Standardization under Group Incentives*

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Abstract

Group-based incentives can reduce a firm’s costs more than individual incentives by providing a rationale for standardizing decisions across employees or agents. We theoretically demonstrate and empirically test this in the context of hospital services, where fragmentation between hospitals and physicians has promoted high growth in spending. Specifically, we analyze recent gainsharing programs in cardiology in which hospitals establish group incentives for their non-employee physicians to control spending on highly priced drugs and devices. We find that gainsharing lowered hospitals’ prices for drugs and devices via switching to lower-priced items, increased contract compliance due to higher standardization of purchasing decisions, and lower negotiated prices due to hospital’s credible threats to switch to alternative sources. The model describes the conditions under which each of these outcomes is achieved. As the model also indicates, actual standardization was less widespread.

Keywords: gainsharing; group incentives;

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1 Introduction

Firms have adopted a wide range of incentives to align their interests with those of their employees and agents (Prendergrast (1999)). These include both individual- and group-based approaches. Existing work has indicated that group incentives are most preferred when firms have difficulty observing output of individuals but not overall, or when agents engage in team production and have greater ability than firms to monitor each others’ productivity (Varian (1990)). Although free-rider problems are well known (Holmstrom (1982)), group incentives and even firm-wide incentives such as profit-sharing have been shown to influence employee behavior (Kandel and Lazear (1992); Hamilton, Nickerson, and Owan (2003); Gaynor, Rebitzer, and Taylor (2004); Knez and Simester (2001)). A general shortcoming of the existing work on group incentives is understanding the mechanisms by which group incentives overcome moral hazard. In one notable exception, they rely on long-term relationships between group members to provide a rationale for group incentives.

In this paper we provide an additional rationale for group incentives that applies even in a static framework, namely their ability to cause agents to internalize costs that increase from a lack of standardization across agents. Many principal-agent models focus on incentives to an increase agent’s effort and subsequent output. In some contexts, however, agents determine the costs borne by the principals. Financial incentives can be established so that agents internalize their principal’s costs. However, in contexts with multiple agents, these costs can also depend on the extent of standardization among the agents and across tasks for a given agent. By providing a rationale for mutual monitoring, peer pressure, and information sharing, group incentives can promote standardization where individual incentives cannot.

We consider the role of group incentives in the context of health care, where fragmentation among physicians and misaligned incentives between hospitals and physicians have
contributed to high growth rates in costs with questionable value (?)). Physicians are typically not hospital employees, yet physicians determine the use of other labor and non-labor inputs such as drugs and medical supplies. These inputs are purchased by the hospital. Hospital-supplier bargaining determines prices, which depends on physicians’ willingnesses to switch suppliers and to standardize their decisions.

Historically, regulatory barriers have prohibited hospitals from offering financial incentives to non-employee physicians. Recent decisions by Health and Human Services Office of Inspector General, however, have allowed these incentive programs known as "gain-sharing" to be implemented on a case-by-case basis. Manufacturing firms initially developed gainsharing to elicit tacit knowledge gained by workers from their experiences and encourage workers to share knowledge with each other (Welbourne, Balkin, and Gomez-Mejia (1995); Saver (2003)). Although gainsharing programs take a variety of forms, they share several common characteristics. First, each individual receives the same payout, which is determined by group-level performance rather than individual actions.\(^1\) Second, payouts are based on performance relative to a historical baseline, rather than absolute targets or performance relative to other firms or units within the firm, as in competitive tournaments. Previous work on gainsharing suggests it incorporates greater risk sharing, potentially aligning individuals’ incentives more closely to the firms’ interests (Gomez-Mejia, Welbourne, and Wiseman (2000)), but at the expense of greater shirking relative to competition-based incentives (Wageman (1995); Nalbantian and Schotter (1997)). Also, gainsharing’s endogenously-determined targets have been found to provide stronger incentives than targets based on external sources (Nalbantian and Schotter (1997)).

\(^1\)Gainsharing, one of several compensation schemes known as ‘forcing contracts’, aims to address potential moral hazard in groups in the context of a principle-agent relationship (Holmstrom (1982); Prendergrast (1999); Gibbons (2005)).
cian incentives result in utilization of inputs that may diverge from the hospital’s optimal utilization of inputs. We then show how the introduction of a group-based incentive for physicians can cause their decisions to move toward the hospital’s optimal utilization. This yields specific predictions about the effect of group incentives on the standardization of physicians decisions and the prices paid by hospitals for drug and devices. We test these outcomes using data from specific gainsharing programs that have been implemented in cardiology, which we describe in more detail below.

Our empirical analysis has several notable strengths that facilitate our ability to build upon prior work on these issues. First, we have data from multiple firms rather than a single firm. These data include firms that adopted group incentives as well as those that have not. For the adopting firms, the data include time periods prior to adoption. Likewise, the programs adopted across the firms were highly similar due to the regulatory approval process, as described below. The data are also very detailed, providing information on every individual product used by every individual worker (physician) for every individual "task" (patient). This includes the firm’s (hospital’s) acquisition costs for each product. They also include other detailed data such as patient clinical measures to eliminate a number of confounding factors. With these data we find that gainsharing moderately reduced the prices paid by hospitals for drugs and devices. The results support the model and indicate that this resulted from a variety of sources, including switching to lower priced products, hospitals negotiating lower prices, or standardization resulting in volume or market share discounts.

[Elaborate on results in separate paragraph]
2 A Theoretical Rationale for Group-Based Incentives

In this section we present a model for hospitals that operate cardiology service lines. Hospitals receive a fixed (prospective) payment for each patient and pay for all of the devices and drugs used during treatment. But treatment decisions about the types and quantities of devices and drugs used are made by non-employee cardiologists and internists. Due to negotiations between hospitals and drug and device manufacturers, hospitals’ prices depend on both the quantity of devices purchased as well as the share of devices purchased for a given type of device.

After presenting a simple model to reflect the environment that we wish to study, we first show that in the absence of a group-based incentives, physicians will not internalize the effects that their decisions about devices have on prices. We next demonstrate when group-based incentives can cause physicians to internalize the effects of their choices on the prices paid by the hospital. Because lower prices are achieved by standardization across physicians or the credible threat to collectively switch purchasing, group incentives create benefits to mutual monitoring and peer pressure. This causes physicians’ optimal choices of inputs to move toward that of the hospital in ways that various individual payment mechanisms such as prospective payment (including capitation) cannot. Although we demonstrate this in the context of hospitals and physicians specifically, this applies to any context in which a principal’s costs depend on coordination among its multiple agents.

Denote hospital $h$’s objective function $\Pi_{h,t}$ as:

$$
\Pi_{h,t} = \sum_{i=1}^{n} DRG_{i,t} - \sum_{a=1}^{A} \left( \sum_{c=1}^{C_a} p_{ca,t} q_{ca,t} \right) + \gamma \sum_{i=1}^{n} h(\theta_{i,t}, \bar{q}_{ca,t}),
$$

(1)

where: (i) $DRG_{i,t}$ stands for "diagnosis related group" and denotes the per-patient payment made by the third-party (insurer) to the hospital for treating patient $i$ in period $t$, (ii) $p_{ca,t}$
is the price (paid by the hospital to the manufacturer) of device \(c\) in category \(a\) at time \(t\), and \(q_{ca,t}\) is the quantity of devices \(c\) in category \(a\) purchased at time \(t\), and where

\[
\begin{align*}
    a & = \{1, \ldots, A\}, \\
    c & = \{1, \ldots, C_a\},
\end{align*}
\]

and (iii) \(\gamma\) denotes the weight the hospital puts on patient \(i\)'s post-treatment health \(h(\theta_i, q_{ca})\). This weight is greater than zero if either reputation or competitive effects increase profitability, or if the hospital directly values patient health outcomes per se.

2.1 Price setting

Prices for each device \(c\) in each category \(a\) (i.e., the vector of prices

\[
\{ p_{11}, \ldots, p_{C_1 1}; p_{12}, \ldots, p_{C_2 2}; \ldots; p_{1A}, \ldots, p_{C_A A} \}
\]

are the result of a bargaining process between the hospital \(h\) and the manufacturers. Hospitals can achieve two forms of discounts: (i) volume (based on the quantity of items purchased at the hospital level), and (ii) market share (based on the hospital's total purchases in the category). Thus, we can write hospital \(h\)'s pricing function to be:

\[
p_{ca,t} = p_h \left( q_{ca,t}^T, \frac{q_{ca,t}^T}{q_{a,t}^T} \right),
\]

(2)

where \(q_{ca,t}^T\) denotes the total quantity purchased of devices \(c\) in category \(a\) whereas \(q_{a,t}^T\) denotes the total quantity of devices purchased in a given category \(a\). We allow for a hospital-specific pricing function because the price levels and the volume and market share discounts depend on the bargaining power of the hospital. Both of these types of discounts are non-linear, with distinct tiers or thresholds at which points the price of every device purchased (including those purchased previously) under the current contract becomes lowered.
2.2 Patients

We define patients’ health as a decreasing function of their illness severity and increasing function of the care they receive from their physicians. That is, patient $i$’s health production function is given by:

$$h(\theta_i, \bar{q}_{ca,t}),$$

where the patient’s illness severity $\theta_i$ is drawn from a known illness severity distribution $F(\theta)$ and $\bar{q}_{ca,t}$ denotes the vector of care received (i.e., $\bar{q}_{ca} = \{q_{C11}; q_{C12}; ..., q_{C21}; q_{C22}; ..., q_{CA1}; ..., q_{CA}\}$) at time $t$.

2.3 The Hospital’s Problem

Suppose that the hospital could directly dictate the treatment vector for each of its patients. In the absence of endogenous prices (i.e., in the absence of a pricing function such as (2)), the hospital would maximize (1) by choice of vector $\bar{q}_{ca,t}$ for each patient $i$ separately without considering its impact on other patients.

In such a setting, the optimal vector $\bar{q}_{ca,i,t}^*$ would be chosen such that:

$$\bar{q}_{ca,i,t}^* \argmax_{q_{ca,t}} DRG_{i,t} - \sum_{a=1}^{A} \sum_{c=1}^{C_a} p_{ca,t} q_{ca,t} + \gamma h(\theta_{i,t}, \bar{q}_{ca,t}).$$

Holding prices as given, the marginal effect of increasing the quantity of a particular device $q_{ca,t}$ is given by:

$$-p_{ca,t} + \gamma \frac{\partial h}{\partial q_{ca,t}}.$$  

On the other hand, by holding quantities constant, the effect of moving from a particular device ($c$) to an alternative device ($c'$) within the same category $a$ (and abusing notation)
is given by:

\[ p_{ca,t} - p_{c' a,t} - \gamma h(\theta_i, q_{ca,t}) + \gamma h(\theta_i, q_{c' a,t}) \]  

(6)

However, as noted previously, prices do depend on the total quantity and concentration of purchases by the hospital in each category. Thus, modifying (5) and (6) to incorporate the endogeneity of prices yields the marginal effect of an increase of a particular device as:

\[ -p_{ca,t} + \gamma \frac{\partial h}{\partial q_{ca,t}} + \left( \frac{\partial p_h}{\partial q_{ca}} \right) q_{ca,t} + \left( \frac{\partial p_h}{\partial q_{ca}} \right) q_{ca,t-H} \]

(7)

where \( \left( \frac{\partial p_h}{\partial q_{ca}} \right) < 0 \) because of quantity and share discounts and where \( q_{ca,t-H} \) denotes the quantities used on other patients at the same hospital.

Similarly modifying the marginal effect of moving from a particular device \( (c) \) to an alternative device \( (c') \) in the same category \( a \), to include the effect on prices yields:

\[ p_{ca,t} + \left( \frac{\partial p_h}{\partial q_{ca}} \right) q_{ca,t} - p_{c' a,t} - \left( \frac{\partial p_h}{\partial q_{c' a}} \right) q_{c' a,t} - \gamma h(\theta_i, q_{ca,t}) + \gamma h(\theta_i, q_{c' a,t}) + \]

(8)

\[ \gamma \frac{\partial h}{\partial q_{ca}} q_{ca,t-H} - \left( \frac{\partial p_h}{\partial q_{c' a}} \right) q_{c' a,t-H} \]

By moving from device \( c \) the price of \( c \) may increase, whereas moving to device \( c' \) may decrease its price, depending on the tiers of the hospital-manufacturer contract.

2.4 The Physician’s Problem

In the absence of gainsharing, physician \( k \) who treats \( I \) number of patients is assumed to value his own income and paternalistically values his patients’ health\(^2\):

\(^2\)A more general form of altruism, in which the physician considers both the patient’s health and consumption (i.e., his entire utility) is equivalent to the paternalistic form taken here if patients are fully
\[ V_k^i = \sum_{i=1}^{I} Revenue_i + \beta \sum_{i=1}^{I} h(\theta_i, \bar{q}_{ca}), \]  

where \( I \) is the subset of \( n \) patients treated by physician \( k \).

Given that the physician faces no effects of his choices on his income, the physician chooses the vector of drugs and devices which maximizes his patient’s health:\(^3\)

\[ \bar{q}_{ca}^* \arg\max h(\theta_i, \bar{q}_{ca}). \]  

### 2.5 Comparing the Hospital’s Optimal Decisions with the Physician’s

This framework illuminates the fact that the physician’s utility maximizing vector \( \bar{q}_{ca}^* \) does not coincide with the hospital’s profit maximizing quantities simply because the physician does not consider the costs associated with his choices (i.e., (4) does not coincide with (10)). Specifically, the physician does not consider the effects of his choices regarding the number and types of drugs and devices. The type of device the physician uses is important for two reasons. First, certain devices are more expensive than others. As a result, the physician has no incentive to move to the lower-priced devices. Second, the price of devices depends on the quantity and mix of devices used by all physicians at the hospital (i.e., purchased by the hospital as a whole). As a result, the physician’s decisions about the quantity and mix of devices affects the prices that the hospital pays for all devices used by all physicians at the hospital. Given that hospitals typically receive prospective payments, higher device prices reduce its profits.

One way that the hospital could encourage physicians to internalize the effect that insured.

\(^3\)We make the simplifying assumption that physicians are not paid directly paid as a function of devices used. More realistically, physicians can receive an additional payment for each additional stent provided to a patient. But physician’s payments are invariant to the type of stent used (bare metal or drug-eluting) and to the quantity of other types of drugs and devices used.
his or her use of devices has on costs is through a prospective payment system (such as capitation) where physicians receive a fixed-payment for each patient they treat but are responsible for all costs (including device costs) without any marginal reimbursement. Paying a fixed amount to a physician for each patient he treats encourages physicians to (i) reduce the amount of devices he uses per patient and (ii) switch to lower cost devices. Such a prospective payment system, however, would not provide the optimal framework for physicians to coordinate their purchasing with one another. More specifically, physicians would have to coordinate their purchases with all other physicians in the hospital and thus large free-riding effects would prevail. By having each physician’s payout tied directly to the behaviour of other well-identified physicians may serve as a way to reduce the free-riding effects. Furthermore, because of tiered discounts, larger groups might have an additional incentive to coordinate as such tiers might be achievable in large groups but not in solo-practice or small groups.

We next provide a model which shows that under some conditions, group incentives such as the existing gainsharing programs can lead physicians to internalize such externalities.

3 Hospital-Physician Gainsharing in Cardiology

In this section we introduce the institutional details of the existing programs in cardiology into the model presented above. The model suggests that gainsharing can reduce costs through three pathways—reductions in quantities, reductions in prices through discounts, and reductions due to substitution of lower-priced items. Each of these is tied to standard-

\footnote{Note that by paying physicians prospectively, each might opt for inexpensive devices but not necessarily the same ones. Thus, the hospital is unlikely to benefit from quantity and market-share discounts. Thus, even in a prospective payment system in which physicians were responsible for drug and device costs currently paid by the hospital, physicians do not internalize the externalities of their choices on the prices paid by other physicians.}
ization, which under some but not all conditions is promoted by gainsharing’s group-based financial incentives that creates a rationale for physicians to monitor each other and share information. Gainsharing is one of several approaches to overcoming misaligned incentives between hospitals and physicians due to regulatory barriers to integration and divergent reimbursement methods. Many insurers including Medicare pay hospitals case rates that do not vary with the cost of medical devices and drugs used, while they pay physicians piece-rate for each service performed. Most hospitals do not employ the physicians who treat their patients, and regulations prohibit hospitals from making direct payments to physicians. These include both the “Stark” self-referral regulations and the Civil Monetary Penalties (CMP) “anti-kickback” restrictions included in the Medicare and Medicaid statutes of the Social Security Act.

In recent years, the Health and Human Services Office of Inspector General (OIG) has permitted a few hospitals to implement gainsharing with their non-employee cardiologists, cardiac surgeons and orthopedic surgeons. The current programs share many features in common as stipulated by the OIG. In each, hospitals pay physicians based on cost reductions in pre-determined areas that are subject to the physician’s control. A separate historical baseline is determined for every physician practice (whether a medical group or solo practice) that participates. Any savings from these baselines are shared equally (50/50) by the hospital and the group, where the group is required to provide the same payouts to each individual member, and physicians are not at risk for cost overruns (the lower bound on payouts is $0). In the programs with cardiologists that we examine, the payouts have averaged $17,000 (approximately 5% of cardiologists’ average income (?)) and ranged from $0-59,000 per physician. Each program runs for one year, at which point savings are estimated and payouts are made. A hospital can run subsequent annual programs, in which
case the baseline is recalibrated. Additional legal, historical and institutional details are provided in (Ketcham and Furukawa (2008), Saver (2003)).

The gainsharing programs relied on physicians’ practice affiliations to define the groups. Physicians formed partnerships prior and unrelated to the implementation of gainsharing, and switching practice affiliations during gainsharing was rarely observed in our setting. Thus we do not examine how gainsharing’s incentives alter the composition of the medical partnerships (Farrell and Scotchmer (1998); Levin and Tadelis (2005)) or the endogenous formation of teams (Hamilton, Nickerson, and Owan (2003)). Rather, we take group membership as exogenously determined. Although there are few interdependencies in production among physicians within the groups, coordination among physicians both across and between groups is relevant in hospitals’ negotiations with their suppliers because it can provide hospitals with the credible threat to shift their purchasing to other device manufacturers in addition to the discounts built into the tiered contracts. To promote coordination, the gainsharing programs provided physicians with financial incentives and information, in the form of detailed benchmarking reports of each physician’s practice patterns (Hansen (1997)). This information lowers the cost of within-group monitoring among physicians and might act through channels of (internal) guilt and (external) shame (Kandel and Lazear (1992)). Additionally, because the incentives are based on the practice’s

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5 Several of these programs were initiated prior to approval, in which case the program ran but physician payouts were held until the program was approved.
6 This is similar to the group-based MD incentives studied by Gaynor, Rebitzer, and Taylor (2004). Related work on factors influencing hospital bargaining power can be found in (Brooks, Dor, and Wong (1997); Cutler, McClellan, and Newhouse (2000); Dor, Grossman, and Koroukian (2004).
7 For further discussion of papers on group incentives see (Chee & Yoo AER01, Laffont & N’Guessan JITE, Varian JITE, Ma ReStat, McAfee & McMillan IER91, Jeon, Macho-Stadler & Perez-Castrillo) and papers on group incentives among physicians (Gaynor Rebitzer Taylor, Newhouse 73; Gaynor & Pauly, Gaynor & Gertler).
8 For further discussion of dual agency in the healthcare context, including models of physician behavior based on principal-agent relationships with patients, see for example (Dranove and White, 1987; Blomqvist (1991)). Gainsharing creates both dual agency relationships and multi-task agency in which physicians balance the objectives of both quality and cost efficiency (Holmstrom and Milgrom 1991). In our setup, the dual agency comes from the physician’s altruism (towards the patient) and the coordination issues (cost
performance overall, gainsharing creates incentives for a physician to share knowledge, for example regarding the relative advantages or similarities of various alternative drugs and devices, to the extent that such information sharing increases the gainsharing payouts by altering his partners’ choices.

The gainsharing programs studied here apply to cardiologists and internists working in hospital-based coronary catheterization laboratories ("cath labs"), which treat patients with a range of heart conditions including acute myocardial infarction and congestive heart failure. Diagnostic physicians typically inject patients with contrast to indicate the location and severity of blockages of the coronary arteries. The patient might then receive treatment with medication, be treated within the lab by an interventional physician (often the same as the diagnostic physician) with procedures including angioplasty, insertion of a coronary stent, or implanting of an electrophysiology device such as a pacemaker or defibrillator, or be transferred out of the lab for cardiac surgery. Both total cost and device costs per catheterization lab patient have risen sharply during the decade. In Figure 1 we report the average total and device costs per patient from 2000 through 2006 (calculated from a data set described below). During this time, average total cost climbed by 106% ($1598), with medical device costs accounting for 88% ($1409) of the increase and 84% of the total cost per patient at the end of 2006. Although previous work found that these gainsharing programs reduced hospitals’ costs for coronary stent patients by approximately 7% and lowered the prices paid for drugs and devices(Ketcham and Furukawa (2008)), theoretical and empirical research has not investigated how gainsharing lowered prices and the role of physician standardization in lowering prices.
3.1 Theoretical Model

We provide a simple multistage model in which the hospital introduces financial incentives at the physician–practice level to align physicians’ incentives with the hospital’s. Specifically, physicians face a mixed-payment system known as gainsharing whereby hospitals share cost reductions with physicians.

3.1.1 Hospitals

Denote the hospital $h$’s net revenue $\Pi$ from $n$ patients in year $t$ as:

$$\Pi_{h,t} = \sum_{i=1}^{n} DRG_i - \sum_{a=1}^{A} \left( \sum_{c=1}^{C_a} p_{ca,t} q_{ca,t} \right) - \sum_{j=1}^{J} \sum_{a=1}^{A} \text{payout}_{ja}^j,$$  \hspace{1cm} (11)$$

where $DRG_i$ denotes the per-patient payment made by the third-party (insurer) to the hospital for treating patient $i$, $p_{ca,t}$ is the price (paid by the hospital to the manufacturer) of device $c$ in category $a$, and $q_{ca,t}$ is the quantity of devices $c$ in category $a$, and where

$$a = \{1, ..., A\},$$

$$c = \{1, ..., C_a\}.$$  

Finally, $\text{payout}_{ja}^j$ denote the payouts made to physician group $j$ (where $j = \{1, ..., J\}$) for category $a$ of medical devices as part of the gainsharing agreement. For simplicity, and without loss of generality, we omit $\gamma \sum_{i=1}^{n} h(\theta_{i,t}, \overline{q}_{ca,t})$ term from the hospital’s objective function.

3.1.2 Payouts in Gainsharing

A framework of gainsharing and payouts to physicians:

The idea of gainsharing is to share cost-savings made over a given period between
physician groups and the hospital. In this framework, total savings incurred by physician group \( j \) between \( t \) and \( t - 1 \) are given by:

\[
savings^j_{(t-1,t)} = A \sum_{a=1}^{A} \left( \sum_{c=1}^{C_a} p_{ca,t-1} q^j_{ca,t-1} \right) - \sum_{a=1}^{A} \left( \sum_{c=1}^{C_a} p_{ca,t} q^j_{ca,t} \right)
\]

\[
= \sum_{a=1}^{A} \left( \sum_{c=1}^{C_a} p_{ca,t-1} q^j_{ca,t-1} - \sum_{c=1}^{C_a} p_{ca,t} q^j_{ca,t} \right)
\]

\[
= \sum_{a=1}^{A} (g^j_{a,t-1} - g^j_{a,t})
\]

\[
= \sum_{a=1}^{A} g^j_{a,t}
\]  

(12)

where \( g^j_{a,t} \) denotes total expenditures for category \( a \) in period \( t \) by physician group \( j \), and \( \tilde{g}_{a,t} \) denotes total savings (cost-savings) per category \( a \) for the same group of physicians. In our context, the categories are defined to be mutually exclusive (no potential for substitution between them) with the important exception of drug-eluting stents and bare-metal stents, which are substitutes but are treated as distinct categories.

In such a framework, payouts to group \( j \) would simply be:

\[
payout^j_t = \sigma \sum_{a=1}^{A} g^j_{a,t}
\]

(13)

where \( \sigma \) is the sharing parameter.

In this framework, savings can come from several sources: (i) moving to a lower price device \( c \) in category \( a \) (substitution effect), (ii) reducing the quantity of devices used (quantity effect), and (iii) discounts in the hospital-level price of a device \( p_{ca,t} \) (discount effect) due to negotiating or the volume or market share discounts (equation (2)).

The actual model of gainsharing and payouts:
The actual hospital-physician gainsharing programs that have been implemented and form the basis of our study deviate from this general framework in several respects. For all of the approved programs, the OIG has required $\gamma = \frac{1}{2}$. Also, physicians are not held responsible for increases in costs in any category, i.e. the category-specific savings are defined as

$$payout_{a,t}^j = \max \left( 0, \tilde{g}_{a,t}^j \right),$$

and the group’s payout is simply

$$payout_t^j = \frac{1}{2} \sum_{a=1}^{A} payout_{a,t}^j.$$  \hspace{1cm} (15)

Furthermore, the group’s own costs in the baseline year are not used to determine its payouts. Instead, a single baseline is calculated for each hospital $h$, and the baseline costs are allocated to each medical group based on the group’s share of the cardiac catheterization lab’s total patient volume in the baseline year.

Physician group $j$’s share of the hospital $h$’s total volume in $t-1$ is $s_{t-1}^j$, where

$$s_{t-1}^j = \frac{\text{volume}_{t-1}^j}{\text{Total volume}_{t-1}}.$$  \hspace{1cm} (16)

Then, the baseline share of total expenditures in category $a$ attributed to group $j$ is given

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$^9$For example, physician group $j$ treated 30% of all patients seen in the hospital’s cath lab.
by:

\[ \hat{g}^j_{a,t-1} = \frac{volume^j_{t-1}}{Total\ volume_{t-1}} \times Total\ Expenditures_{a,\ t-1} \]
\[ = \frac{volume^j_{t-1}}{Total\ volume_{t-1}} \times \sum_{j=1}^{J} \left( \sum_{c=1}^{C_a} p_{ca,t-1} \hat{g}^j_{ca,t-1} \right) \]
\[ = s_{j,t-1} \times \sum_{j=1}^{J} g^j_{a,t-1}. \]  

(17)

Thus, a group \( j \) which is responsible for 30 per cent of the patient volume in hospital \( h \) in year \( t - 1 \) will be attributed a baseline equal to 30 percent of total expenditures in each category \( a \) for year \( t \).

Consequently, the actual payout made to group \( j \) for category \( a \) is given by:

\[ payout^j_{a,t} = \frac{1}{2} \max \left( 0, \hat{g}^j_{a,t-1} - \hat{g}^j_{a,t} \right). \]  

(18)

As a result, (13) becomes:

\[ payout^j_t = \sum_{a=1}^{A} \left[ \frac{1}{2} \max \left( 0, \hat{g}^j_{a,t-1} - \hat{g}^j_{a,t} \right) \right], \]  

(19)

where the per-physician payout (in a group of size \( D_j \)) is simply given by:

\[ payout^j_{k,t} = \sum_{a=1}^{A} \left[ \frac{1}{D_j} \frac{1}{2} \max \left( 0, \hat{g}^j_{a,t-1} - \hat{g}^j_{a,t} \right) \right]. \]  

(20)

This payout rule can lead to the case where a physician group \( j \) receives a large payout without changing its behavior. For example, a physician group that accounts for 30 percent of the cath lab volume in the baseline year will have its baseline set at 30% of the total expenditures for each category. If the group had below-average expenditures in the
baseline year, it would receive a payout (i.e., $g_{a,t-1}^j > g_{a,t}^j$ even if $g_{a,t-1}^j = g_{a,t}^j$) simply by maintaining the same level of use.

Additionally, the current version of gainsharing requires that payouts are made only for predetermined "targets": prior to initiating the program, hospitals choose specific categories of drugs and devices for which payouts will be calculated, as well as whether the payouts will be generated due to reductions in quantities, average prices (whether through substitution or discounts), or both. That is, not all arguments in (12) are used to calculate the payouts to physicians. If only prices are targeted for a category, physicians have incentive to increase quantities, both because of the volume discounts and because the payouts are calculated by multiplying the reductions in price by the volume used in the program year.\(^{10}\)

3.1.3 Physician Preferences

Similar to (9), physician $k$ in group $j$ is assumed to have preferences over his income (which now include gainsharing bonuses), his patients’ health (a paternalistic form of altruism) and sanctions:\(^{11}\)

\[
V_{k,t}^j = \sum_{i=1}^{l} Revenue_{i,t} + \sum_{a=1}^{A} \frac{1}{D_j} payout^j_{a,t} + \beta \sum_{i=1}^{l} h(\theta_{i,t}, \bar{q}_{ca,t}) - \sum_{i=1}^{l} [\Lambda(\bar{q}_{ca,t}(\theta_i), \bar{q}_{ca,t}(\theta_i), D_j)],
\]  

\(^{10}\)This incentive is offset by the government requirement that payouts cannot be made for any volume of federally-insured patients beyond the volume in the baseline year, as well as by the requirement that physicians who alter the average clinical characteristics of their patients be excluded from the payouts altogether.

\(^{11}\)A more general form of altruism, in which the physician considers both the patient’s health and consumption (i.e., his entire utility) is equivalent to the paternalistic form taken here if patients are fully insured. This disutility from deviating from appropriate treatment is similar to prior models of physician behavior, e.g. Gaynor, Rebitzer and Taylor (2004).
where Revenue$_i$ represents the payment the physician receives for treating the patient $i$, $eta$ represents the physician’s level of altruism and $\theta_i$ denotes the patient’s illness severity. The vector of quantities provided by the physician is given by $\overline{q}_ca$ whereas the ‘appropriate or agreed upon’ vector of quantities is denoted by $\hat{q}_ca(\theta)$ (which we define in detail later). Finally, $\Lambda(.)$ denotes the utility loss (sanctions) associated with deviating from the agreed upon vector of drugs and devices (agreed upon at the hospital level). We assume that the utility loss is a function of the actual care provided, the agreed upon care as well as the number of physicians in the group. One can think of the $\Lambda(.)$ as a reduced-form punishment device for physicians that deviate from the group-norm.\(^{12}\)

Although the above specification assumes that physicians are altruistic (i.e., the patient’s health enters directly into the physician’s utility function) where $\beta$ denotes the level of altruism, the model could be modified in a simple manner to reflect heterogeneity in physicians’ preferences for specific devices. Specifically, (21) could be modified by dropping the term related to altruism (i.e., $\beta \sum_{i=1}^{I} h(\theta_i; \overline{q}_ca)$) and introducing a physician-specific preference for particular devices ($\sum_{i=1}^{I} h_k(\theta_i; \overline{q}_ca)$). As such, $h_k(\theta_i; \overline{q}_ca)$ can be thought of as the utility that physician $k$ receives from treating a patient $i$ with illness $\theta_i$ with the vector of particular devices $\overline{q}_ca$. In such a setting, a physician who has strong preferences for particular devices will see his utility vary greatly from one vector of devices to another for a particular $\theta_i$. On the other hand, a physician with very weak preferences for particular devices yield utility which is invariant to the vector of devices used (i.e., $h_k(\theta_i; \overline{q}_ca)$ will not vary from one vector of devices to another for a given $\theta_i$).Although we do not use this alternative representation in the derivations below, we discuss the results in both settings (i.e., for heterogeneity in physicians’ altruism and preferences for devices).

For physicians in solo practices, (21) reduces to:

\(^{12}\)This disutility from deviating from appropriate treatment is similar to prior models of physician behavior, e.g. Gaynor, Rebitzer, and Taylor (2004).
\[ V^j_{k,t} = \sum_{i=1}^{I} Revenue_{i,t} + \sum_{a=1}^{A} payout^{j}_{a,t} + \beta \sum_{i=1}^{I} h(\theta_{i,t}, q_{ca,t}). \] (22)

A solo physician does not face the free-riding problem—he simply decides how much he is willing to trade off his monetary payouts for his preferences for specific items, including the items’ effects on his patients’ health.

3.1.4 The Multi-Stage Game

Stage 1: Hospitals negotiate with manufacturers on the prices (contingent contracts with the manufacturers based on the quantity of the devices to be purchased).

Stage 2: Hospitals decide on the “appropriate” illness-specific treatment vectors \( q_{ca}(\theta) \) (treatment guideline for each illness severity \( \theta \)).

Stage 3: Physicians treat their patients maximizing their utility (i.e., decide on \( \theta_{ca}(\theta) \)) i.e., maximize (21).

Stage 4: The physician group monitors the members’ behavior.

Stage 5: Payouts are distributed and penalties attributed.

4 Solving the Model

We solve the model by backward induction. Because we have assumed Stages 5 and 4 to be deterministic, we solve Stages 3 through 1.

Stage 3: Physician \( k \)’s maximization problem:

Each physician \( k \) in group \( j \) chooses the vector of quantities \( q_{ca}(\theta) \) at time \( t \) that solves:
\[
\max_{\bar{q}_{ca}(\theta)} V^j_k = \sum_{i=1}^I \text{Revenue}_i + \sum_{a=1}^A \frac{1}{D_j} \text{payout}_a^j + \sum_{i=1}^I \beta h(\theta_i, \bar{q}_{ca}) - \sum_{i=1}^I \Lambda (q_{ca}(\theta_i), \bar{q}_{ca}(\theta_i), D_j),
\]

or

\[
\max_{\bar{q}_{ca}(\theta)} V^j_k = \sum_{i=1}^I \text{Revenue}_i + \sum_{a=1}^A \left[ \frac{1}{D_j} \max \left( 0, \frac{1}{2} \hat{g}_{a,t-1}^j - \sum_{c=1}^{C_a} \sum_{D \neq k}^D p_{ca,t} q_{ca,t} - \sum_{c=1}^{C_a} p_{ca,t} q_{ca,t}^k \right) \right] + \sum_{i=1}^I \beta h(\theta_i, \bar{q}_{ca,i}) - \sum_{i=1}^I \Lambda (q_{ca,i}, \bar{q}_{ca}(\theta_i), D_j),
\]

The benefits of deviating from \(\bar{q}_{ca}\) by increasing the quantity or substituting to higher-quality/higher-priced (or preferred) items is its effect on the patient’s health (or the physician’s utility). It may also decrease the price paid for the device which would apply to all devices used (on all patients) if this increase in quantity reached tier or market share discounts. The costs, on the other hand, are threefold: (i) it decreases the payout, (ii) it can lead to punishments due to monitoring by other members of the group, and (iii) a lack of coordination results in smaller market-share or volume price discounts. Because the payouts are shared equally between the group and the hospital, and the group’s share is split equally among its members, the payouts create free-riding incentives because each physician only bears a \(\frac{1}{D_j}\) share of his increases in medical expenditures. Furthermore, because the discount effect is shared equally among all physicians in the hospital, the free-riding effect associated with price reductions due to increased contract compliance are likely to be substantial. As a result, this mechanism alone is theoretically insufficient at controlling costs—hence the need for a group incentive to promote coordination and monitoring within the group. The programs implemented to date additionally incorporate incentives for coordination between groups by requiring positive net savings across all the groups at the
hospital for any group to receive a payout.

By solving (24), we denote the group-physician’s and solo-practice physician’s utility maximizing vector of care or reaction function to be \( \mathbf{q}_{\text{ca},i}^*(\theta_i, \beta, \tilde{q}_{\text{ca},i}, D_j) \) and \( \mathbf{q}_{\text{ca},i}^*(\theta_i, \beta, \tilde{q}_{\text{ca},i}) \), respectively.

**Highlights from stages 3-5:**

(A) For a group-practice physician, the marginal effect of increasing one unit of a given device \( q_{\text{ca}} \), holding fixed the type of device and the number of patients, is (assuming an interior solution):

\[
- \frac{1}{D_j} \frac{1}{2} p_{\text{ca},t} - \frac{1}{D_j} \frac{1}{2} q_{\text{ca},t}^t p'_{\text{ca},t} + \beta h' - \Lambda' - \frac{1}{D_j} \frac{1}{2} q_{\text{ca},t} - J p'_{\text{ca},t},
\]

where \(- \frac{1}{D_j} \frac{1}{2} q_{\text{ca},t} - J p'_{\text{ca},t}\) denotes the increase in the payout that comes from potentially decreasing the prices paid on ALL devices (within the category) used by all Team members (including the physician himself).

If we assume that the price effects are negligible, then (25) reduces to:

\[
- \frac{1}{D_j} \frac{1}{2} p_{\text{ca},t} + \beta h' - \Lambda'.
\]

For a solo-practice physician, the marginal effect of increasing one unit of a given device \( q_{\text{ca}} \), holding fixed the type of device and the number of patients is (assuming an interior solution):

\[
- \frac{1}{2} p_{\text{ca},t} - \frac{1}{2} q_{\text{ca},t}^t p'_{\text{ca},t} + \beta h' - \frac{1}{2} q_{\text{ca},t} - J p'_{\text{ca},t},
\]

where \(- \frac{1}{D_j} \frac{1}{2} q_{\text{ca},t}^t p'_{\text{ca},t}\) denotes the increase in the payout that comes from potentially decreasing the prices paid on ALL devices (within the category) used by that solo-practice physician.
If we assume that the price discount effect is negligible, then it becomes:

\[-\frac{1}{2}p_{\text{ca},t} + \beta h'.\]  

(27)

Thus a group-practice physician has: (i) on the one hand a greater incentive to increase the quantity of a given device \(q_{\text{ca}}\) as the costs of doing so are shared by both the hospital and the other physicians, and (ii) on the other hand smaller as there is group monitoring. If the free-riding effect dominates (is dominated by) the monitoring effect, a group-practice physician will have a greater (smaller) incentive to increase his quantity of devices (i.e., a smaller incentive to decrease the quantity of devices used) than a solo-practice physician. [Although the free-riding effect might be larger is larger groups, larger groups may have more incentive to coordinate in the first place as they are likely to be able to benefit from tier-discounts that smaller groups cannot]

(B) For a group-practice physician, the marginal effect of moving away from the agreed upon device \(c\) to the physician’s utility-maximizing (or preferred) device \(c'\) holding fixed the quantity of devices and the number of patients and ignoring the discount effect is:

\[
\frac{1}{D_j} \frac{1}{2} \left( p_{\text{ca},t} q_{\text{ca},t} - p_{c',a,t} q_{c',a,t} \right) + \beta(h(\theta_i, q_{c',a,i}) - h(\theta_i, q_{\text{ca},i})) - \Lambda(q_{c',a,i}, \tilde{q}_{\text{ca},i}(\theta_i), D_j) \]  

(28)

For a solo-practice physician, the marginal effect of moving away from a given device \(c\) to the physician’s utility-maximizing (or preferred) device \(c'\) holding fixed the quantity of devices and the number of patients and ignoring the discount effect is:

\[
\frac{1}{2} \left( p_{\text{ca},t} q_{\text{ca},t} - p_{c',a,t} q_{c',a,t} \right) + \beta(h(\theta_i, q_{c',a,i}) - h(\theta_i, q_{\text{ca},i})).
\]
Thus as the number of physicians in the practice increases, a physician has: (i) on the one hand a greater incentive to move to his preferred device $c'$ because the costs of doing so are shared by both the hospital (half) and his other group members, and (ii) on the other hand smaller as there is monitoring within the group. If the free-riding effect dominates (is dominated by) the monitoring effect, a physician in a larger group will have a greater (smaller) incentive to use his preferred device $c'$ rather than the agreed upon device $c$.

(C) The free-riding effect is larger with larger group size (i.e., less incentive to decrease quantity and more incentive to use the preferred device). Without formally modelling the marginal benefits and costs of monitoring, its relationship with physician practice size is unclear.

(D) The willingness of physicians to coordinate on particular devices is a direct function of each physician’s willingness to align their use of particular devices to the hospital-level treatment guidelines. To highlight this effect, we examine different potential levels of the preference parameter $\beta$ and examine its likely effect on coordination of devices. Alternatively, this can be conceptualized as how much the $h_k$ function varies from one device to another, that is, the degree of substitutability between alternative products within the category.

(i) Suppose that physicians have no preferences for one device over another in the category (i.e., $\beta = 0$). This could result if devices are identical, if they do not face costs due to switching (for example due to learning by doing), or if they gain no utility from their patients’ health. In this case, physicians do not receive any benefit from deviating and will exclusively use the agreed-upon device, because this standardization decreases the prices paid by the hospital, increasing the gainsharing payout. This also eliminates the utility loss due to monitoring. Thus coordination on devices at the physician, group and hospital levels should be strong.

24
(ii) Suppose that physicians had extremely strong preferences for particular devices, for example due to large clinical differences between them combined with strong altruistic preferences for patient health, or due to steep learning curves. In this case, the model predicts that gainsharing will have no effect on the physicians' choices of devices. Thus, gainsharing will not promote coordination on devices at the physician, group or hospital level.

(iii) Finally, suppose that physicians have preferences over some devices under certain situations but not for others (or similarly, have some preferences over some devices but not others). For example, suppose that for some of a physician’s patients, two alternative devices in a category yield identical outcomes, but for his other patients one device is clinically superior than the other. This could yield divergence in device use at the physician level, because physicians might be willing to move away from their preferred device to the agreed upon device for some cases/patients but not for others. Thus if a physicians preferences vary across his patients, gainsharing could generate divergence at the physician level. What happens at the group and hospital level is ambiguous as it depends on the patterns of convergence at the physician level. Nonetheless, we should see convergence for a given level of illness severity $\theta$.\footnote{This depends in part on the degree of heterogeneity across physicians, which we have not considered in depth here.}

Given (i)-(iii), the model indicates that gainsharing might not promote standardization in physicians’ choices of devices and drugs, and in fact it might decrease coordination. The result ultimately depends on how strong the physicians preferences for particular devices is weighed relative to the monetary benefits of coordination and the monitoring effects of the groups. Because this in part depends on the outcome of hospital-manufacturer negotiation, we return to this following the solution to stage 1.

**Stage 2: Choosing the optimal vector $\tilde{q}_{ca}(\theta_1)$:**
In this stage, the hospital must decide on treatment guidelines. These guidelines seek to minimize health-care expenditures for a given level of quality, which is determined by the hospital’s preferences for quality and the OIG’s restrictions on reductions in device quantities. Gainsharing incorporates two mechanisms that align the hospital’s and physicians’ incentives: the financial incentive of the payouts themselves, and the benchmarking information that facilitates physicians’ ability to monitor each other and punish those who deviate from the treatment guidelines. Each vector $\hat{q}_{ca}(\theta_i)$ chosen by the hospital elicits a reaction from each of its physicians (i.e., $\eta^*_c(\theta_i, \hat{q}_{ca}, \beta, D_j)$) and an expected income (where the expectation comes from uncertainty about the distribution of patients’ illness severities under gainsharing relative to the baseline year). In addition to aligning physician-hospital incentives, because the payouts are dependent on the choices of the entire group, and to a lesser extent on the choices of all of the physicians at the hospital, gainsharing also creates incentive for physicians to share information about the similarities and relative advantages of alternative devices. This information-sharing enters into the physician reaction function and thereby influences the hospitals’ choice of optimal vector of $\hat{q}_{ca}(\theta_i)$.

We denote the hospital’s income maximizing optimal vector of $\hat{q}_{ca}(\theta_i)$ as $\hat{q}^*_{ca}(\theta_i)$. That is, $\hat{q}^*_{ca}(\theta_i)$ is the vector which maximizes the income of the hospital conditional on the reaction function of each of its physicians (i.e., conditional on $\eta^*_c(\theta_i, \hat{q}_{ca}, \beta, D_j)$ for all $i$).

**Stage 1: Hospital-manufacturer negotiation:**

In this first stage, the hospital must negotiate with each manufacturer to determine a price function (i.e., $p_{ca} = p_h \left( q^T_{ca}, \frac{\partial q^T_{ca}}{\partial \theta} \right)$).

From the previous stages, $\hat{q}^*_{ca}(\theta_i)$ was the hospital’s profit maximizing vector given the physicians’ reactions functions where prices were taken as exogenous. Specifically, $\hat{q}^*_{ca}(\theta_i)$ depends not only on how physicians will react but also the prices associated with each of the devices in each of the category. To make this explicit, we re-write $\hat{q}^*_{ca}(\theta_i)$ as $\hat{q}^*_{ca}(\theta_i|p_{ca})$. 

26
In the absence of manufacturer competition, the manufacturer would choose a price function \( p_{ca}^* \) that would maximize its profit given the hospital’s optimal response vector \( \tilde{q}_{ca}^*(\theta_i|p_{ca}) \) and its associated physicians’ reaction functions \( \overline{q}_{ca,i}^*(\theta_i, \beta, \tilde{q}_{ca,i}, D_j|p_{ca}) \). Thus, \( p_{ca}^* = \arg \max_{\tilde{q}_{ca}^*(\theta_i|p_{ca})&\overline{q}_{ca,i}^*(\theta_i, \beta, \tilde{q}_{ca,i}, D_j|p_{ca})} \). (29)

In the presence of manufacturer competition, the manufacturer must not only consider how the hospital and its physicians will respond to each price it sets, but also how its competitors will react. However, level of competition depends on the number of manufacturers, and more importantly, the physicians’ willingness to move away from their preferred devices to the agreed-upon devices. If physicians are very reluctant to deviate from their preferred devices (i.e., devices are very weak substitutes for each other) and convergence is expected to be very weak, then manufacturers of those devices can exert market power and set prices accordingly. Thus, prices of the hospital are not expected to converge across manufacturers in the category.

If, however, physicians have very weak preferences for particular devices, then devices are strong substitutes for each other. Consequently, the hospital’s credible threat to switch purchasing decisions to lower-priced alternatives will create strong incentives for manufacturers to reduce their prices and converge to a single price. If the remaining differences in prices are small, then physicians and hospitals may have little incentive to actually converge devices. Because this price convergence eliminates savings from substitution of cheaper alternatives, the main remaining incentive to converge on devices is to achieve greater contract compliance and realize lower prices through the market share or volume discounts. Thus, a potential outcome of gainsharing is the convergence on prices without a strong convergence on devices when preferences are weak.

**Summary of the Comparative Statics:**
I - Physicians have strong preferences for particular devices and quantities:

In this case, physicians are reluctant to switch devices or reduce quantities and little standardization will occur. Given these strong preferences, manufacturers will exert market power and maintain their previous levels of price dispersion. Thus in this case we expect to see little within-category standardization on either devices or prices. When physicians have strong preferences, we expect gainsharing will generate few savings from any of the quantity, substitution, or discount effects.

II - Physicians have weak preferences for particular devices and quantities:

In this case, physicians have strong incentive to switch to the agreed upon devices and the willingness to converge is strong. Given this strong willingness to convergence, manufacturers will face strong competition and convergence on prices should be strong. Thus in this case we expect to see strong convergence on prices but ambiguous convergence on devices. When physicians have weak preferences, we expect to see gainsharing reduce costs due to quantity and discount effects, and potentially but not necessarily due to substitution effects.

III - Physicians’ preferences for particular devices vary across their patients:

In this case, the results are ambiguous. A given physician might either increase or decrease his degree of device standardization across his patients. Given this ambiguity at the physician level, the implications for standardization at the group or hospital level are also ambiguous. In this case, we expect to see that gainsharing lowers costs via both quantity and substitution effects for some types of patients but not for others. The degree of savings due to discount effects is positively related to the proportion of patients for whom physicians have weak preferences about devices.

Hospital-level standardization without group-level standardization:
a special case.

In the above discussion, we implicitly assumed that each physician faced a similar distribution of patient types (or at least, each was choosing his or her patients randomly from the distribution $F(\theta)$). Thus, we should see convergence on devices if physicians have weak preferences (or weak altruism) as physicians will follow the treatment guidelines. If, however, physicians face very different types of patients (because of pre-gainsharing specialization) then we may see very little convergence at the group level simply because the treatment guidelines are different from one physician to another within the same group (i.e., because the treatment guidelines are different from one patient to another). Take the extreme case where each physician faces a group of patients where the distributions of illnesses are mutually exclusive from one subset to another. If each physician follows the treatment guidelines (i.e., $\tilde{q}_{ca}(\theta)$) but that these treatment guidelines are very different from one subset of patients to another, then within-group convergence will not occur. Nonetheless, we may see convergence at the hospital level conditional on illness severities. This would occur if all physicians who treat similar patients (i.e., patients with similar illness severities $\theta$) moved to the same type of device. Doing so would lead to savings (and thus gainsharing payouts) as coordination would lead to lower prices due to quantity and market share discounts (as these are negotiated at the hospital level NOT the group level).

5 Empirical Analysis of Gainsharing in Cardiology

5.1 Data

All of the approved programs in cardiology were submitted by clients of Goodroe Healthcare Solutions, a health care consulting firm owned by VHA. Goodroe provided us with detailed
data covering the fourth quarter of 2001 through the end of 2006. To our knowledge, Goodroe has also overseen all of the non-approved programs as well, totaling 13 annual programs at 6 hospitals completed or initiated before the end of 2006. Table 1 reports the timing of each program and the number of groups and physicians in each. These data are an unbalanced panel, where inclusion is determined by employment of Goodroe's services and installation of their software to capture the data. These data cover time periods before and during gainsharing. We eliminated data from gainsharing hospitals that were between or after but not currently operating a gainsharing program. We also eliminated patients treated at gainsharing hospitals by physicians who never participated in gainsharing. In total, 161 physicians from 35 groups treated 58,399 patients under these programs. Practice sizes ranged from 1 to 17 physicians, and the average patient under gainsharing was treated by a physician in a group of 11. The data include an additional 123 hospitals that did not participate in gainsharing.

These data incorporate both real-time information gathered in the cath lab and other data collected by the hospital. They include numerous patient clinical characteristics (more detailed than insurance claims data) such as severity of illness and existence of comorbidities; which procedures were performed; whether the patient incurred in-lab complications, and the outcome of the procedure; various characteristics of the drugs and devices provided to each patient, including the manufacturer, product number and model number, the size or strength (where relevant), and prices paid for them by the hospital, net of rebates; identifiers for the diagnostic and interventional physician; and, for gainsharing physicians, their practice affiliations.

Patients treated in cath labs receive drugs and devices from up to 20 distinct categories.

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14 Data from 2000 and earlier in 2001 were provided but were missing some important features we use in the analysis.

15 These non-participating physicians treated only 0.35% of the patients treated at gainsharing hospitals.
We focus on the five most expensive: drug-eluting stents, bare metal stents, coronary balloon catheters, antithrombotic therapy, and vascular closure devices.\textsuperscript{16} These categories varied in their number of competing suppliers and the degree of substitutability among them. For example, drug-eluting stents were not available in the US at the beginning of the study period, but two manufacturers, Cordis (part of Johnson & Johnson) and Boston Scientific, introduced their product to the US during the study period. Alternatively, hospitals in our study sample purchased bare metal stents from eight different manufacturers.\textsuperscript{17}

These data incorporate selection on unobserved characteristics along multiple dimensions: physicians sort into practices, practices decide whether to enter and exit gainsharing, physicians decide whether to treat their patients at the gainsharing hospital or elsewhere, hospitals decide whether to enter and exit gainsharing, and hospitals decide to employ Goodroe Healthcare.\textsuperscript{18} Despite the richness of the data, they offer few approaches to identify these selection models and address any bias that results. Thus we do not generalize our results to physicians, hospitals and clinical service lines that have not yet adopted gainsharing.

5.2 Standardization on Device Manufacturer and Price

We consider standardization at the physician, practice, and hospital level. As the model indicated, gainsharing’s incentives can diminish the amount of within-physician standard-

\textsuperscript{16} We exclude the highest-cost category, electrophysiology (e.g. pacemakers and defibrillators), because they were not always included in gainsharing programs, because they are used typically by only one or two physicians in each hospital, and because unlike the other categories they were not consistently captured by the Goodroe software during all of the study periods. Lower-cost categories included peripheral stents, guides, other catheters, sheaths and contrast.

\textsuperscript{17} When the patient was treated by different diagnostic and interventional physicians, we ascribe the relevant drugs and devices to each physician based on which type of physician uses which type of item. If a patient was treated by two or more of the same type of physician, the devices and drugs were assigned to all physicians. We included these observations in the reported analysis, but excluding them did not meaningfully alter the results.

\textsuperscript{18} In previous work we found no evidence that gainsharing altered physician’s treatment volumes or caused steering of healthier patients toward gainsharing (Ketcham and Furukawa (2008)).
ization when a physicians’ preferred drugs and devices vary across his patients. When preferences are weak or alternative products are close substitutes, however, gainsharing can promote standardization on prices by enhancing hospitals’ negotiating power with manufacturers, and the resulting similarity of prices can attenuate physicians’ need to actually standardize on manufacturer. We also investigate the degree of standardization at the practice level, since the group incentives of gainsharing might promote coordination through information sharing and monitoring; and the hospital level, which influences the prices paid by the hospital for the drugs and devices and will reflect coordination and information sharing between practices as well as within the lower two levels. Although these group and hospital-level measures reflect the aggregation of the physicians’ decisions for each patient, standardization at the three levels are not necessarily positively correlated because physicians or groups can standardize to different treatment vectors.

We generate several measures of standardization. For standardization on manufacturer, we create a Herfindahl-Hirschman Index \( HHI_{aght} = \sum_{c=1}^{C_a} \left( \frac{q_{aght}^c}{q_{aght}} \right)^2 \) for category \( a \) with \( C_a \) manufacturers) and the top manufacturer’s share of the total volume in the category (CR1). Standardization on price is measured as the standard deviation of prices in the category.\(^{19}\) This measure incorporates the effects of both physicians’ choices of devices (the substitution effect) and the outcomes of hospital-manufacturer bargaining. In the section on prices below we further distinguish between them.

We conduct reduced-form analysis

\[
Y_{ght} = \beta_0 + \beta_1 G_g + \beta_2 T_t + \beta_3 H_h + \epsilon_{ght} \tag{30}
\]

where \( Y_{ght} \) is the HHI, CR1 or standard deviation of prices, \( T \) is a vector of year-by-quarter

\(^{19}\)The data include a few implausible outliers. Those below the 0.1 percentile or above the 99.9 percentile of the price distribution for each category are recoded to missing.
fixed effects, $H$ is a vector of provider fixed effects that depend on the level of analysis (physician, practice, or hospital), $G$ is an indicator for gainsharing, and $\varepsilon_{ght}$ is an i.i.d error term. Data from the non-gainsharing hospitals are included to define the secular time trend in the physician and hospital-level analyses. However, because the data for these hospitals lack the physician practice affiliations, they are excluded from all practice-level analysis, and the time trend is identified by the gainsharing-participating hospitals only.

The HHI and CR1 range from 0 to 1 and ideally would be estimated with fractional logit models (Papke and Wooldridge (1996)). However, the large number of physician identifiers makes this not feasible for the physician-level estimates. To be consistent, we estimated linear models for all three levels and noted that they yielded similar results to the fractional logit models for hospital and group-level standardization. The estimates for drug-eluting stents begin in the first quarter of 2004 after the second manufacturer, Boston Scientific, entered the market, giving physicians a choice of manufacturer.

Tables 2-5 present the incremental effects of gainsharing on standardization as measured by HHI, CR1 and the standard deviation of product prices. Robust standard errors clustered by the level of analysis (e.g. physician) are reported. The results in Table 2 indicate that gainsharing promoted within-physician standardization, with increases in the manufacturer HHI and CR1 of 5-10% for drug-eluting stents (DES), balloons, and vascular closure devices. Antithrombotic therapy experienced strong convergence on prices, with reductions due to gainsharing over 100% of the mean of standard deviation in prices. This convergence on prices was not accompanied by convergence on manufacturer, which is expected if gainsharing resulted in a hospital achieving more standardized prices across manufacturers rather than physicians switching to lower-priced devices. The only category not experiencing within-physician standardization was bare metal stents (BMS). This

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20The intraclass correlation coefficients of the residuals were consistently significantly different from zero, indicating the need for clustering.
likely result from the fact that even apart from gainsharing, BMS market share was rapidly declining and manufacturers were exiting during this time as DES became the standard of care, leaving little room for gainsharing to generate additional standardization.

The results for within-hospital standardization in Table 3 generally concur with those for within-physician standardization, with significantly higher standardization on manufacturer for DES and balloons. In these two categories, the magnitude of the within-hospital effects are consistently larger than the within-physician effects. This suggests that in the cases when physicians did alter their choices under gainsharing, they did so in ways that converged to their peers in the hospital.

In Table 4 we report the results from the analysis of within-practice standardization. While for solo physicians this is identical to the within-physician standardization, for physicians in larger practices it incorporates both the within- and between-physician standardization. In contrast to the previous results, we find little evidence that gainsharing promoted physicians to standardize within their practices. The only exception is the significantly lower degree of price variation for antithrombotic therapy. One likely explanation of this large discrepancy is the fact that non-gainsharing hospitals were not available to use as a control group in this analysis.\footnote{Additional investigation of these results are required. For example, the non-significant results might stem from the unbalanced nature of the data, or from measurement error in the group affiliations.}

To lessen the impact of this limitation, we focus on how the within-practice standardization under gainsharing varied by practice size. To do this we analyzed the regression

\[
Y_{ght} = \beta_0 + \beta_1G_g D_h + \beta_2T_t + \beta_3H_h + \varepsilon_{ght}
\]  

(31)

where $D$ is a vector of physician practice size indicators (solo practice and 2 physicians, 3-5, 6-10, and 11 or more physicians). Table 5 reports the incremental gainsharing effect
for the smallest size category, followed by the additional incremental effects for each of the larger sizes. The significance levels reported in the table for each of the larger practice sizes indicate the differences in gainsharing’s effect for them relative to solo and two physician practices. Below the coefficients in the table are the P-values for gainsharing’s total effect for each of the larger practice sizes (relative to 0). The results are consistent with those in Table 4, with few examples of gainsharing altering within-practice standardization for any of the practice sizes. Statistically significant gainsharing effects on within-practice standardization appear only for the largest practices’ choices of antithrombotic therapy.

5.3 Price Effects from Substitution and Discounts

To estimate the overall effects on the price per drug or device, we estimated device-level versions of (??), where \( I_i \) is a vector of hospital indicators. To isolate the price effects due to discounts, we also estimated this regression with product-level fixed effects, where products are defined based on codes in the data and refer to a group of specific models sold by a given manufacturer (the models vary by size or other specific characteristics.) We implemented a third specification with product fixed effects and controls for the product’s volume and market share for the quarter at the hospital. This allowed us to further distinguish price discounts that arose from greater contract compliance from those that resulted from gainsharing altering the negotiating between hospitals and manufacturers. The drug-eluting stent analysis begins in the second quarter of 2003, following the FDA’s April, 2003 approval for Cordis to sell drug-eluting stents in the US. The analyses of all of the other categories begin in the fourth quarter of 2001.

Table 6 reports the results from linear models with robust standard errors clustered by hospital. The results provide strong evidence that gainsharing reduced the prices paid for drugs and devices. The largest absolute overall reductions were $169 (6.5% of the mean) for
DES, and the statistically significant largest percent reduction was 21.1% ($40) for vascular closure devices. Gainsharing also significantly reduced average prices for BMS and balloon catheters, and large but statistically insignificant reductions for antithrombotic therapy.

These overall price effects reflect the weighted sum of the within-product discount effects and between-product substitution effects. The second column in Table 6 indicates that discounts account for a large share of the price reductions for DES and BMS. Alternatively, much of the price reductions for balloons and vascular closure devices are due to physicians switching to lower-priced products. The third column decomposes these discount effects further and indicates that how gainsharing led to discounts varied across categories. For DES and BMS, the effect was entirely due to gainsharing increasing a hospital’s greater ability to negotiate lower prices. In fact, balloon catheters is the only category in which hospitals appear to achieve either volume or price discounts. (Because we specified the relationships between volume and market shares and prices as linear, in the other categories this might not detect the non-linear pricing contracts that we believe to be more common.) Thus the within-hospital standardization we observed for balloon catheters appears to be due to physician’s coordinating to achieve lower prices through contract compliance.

Alternatively, the within-physician standardization of vascular closure devices appears to be due to switching to lower-priced items. To investigate this further, we analyzed how gainsharing altered a manufacturer’s average price at a hospital in a quarter. Specifically, we estimated the elasticity of demand and allowed elasticity to differ under gainsharing by implementing the regression

\[
Y_{ghtm} = \beta_0 + \beta_1 G + \beta_2 P_{htm} + \beta_3 G_g P_{ghtm} + \beta_4 T_t + \beta_5 H_h + \beta_6 M_M + \varepsilon_{ght} \quad (32)
\]

where \( Y \) is manufacturer \( m \)'s share of the hospital’s total purchases for the category for a given quarter and gainsharing status, and \( P \) denotes the average product price. Because
conditional logit models could not be estimated with the large number of fixed effects, we estimated these with linear models and defined the market share to range from 0 and 100.

Several results are evident in Table 7. First, gainsharing in general does not appear to alter physician’s purchasing patterns apart from its effects on manufacturer’s relative prices. The exception is for vascular closure devices, where gainsharing generated a large increase in the average market share for vascular closure device manufacturers conditional on their prices. This suggests that physicians are sharing information about vascular closure devices that alters their purchasing patterns.

Second, hospitals have elastic demand even apart from gainsharing for BMS, DES and balloon catheters. This suggests that non-gainsharing hospitals are able to have some influence over physician’s purchasing decisions. This could result from other programs offered by Goodroe to its non-gainsharing clients, such as reinvestment programs for cost reductions and might not be generalizable to hospitals in the US as a whole. Finally, manufacturer’s market shares under gainsharing are substantially more responsive to prices for DES, balloon catheters, and vascular closure devices. This is consistent with the results in Table 6: physician’s greater sensitivity to the hospital’s prices in their choice of device manufacturer resulted in greater bargaining discounts for DES and switching to lower-priced items for balloon catheters and vascular closure devices. Given the lack of gainsharing’s effect on the sensitivity to BMS prices, however, the rationale behind the price discounts for them observed in Table 6 remains uncertain.

5.4 Discussion

When a firm’s costs depend on coordination across workers or agents, group incentives can lower costs by promoting standardization. By causing individuals to internalize the effects of their own decisions on the costs created by others, group incentives have a rationale even
in contexts without team production or long term relationships among group members. Because of this externality, group incentives can reduce costs even more than individual incentives that cause a worker to consider the effects of his choices on only his own costs.

Empirical analysis in the context of hospital-physician gainsharing in cardiology illustrated this. Specifically, we found that implementing group incentives for physicians systematically lowered the prices hospitals paid for high-priced drugs and devices purchased by the hospital at the discretion of physicians. As our theoretical model of gainsharing demonstrated, the mechanism by which prices were lowered varied across types of devices and drugs, and the relationships between lower prices and actual standardization varied. For some types of devices, prices were lowered primarily by switching to lower-priced substitutes. For others, price discounts were achieved via enhanced hospital bargaining power due to the credible threat of switching. And for others, discounts resulted from greater contract compliance. In some cases these lower prices were accompanied by physicians’ standardizing their purchasing decisions both across each one’s individual tasks (patients) and across physicians at the hospital.

We also found evidence that when prices converge across manufacturers due to physicians’ willingness to switch, little actual standardization becomes necessary because the price effects were achieved through discounts rather than through substitution. Additional empirical analysis should consider the extent to which these differences across categories are due to differences in physicians’ views about the substitutability of available alternative products within the category. Other areas for future work include identifying the importance of group incentives in promoting information sharing among group members, particularly whether lower-cost group members appear to influence the decisions of their highest-cost peers.
References


