one or two vendors	201	2.24	1.11
Physician loses leverage in influencing decisions on vendors to use	200	2.94	1.24
Hospital allows physician to select implant vendor of choice (reverse coded)	201	2.21	1.00
Factor: constrained vendor choice	197	1.30	0.41
Patient requests for specific products influence physician's choice	200	1.86	0.89
Hospital value analysis and technology committees influence physician's choice	201	2.35	1.13
Materials managers and operating room managers influence physician's choice	200	2.04	1.02
Factor: outside influence	200	1.18	0.45
Physician approves hospital efforts to cut costs by standardizing implant vendors	198	3.19	1.26
Physician would rather drop hospital privileges than comply with hospital efforts to standardize on fewer implant vendors (reverse coded)	200	3.74	1.01
Factor: support standardization	196	1.86	0.51
During the past year, my hospital has reduced the number of implant vendors	197	2.27	1.23
Hospital purchasing staff approves all of the physician's implant requests	199	3.48	1.29
Hospital generates cost savings from efforts to cut implant costs	200	3.78	1.00

orthopedic surgeons do express their greatest alignment with the vendors' sales representatives and their least alignment with the hospital's materials manager. However, the difference in surgeon alignment with vendors and hospitals is small and not statistically significant. All other pairwise differences are significant at the $p < .05$ level. This suggests that the key relationship is between the surgeon and the sales representative, not the surgeon and the vendor. It is interesting to note that the extreme levels of alignment are with individuals, whereas intermediate levels of alignment are expressed about organizations. We also note that the alignment with the materials manager exhibits much higher dispersion (measured by the coefficient of variation = standard deviation divided by the mean) than does alignment with the other stakeholders. This suggests that materials managers have a wider variety of impacts on surgeons, perhaps both positively and negatively. This is a point to which we shall return later.

There is also only mixed support for Hypothesis 3 dealing with surgeons' attitudes toward hospital cost-containment efforts. In support of Hypothesis 3a, surgeons stated that they do not face strong constraints over their choice of implants. In support of Hypothesis 3b, orthopedic surgeons also asserted that they do not face strong influence over their implant decision making exerted by patients, VATs, or NTCs. In contrast to Hypothesis 3c, however, surgeons mildly supported hospital efforts to standardize on fewer implant vendors to cut costs (M = 3.19 on a 5-point scale). Moreover, surgeons asserted that hospital strategies to generate cost savings on orthopedic implants have been effective (M = 3.78 on a 5-point scale). Hospital success here does not seem to stem from efforts to constrain physicians' vendor preferences or choice of implant. Most physicians reported that their purchasing managers approve all of their implant requests (M = 3.48). This may at least partially explain why surgeons support hospital efforts to standardize implant vendors: They simply do not have much impact on surgeon's choice of vendor.

Multivariate Statistics

Tables 3 and 4 present the results of our two-stage models used to test Hypotheses 2 and 4. The bottom panel of each table presents the results from the first stage (Heckman sample selection) model, which uses several hospital and physician characteristics as predictors of survey nonresponse. The selection model results indicate that nonresponse is higher among surgeons

Table 3

Multivariate results—physician alignment with four stakeholders regression coefficients (*SE*)

Coefficient	Alignment with hospital	Alignment with vendor	Alignment with materials manager	Alignment with sales representative
Full model				
Size (×100,000)	−0.173 (0.22)	−0.181 (0.21)	−0.243 (0.21)	−0.433* (0.23)
Physician volume (×1,000)	0.375* (0.21)	0.026 (0.02)	0.163 (0.19)	0.169 (0.22)
Vendor tenure (×100)	0.060** (0.03)	0.090*** (0.03)	0.069** (0.03)	0.089*** (0.03)
Vendor payments	0.072 (0.34)	0.909*** (0.33)	0.110 (0.31)	0.614* (0.35)
Hospital system member	0.291 (0.33)	0.456 (0.32)	−0.288 (0.31)	0.300 (0.34)
Herfindahl–Hirschman Index (×10,000)	−0.247 (0.92)	−0.292 (0.88)	0.668 (0.84)	0.522 (0.93)
Vendor used in residency	−0.063 (0.32)	0.263 (0.30)	0.165 (0.29)	0.459 (0.32)
% Practice in spine (×100)	−0.237 (1.70)	0.737 (1.60)	0.970 (1.60)	0.713 (1.70)
Investor-owned hospital	0.204 (0.82)	0.767 (0.78)	1.161 (0.75)	0.426 (0.83)
Local government hospital	−1.083 (1.39)	0.568 (1.33)	−0.392 (1.28)	−0.779 (1.42)
Constant	3.072** (1.38)	1.756 (1.34)	1.432 (1.27)	2.324 (1.43)
Select				
Physician volume: hips (×1,000)	−0.069 (2.20)	−0.069 (2.20)	−0.190 (2.20)	−0.069 (2.20)
Physician volume: knees (×100)	0.229 (0.15)	0.229 (0.15)	0.242 (0.15)	0.229 (0.15)
Number of hospitals used	−0.266*** (0.08)	−0.266*** (0.08)	−0.269*** (0.08)	−0.266*** (0.08)
AMC	0.084 (0.24)	0.084 (0.24)	0.094 (0.24)	0.084 (0.24)
Constant	−0.105 (0.15)	−0.105 (0.15)	−0.114 (0.15)	−0.105 (0.15)
Observations	436	436	437	436

Note. AMC = academic medical center.
*$p < .1$.
**$p < .05$.
***$p < .01$.

Table 4

Multivariate results—physicians' views of hospital efforts to deal with implant vendors regression coefficients (*SE*)

Coefficient	Constrained choice	Outside influence	Support standardization
Full model			
Size (×100,000)	−0.308 (0.48)	−0.041 (0.51)	−0.271 (0.60)
Physician volume (×1,000)	−0.016 (0.44)	0.430 (0.48)	−1.200* (0.73)
Vendor tenure (×100)	−0.293 (0.65)	0.344 (0.69)	0.811 (0.77)
Vendor payments	0.038 (0.07)	0.112 (0.08)	−0.047 (0.09)
Hospital system member	0.130* (0.07)	−0.022 (0.08)	−0.051 (0.08)
Herfindahl–Hirschman Index (×10,000)	−0.148 (0.20)	−0.238 (0.21)	−0.141 (0.23)
Vendor used in residency	0.069 (0.07)	−0.099 (0.07)	0.011 (0.08)
% Practice in spine (×100)	0.343 (0.36)	0.527 (0.39)	−0.268 (0.42)
Investor-owned hospital	0.027 (0.17)	0.067 (0.19)	−0.021 (0.22)
Local government hospital	−0.241 (0.30)	−0.284 (0.32)	−0.716* (0.38)
Alignment with hospital	−0.068*** (0.02)	−0.020 (0.02)	0.049** (0.02)
Alignment with vendor	0.029 (0.03)	−0.008 (0.03)	−0.045 (0.03)
Alignment with materials manager	−0.014 (0.02)	0.049** (0.02)	0.049** (0.03)
Alignment with sales representative	−0.033 (0.02)	0.006 (0.03)	0.011 (0.03)
Constant	1.562*** (0.29)	1.214*** (0.32)	2.671*** (0.45)
Select			
Physician volume: hips (×1,000)	−0.970 (2.30)	0.056 (2.20)	−0.199 (2.20)
Physician volume: knees (×100)	0.285* (0.15)	0.228 (0.15)	0.244 (0.15)
Number of hospitals used	−0.274*** (0.08)	−0.268*** (0.08)	−0.259*** (0.08)
AMC	0.120 (0.24)	0.078 (0.24)	0.099 (0.24)
Constant	−0.112 (0.15)	−0.105 (0.15)	−0.139 (0.15)
Observations	435	433	435

*$p < .1$.
**$p < .05$.
***$p < .01$.

who utilize more hospitals for hip and knee implants. The top panel of each table presents the regression estimates from the second-stage model that predicts the physician's alignment of interest with four stakeholders (Table 3) and their evaluation of hospital efforts to contain implant costs (Table 4). The latter analysis includes the alignment scores as additional covariates.

Table 3 provides support for Hypothesis 2a: Vendor tenure is a key driver of the surgeon's alignment of interests with both the vendor and its sales representative. In fact, tenure also promotes alignment with the hospital and its materials manager. One explanation is that vendor tenure masks the effect of the physician's age, which is likely to be positively associated with hospital alignment. Academic research indicates that older physicians tend to have practiced at the facility for some time and built up loyalties and commitments to that institution (Burns et al., 2001). Older physicians who concentrate their procedures at one hospital have also accrued learning curve efficiencies and patient safety benefits by virtue of working with dedicated OR teams and thus have more to lose by leaving the institution. Another possible explanation is that older surgeons have more static relationships with vendors which may be less challenged by hospitals and their materials managers, leading to less adversarial relationships. Of course, there may be other explanations for the positive effect of vendor tenure on alignment with the materials manager, for example, if the surgeon's preferred vendor and sales representative have also developed an accommodation with the hospital's purchasing department.

There is little support for Hypothesis 2b: The surgeon's use of the vendor during residency training does have a positive impact on alignment with the vendor and its sales representative, but the effects are not statistically significant. On the other hand, there is support for Hypothesis 2c: Receipt of payments from the vendor does positively impact the surgeon's alignment with the vendor and its representative.

Finally, there is no direct support for Hypothesis 4 dealing with the determinants of the surgeons' perceptions (see Table 4). Tenure with the primary vendor, use of that vendor during residency training, and receipt of payments from the vendor do not directly impact surgeons' views of hospital efforts to deal with implant vendors. Vendor tenure does diminish the surgeon's perception of

constrained choice indirectly through its effect on hospital alignment. Conversely, vendor tenure also increases the surgeon's perception of outside influence through its effect on alignment with the materials manager and the surgeon's support of standardization through its effect on both hospital and materials manager alignment. Only one physician variable exerts a significant direct effect: Surgeons with high volumes are less likely to support hospital efforts to standardize vendors.

Few of the hospital-level variables exert any significant effects in Table 4. Surgeons practicing in multihospital systems were more likely to state that their choice of implants is constrained, whereas surgeons practicing in government-owned hospitals were less likely to support implant standardization efforts.

Limitations

The findings are subject to several limitations. First, we relied on survey responses rather than on empirical analyses of physician product selection. Second, the study relied heavily on responses to one survey, from which we gleaned many of the independent and dependent variables. There is thus the possibility of common methods bias which can inflate the association among variables (Meade, Watson, & Kroustalis, 2007). Third, the data reflect a snapshot at one point in time and do not permit us to analyze how the introduction of hospital cost-containment efforts impacts subsequent physician preferences or product choices. Fourth, the data were taken from surgeons in only one state and may not be generalizable to the rest of the country. Indeed, Pennsylvania is considered by surgeons in the Commonwealth to be "the epicenter of malpractice litigation" in the United States. This may lead surgeons in the state to be less favorably inclined toward hospital programs to reduce implant costs that require them to switch to new and unfamiliar devices. Nevertheless, the Pennsylvania survey is the largest survey of orthopedists to date. Fifth, there is the possibility of social desirability bias, which might lead surgeons to underreport their financial ties with vendors and/or the degree to which hospital efforts constrain their professional prerogatives. Sixth, the survey considered only the views of orthopedic surgeons and not those of the other two parties. Seventh, we were unable to infer causality from our data because we cannot determine whether surgeons' views of hospital practices and alignment of interests with stakeholders are a function of their implant patterns or vice versa.

Conclusions

Our findings present several dilemmas for hospital executives seeking to contain orthopedic implant costs. First, despite prior evidence suggesting strong medical opposition to hospital efforts to limit vendor choice, there is little sign of such opposition among Pennsylvania orthopedists, contradicting Hypothesis 3c. Generally, orthopedists believe that limiting the number of vendors used is appropriate for both hospitals and physicians because both benefit from the focus on a narrower set of products and technological platforms. The lack of opposition may be attributable to the fact that such efforts have not affected most surgeons (supporting Hypotheses 3a and 3b). These results may help to explain why surgeons believe that their hospitals have been successful in generating savings from implants: These savings have not resulted from standardization as much as from other possible strategies, such as gain sharing or capitated pricing.

Second, surgeons tend to use one vendor for most of their implants and tend to stick with that vendor for an extended time. At the same time, hospitals seek to limit the number of implant vendors or standardize on one or two. To be successful with standardization, hospitals must include the vendors that their surgeons use. To the extent that the orthopedic medical staff contains numerous physicians who use different vendors, the strategy of vendor limitation has its own limitations (Hypotheses 3a and 3b). Thus, to really be successful, standardization programs may need to focus on limiting access to implant vendors that are not widely used. This approach will limit the savings that can be reaped from standardization and increase the hospital's dependence on a smaller number of large vendors.

Third, orthopedic surgeons not only remain with their implant vendor for a long time but also can receive financial payments from them and closely identify with their sales representatives. As a result, surgeons seem to develop significant brand loyalty with implant vendors and their representatives, supporting Hypotheses 2a and 2c. This explains why vendor market shares for hip and knee implants are relatively static and surgeons exhibit relatively little switching behavior over time, although there are six major vendors to choose from. This vendor brand loyalty may exceed the surgeon's admitting loyalty to their primary hospital.

Overall, our results suggest that implant manufacturers have the advantage over hospitals in competing for the attention of orthopedists, supporting Hypothesis 1. Although surgeons align with hospitals and vendors to a similar extent, they align much most closely with vendor sales representatives. This advantage has three sources: a historical component (length of tenure with vendor), a financial component (receipt of payments), and a service component (training and services provided by the sales representative). Vendor tenure exerts the most consistent effect, suggesting that these long-standing relationships influence other attitudes and

behaviors (Hypothesis 2a). The receipt of financial payments also positively impacts the surgeon's alignment with the vendor (Hypothesis 2c). Although we did not ask explicitly about the service component, alignment with vendor sales representatives was the strongest relationship reported by surgeons.

Future Research

Our results suggest that the role of sales representatives needs greater attention and study. These individuals accompany orthopedic surgeons in the OR every day and work extensively with them beyond normal business hours. Their primary goal, according to survey respondents, is to facilitate what the surgeon does. The sales representatives speak the surgeon's language, wear the surgeon's uniform, assist the surgeon with the expensive device components and instrumentation, and understand what the surgeon is trying to accomplish. In this manner, the sales representatives serve as unsalaried employees of the hospital who substitute for the efforts of lesser trained OR nurses. At the same time, the sales representatives are confronted by an increasingly suspicious materials management department that envies their high incomes, denigrates their efforts, requires them to sign in every day, may ask them to pay fees to access the hospital, and may require them to wear a GPS button so that their whereabouts in the hospital are known. Sales representatives (and the orthopedic surgeons they serve) perceive these hospital attitudes and practices as bureaucratic hassle, which inadvertently may increase the level of bonding between them.

Implications for Managers

To be sure, hospitals also provide support to surgeons in the form of a workshop in which to perform their procedures (Pauly & Redisch, 1973; Harris, 1978). Physicians have long enjoyed such support in exchange for participating on hospital committees and taking call in the emergency room. However, this traditional quid pro quo exchange has broken down. Physicians no longer view it as sufficient to warrant their continued contribution, as reflected in their increasing demands for compensation for taking call (Burns & Muller, 2008).

Hospitals will be challenged to deliver comparable benefits to orthopedists in the short-term, given the limited increases in Part A payments and declines in Part B payments for orthopedic procedures under Medicare. Although the mechanisms employed by hospitals to constrain vendor choice have met with limited success, they may instead try to elicit their voluntary participation with hospital protocols. For example, hospitals are beginning to encourage physician participation in VATs and NTCs to incorporate surgeons' input in the technology evaluation process. At the same time, hospitals are beginning to partner with orthopedists in arrangements that could offer benefits in some of these same areas. For example, some hospitals have developed economic joint ventures with orthopedists in ambulatory surgery centers, whereas other hospitals have developed gain-sharing programs with orthopedists—both of which may extend hospital payments to surgeons. Some hospitals are also developing centers of excellence and clinical service line programs around orthopedics—both of which seek to offer increased support and service levels to specialist physicians. Hospitals may have to become more creative in fashioning new partnerships with surgeons to emulate the extensive benefits offered by the vendors.

Hospitals may also need to retailor their current strategies to control implant costs. Orthopedic surgeons dismiss the effectiveness of hospital efforts to reduce implant costs, whether through vendor rationalization, VATs, or NTCs. One survey respondent reported that surgeons are "annoyed by the efforts of low level hospital functionaries or committees to try to restrict their choice of implant." To be more effective, hospital efforts may need to be supplemented by the personal involvement of top managers to champion the initiatives, continually highlight their importance, and personally engage surgeons in a dialogue regarding the need for device cost containment. Hospital efforts may also require greater clinician involvement in VATs and NTCs to wield peer pressure on physician's decisions.

More generally, hospital managers need to recognize that their relationships with physicians have historically been complicated by a succession of third parties. These parties have included boards of trustees, MCOs, PPMCs, patients, and (now) product vendors (Burns, Nash, et al., 2007). Some third parties (boards) seek to unite hospitals and physicians, some (MCOs) seek to divide them, and still, others (patients and vendors) play one off against the other. Hospital managers will need to learn more about how these third parties operate to counterbalance their marketing efforts aimed at the medical staff (Kruger, 2002; Montgomery & Schneller, 2007)

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Appendix A

Orthopedic implant survey

You will be surveyed about the manufacturers of HIPS and KNEES you utilize most frequently in your practice. Please answer each question separately for each vendor.

1) Which manufacturer(s) do you use for (check all that apply):

	HIPS		KNEES	
	Yes	**No**	**Yes**	**No**
Biomet	___	___	___	___
DePuy	___	___	___	___
Smith & Nephew	___	___	___	___
Stryker	___	___	___	___
Zimmer	___	___	___	___
Wright Medical	___	___	___	___
Other	___	___	___	___

Did you use these same vendors during your residency training? Yes ___ No ___

2) What proportion of your orthopedics practice is:

Arthroplasty _____%
Spine _____%
Trauma _____%

3) How many years have you been in practice: _____ **years**

4) Have you completed a fellowship in arthroplasty? Yes___ No___

If you answered "Yes":
In your current practice, do you use the same vendors that you used during your fellowship? Yes___ No___

5) Do you engage in any of the following activities:

	Yes	No
Teach fellows/residents	___	___
Write journal publications	___	___
Speak at extramural meetings	___	___

(continues)

Appendix A

Continued

6) Are you involved with any manufacturers you listed in question (1) in the following ways:

	Yes	No
Consulting fees	___	___
Royalties for patents	___	___
Honoraria for talks	___	___

7) Name of most frequently used vendor for HIPS: _____

Proportion of HIP cases using this vendor: _____ %

Number of years you have used this vendor: _____ years

8) Name of most frequently used vendor for KNEES: _____

Proportion of KNEE cases using this vendor: _____ %

Number of years you have used this vendor: _____ years

9) Name of hospital where you practice arthroplasty the most: _____

10) State your level of agreement/disagreement with the following statements regarding the hospital where you practice arthroplasty the most:

Statement	Strongly Disagree (1)	Disagree (2)	Unsure (3)	Agree (4)	Strongly Agree (5)
a) During the past year, my hospital has reduced the number of implant vendors	1	2	3	4	5
b) I approve of my hospital's efforts to cut costs by standardizing implant vendors	1	2	3	4	5
c) My hospital's purchasing staff approves all of my implant requisitions/requests	1	2	3	4	5
d) My hospital has generated cost savings from efforts to cut implant costs	1	2	3	4	5
e) My hospital has passed on savings from orthopedic cost-cutting efforts to my unit	1	2	3	4	5
f) I am losing leverage in trying to influence hospital decisions over which vendor to use	1	2	3	4	5
g) My hospital and I are in the same boat: we are both being paid less for implant surgery	1	2	3	4	5

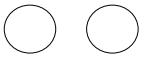
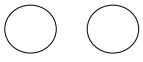
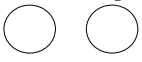
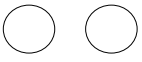
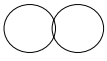
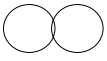
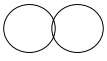
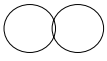
(continues)

Appendix A

Continued

Statement	Strongly Disagree (1)	Disagree (2)	Unsure (3)	Agree (4)	Strongly Agree (5)
h) **I would rather drop my hospital privileges than comply with my hospitalís request to standardize on fewer implant vendors**	1	2	3	4	5
i) **My hospital is restricting access to vendors of innovative products and technologies**	1	2	3	4	5
j) **My hospital allows me to select the implant vendor of choice**	1	2	3	4	5
k) **My hospital requires me to utilize implant products from only one or two vendors**	1	2	3	4	5
l) **Patient requests for specific products influences my decision to use a given product or work with a given vendor**	1	2	3	4	5
m) **Deliberations by value analysis or new technology committees in the hospital influence my decision to use a given product or work with a given vendor**	1	2	3	4	5
n) **Decisi ons b y mat erials mana gers or OR managers influence my decision to use a given product or work with a given vendor**	1	2	3	4	5

11) Please indicate how much of your (physician) professional identity and interest overlaps with each of the four parties below. Shade the appropriate circle in each of the four sets of columns.

Degree of Shared Identity & Interest		Physician Hospital	Physician Vendor	Physician Materials Management	Physician Vendor Sales Rep
1.	Far Apart				
2.	Close together, But Separate				
3.	Very Small Overlap				
4.	Small Overlap				
5.	Moderate Overlap				
6.	Large Overlap				
7.	Very Large Overlap				
8.	Near total or Complete Overlap				

Appendix B

Construction of factor scales for independent and dependent variables

Independent Variables	Construction of Factor Scales
Hospital Size	[number of beds * 0.79] + [total surgical operations * 0.76]
Academic Status	[academic medical center * 0.55] + [teach fellows/residents * 0.49] + [write publications * 0.67] + [speak at meetings * 0.56]
Physician Volume	[number hip implants * 0.86] + [number knee implants * 0.89]
Physician Splitter	[number of hospitals used * 0.93] + [1 – (proportion of hospitalís implant volume accounted for by physician * 0.80)]
Vendor Tenure	[number of years physician has used current hip vendor * 0.95] + [number of years physician has used current knee vendor * 0.96] + [number of years physician has been in practice * 0.52]
Vendor Payments	[receipt of consulting fees * 0.80] + [receipt of honoraria for professional talks * 0.88]
Vendor Splitter – Hips	[number of hip vendors used * 0.91] + [1 – (proportion of hip cases performed using primary hip vendor * 0.65)]
Vendor Splitter – Knees	[number of knee vendors used * 0.77] + [1 – (proportion of knee cases performed using primary hip vendor * 0.14)]
Dependent Variables	
Constrained Choice	[hospital has reduced number of implant vendors * 0.39] + [hospital restricts access to vendors of innovative products and technologies * 0.45] + [hospital requires physician to use implant products from only one or two vendors * 0.62] + [physician losing leverage in trying to influence hospital decisions over which vendor to use * 0.50] + [1 – (hospital allows physician to select vendor of choice * 0.71)]
Outside Influence	[patient requests influence physician decision * 0.47] + [hospital committees influence physician decision * 0.55] + [materials managers or O.R. managers influence physician decision * 0.67]
Support Standardization	[physician approves hospital efforts to standardize * 0.61] + [1 – (physician would drop privileges rather than comply * 0.47)]