The When and Why of Abandonment: The Role of Organizational Differences In Medical Technology Life Cycles

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Although the adoption of new technology has received significant attention in management research, investigations of abandonment have lagged. In this study, we examine differences in the rates of abandonment of medical technologies based on whether abandonment occurs in response to the emergence of a superior technology or in light of new information questioning its efficacy. We link differences in responses to underlying differences in the missions and incentives of organizations. Examining coronary stents across three technological regime changes using a census of approximately two million patients admitted to Florida hospitals from 1995 to 2007, we show meaningful differences across three hospital types: for-profit, not-for-profit, and academic medical centers. Results show that for-profit hospitals abandon the earlier generation in favor of a superior technology faster than not-for-profit hospitals, but this is not the case if the efficacy of the technology is questioned. Academic medical centers, however, have the highest rates of abandonment under both triggers. Importantly, we find that organizational factors dominate physician differences as explanatory factors for abandonment. Implications of these findings are twofold. First, we identify the factors likely at play, i.e., the salience of norms of science and the corresponding trade-offs with economic benefits, when organizations make abandonment decisions. Second, our work underscores the importance of organizational mission, which dominates individual preferences in determining rates of abandonment.

Keywords: technology abandonment; organizational incentives; norms of science; financial incentives; healthcare; medical devices; medical guidelines; econometric analysis

History: Received October 1, 2014; accepted December 7, 2015, by David Hsu, entrepreneurship and innovation. Published online in Articles in Advance August 11, 2016.
mission along two salient and critical dimensions. First, significant variation exists in both the degree to which hospitals are motivated to maximize profits and the value they accord to being at the cutting edge of medical practice. Second, innovation, discovery, and the development of new technologies are quintessential characteristics of the practice of medicine, which can be traced back over centuries (Bynum and Porter 2013). To the extent that organizations in medicine frequently and inevitably wrestle with adoption and abandonment decisions, an analysis of the interaction of innovation adoption, abandonment, and organizational norms is especially pertinent in the context of hospitals.

Our focus is on one specific medical technology—coronary stents (or percutaneous coronary interventions), which are utilized for the treatment of stable coronary arterial disease (SCAD). The utilization of stents has evolved significantly since their introduction through two discrete changes in the surrounding technological regime, making this setting appropriate for our study. First approved by the U.S. Food and Drug Administration (FDA) as bare metal stents (BMSs) in 1995, the initial stenting technology presented a revolutionary advancement for treating SCAD. The first regime change occurred in 2002, with the development of drug-eluting stents (DESs), a significant improvement in the base technology (i.e., the emergence of a superior technology). The second change occurred in December 2005, due to a watershed medical guideline released jointly by the American Heart Association (AHA) and the American College of Cardiology (ACC; Smith et al. 2006). This guideline questioned the efficacy of stents for low-severity SCAD patients and explicitly recommended a discontinuation of their use for those patients.

We leverage a longitudinal data set from 1995 to 2007 that captures the census of stenting decisions in Florida hospitals to investigate organizational adoption and abandonment patterns resulting from these changes. Empirically, this context offers two further benefits. First, the introduction of BMSs, DESs, and the AHA/ACC guideline are exogenous to the studied hospitals and physicians. Second, both abandonment triggers occur within serially introduced generations of the same technology, which enables the use of a within-subjects design. As a result, we are able to mitigate the threat of unobserved contextual heterogeneity that may arise when examining different technologies across varying contexts.

Results indicate several notable findings. First, for-profit hospitals, organizations with strong financial incentives, vary their rates of abandonment significantly based on why the abandonment is occurring. Relative to not-for-profit hospitals, for-profit hospitals are faster in both adoption and abandonment when a superior technological option is made available. However, this is not the case when the efficacy of the technology is questioned. In contrast, academic medical centers (AMCs)—organizations with incentives to remain at the cutting edge of medical practice for both teaching and research—adopt new technologies faster than all other hospitals. Furthermore, these hospitals also have the fastest abandonment rates, both when there is a superior technology available and when the efficacy of an established technology is called into question. Strikingly, robustness tests suggest that these differences are not a result of individual-level (i.e., physician) response. Results indicate no differences in behavior across physicians with faculty placements in each setting. Furthermore, physicians who split their practice across hospitals (i.e., freelancers) vary their treatment decisions to conform to the norms of the organization where they are performing the procedure, i.e., the setting matters even within physician. These results suggest that in spite of the significant agency physicians possess, their behavior is consistent with the norms of the organization where they practice (Tripsas 2009).

Our study contributes to ongoing research in technology adoption and abandonment in four ways. First, we study an important organizational process—technology abandonment—that has received limited attention in prior work (Burns and Wholey 1993, Howard and Shen 2012). Second, by capturing differences in rates of abandonment for each trigger across organizational types, we highlight the underlying factors potentially at play, i.e., the salience of norms of science and the corresponding trade-offs with economic benefits that may drive abandonment decisions. Third, to the extent that our individual-level analysis reveals that decision makers known for significant agency conform to the norms of their organizations, our work underscores the importance of organizational mission, which dominates individual preferences. Finally, our results offer a plausible explanation for mixed findings reported in studies of organizational abandonment (Burns and Wholey 1993, Finkelstein and Gilbert 1985, Greer 1981, Howard and Shen 2012); i.e., the divergent results may be a function of underlying heterogeneity in triggers for technology abandonment and organizational type.

The Abandonment of Medical Treatments
The adoption and diffusion of new technology and practices has been an important field of study in management research for decades (Abrahamson and Rosenkopf 1993, Angst et al. 2010, Gort and Klepper 1982, Kapoor and Furr 2015, Kennedy and Fiss 2009, Venkatesh et al. 2003); see Agarwal and Tripsas (2011).
for a more recent summary. However, perhaps as a result of a predominant focus on innovation and the adoption of emerging technologies, research on technology abandonment has lagged. Even within extant work that specifically examines the abandonment of technology and practices, researchers have abstracted away from differences in the underlying triggers for abandonment (Adner and Kapoor 2016, Adner and Snow 2010, Greve 1995, Rao et al. 2001). In contrast, we explicitly focus on differences in triggers by defining and distinguishing between two triggers that may result in the abandonment of technology. First, abandonment may be triggered by the advent of a superior technology. In these cases, abandonment of the old technology may be the dual, or “twin,” of the adoption of the new technology (Adner and Kapoor 2016, Adner and Snow 2010). Second, abandonment may be triggered by the release of new information questioning efficacy of the technology. These instances represent a delegitimation of the technology, rather than a response to a superior alternative (Finkelstein and Gilbert 1985, Greve 1995, Howard and Shen 2012, Kennedy 2011).

Both triggers are observed widely in medicine. The first trigger occurs regularly with the introduction of superior medical devices and treatments that then displace older practices and technology (Greer 1981). However, the second trigger is also a driver of abandonment of medical treatments due to both safety and comparative effectiveness concerns. For example, episiotomies have seen a significant decline in utilization after information about both their health effects and costs was revealed (Howard and Shen 2012; much like pharmaceutical drugs being discontinued when information on their efficacy is released; Finkelstein and Gilbert 1985)). Disturbingly, this is not always the case. Gawande (2015) identifies several medical practices that continue to be used in spite of ambiguous clinical care outcomes and high costs. In the face of such evidence, and in the presence of prohibitive costs, several important and unresolved questions regarding the abandonment of technology arise. One such critical question is the following: Are the patterns of abandonment sensitive to the differences in triggers (as they relate to the introduction of a superior technology or questioned efficacy)? And, if so, how do differences in organizations based on norms and incentives moderate such a response? To answer the latter question more fully, we next discuss key types of medical organizations.

The Abandonment of Medical Treatments and Differences in Medical Organizations

The empirical literature (see a review in Horwitz 2005) has noted similarities across hospitals along multiple dimensions—they “all treat patients with a mix of needs, contract with the same insurers and government payers, operate under the same health regulations, and employ staff with the same training and ethical obligations” (Horwitz 2005, p. 790). This is to be expected, as every hospital shares the broad organizational mission of providing care and is subject to regulations when treating patients (e.g., the Stark Law (Wales 2003) and the Emergency Medical Treatment and Labor Act (Lee 2004)). Nonetheless, Horwitz (2005) also identifies other dimensions, including “quality, physician control, and patient access” (p. 791) that have received less scholarly attention; specifically highlighting that hospitals have significant agency in the services they choose to offer based on the incentives and constraints each faces.

We distinguish between three types of hospitals: for-profit, not-for-profit, and academic medical centers. As the names indicate, the hospital types differ in their missions and in associated incentives, costs, and applicable regulations. For-profit hospitals are private institutions and are often governed by corporate boards. Among the three hospital types, for-profit hospitals have significantly fewer regulatory requirements placed upon them, and substantially greater leeway in the portfolio of services they can offer (Florida Hospital Government and Public Affairs 2011). Although required to provide emergency care to individuals in need (Lee 2004), for-profit hospitals have the flexibility to choose the services they offer to reap higher profits and selectively use clinically equivalent medical treatments that offer greater return. Accordingly, they are permitted to occupy strategic market niches if such actions will increase margins (Florida Hospital Government and Public Affairs 2011). Instances of such behavior are widely observed: e.g., for-profit hospitals are more likely to offer profitable services, such as neonatal intensive care, and may refrain from providing relatively unprofitable services, like HIV treatment (Horwitz 2005).

In contrast, not-for-profit hospitals, while motivated to remain financially solvent and even generate profits that can be reinvested into the organization, have significant community-related incentives and constraints. They are directly accountable to the communities they serve (Florida Hospital Government and Public Affairs 2011) and are required to perform triennial community assessments to maintain their 501(c)(3)

1 We exclude some other types of hospital facilities, given their irrelevance to our empirical context of the treatment of SCAD. These include health facilities that are unable to host patients overnight (e.g., ambulatory surgery centers, urgent care centers), or have focused missions around specific patient groups or treatments (e.g., residential treatment centers and geriatric care facilities).
tax exempt status\(^2\) (Bales et al. 2014). The requirement that they meet the needs of the local community suggests that not-for-profit hospitals face an inherent tension in the trade-off between offering cutting-edge medical options for patients and cost-effective treatments (which are responsive to the needs of the majority of their constituents).

Finally, AMCs, in addition to providing patient care, serve the important mission of training the next generation of healthcare providers and conducting research. To the extent that the infrastructural and human capital costs of providing medical education are substantial, the hospitals associated with AMCs are typically required to subsidize the medical school they are attached to Wartman (2008, 2010). AMCs also are subject to science-related norms of practice (Merton 1973). Given that research is critical to the organizational mission (Wartman 2008, 2010), these hospitals are incentivized to ensure that their treatments are at the vanguard of medicine. As a result, it is unsurprising that AMCs are often “finely tuned” to avant-garde medical research (Wartman 2010) and often have better clinical outcomes than their peers (Jha et al. 2005).

The differences between hospital types become particularly salient in the context of technology adoption and abandonment decisions for several reasons. One, such decisions represent discretion in service offerings, which, as noted above, has been identified to be a critical dimension where hospitals have agency (Horwitz 2005). Two, these decisions are precisely where differences in the mission of and incentives within these hospitals result in a divergence in the inherent trade-offs they face under distinct triggers for abandonment. Yet, extant theory lacks an explanation of how these differences will impact technology adoption and abandonment decisions across hospital types. It may be the case that when new, clinically superior technologies emerge, the incentives for all types of hospitals are aligned because they can simultaneously improve financial payoffs and offer better treatment to patients. Alternatively, different hospital types may vary in the emphasis they place on the competing social incentives. Furthermore, divergence may also occur due to adoption costs. Even if the cost of adopting a technology is the same across hospitals, differences in payment mix may result in differences in adoption given that Medicare/Medicaid payment updates often fail to incorporate the full costs of emerging technologies (American Heart Association 2006).

These triggers may also differentially impact the speed of abandonment across hospital types, because of differences in the social and financial incentives faced by the hospitals. Consider when technology abandonment occurs as a result of new information questioning the efficacy of a prevailing technology (rather than the well-studied case of a new and better technological option). In such situations, the hospital faces a more complex trade-off between financial and social incentives, because the technology could still be leveraged for economic gain, even if it is not as effective as initially thought. To the degree that all hospitals face significant financial constraints (Aaron 2000), they may prefer to continue treatments that offer financial benefits over discontinuing their use in favor of options that are less lucrative. Alternatively, differences in social incentives, such as the extent to which staying at the cutting edge of practice is a valued organizational norm, may again cause divergence in abandonment rates.

Motivated by these ambiguities in expected behavior, we examine the abandonment decisions in the use of stents for SCAD treatment across hospital types. As noted earlier, our empirical setting is one where both forms of triggers (superior technology option and questionable efficacy of current option) have been serially observed.

**Empirical Context: The Use of Coronary Stents**

Patients diagnosed with stable coronary arterial disease are generally categorized into four groups using the widely adopted Canadian Cardiovascular Society (CCS) standard. Those with low-severity SCAD are classified as Class I or II, and higher-severity SCAD patients are classified in Class III or IV.\(^3\) Coronary stents were first approved by the FDA in 1995 in the form of BMSs. In 2002, the original technology was displaced by a superior alternative, drug-eluting stents. Since their approval, stents have been used to treat all manner of SCAD patients, until the release of a 2005 medical guideline by the American Heart Association and the American College of Cardiology (Smith et al. 2006). This guideline questioned the efficacy of stents, relative to less invasive and cheaper pharmacological options, for low-severity SCAD patients and explicitly recommended discontinuation of use in such cases.

\(^2\) The purpose of the triennial assessment is to gather information about the needs of the community and ensure the hospital meets the needs of medically underserved populations. In Florida, our context, the tax exemptions are explicitly tied to higher levels of charity care, Medicare and Medicaid patients, and provision of low margin services, relative to for-profit hospitals (Florida Hospital Government and Public Affairs 2011).

\(^3\) See Appendix A for a detailed description of SCAD and CCS classification. We note that unstable coronary arterial disease, associated with conditions like heart attacks, is outside the scope of this research even though stents can also be used to treat these conditions.
Stents represent an ideal context for our study for several reasons. First, coronary arterial disease is currently the leading cause of death in the United States (Rosamond 2007), and as of 2011, stenting represented a $5 billion market within the treatment of this condition (Wieffering 2011). We are therefore able to shed light on a significant practical problem for hospital administrators and policy makers. Second, our data cover the entire life cycle of coronary stents, starting from genesis. During that time the practice of stenting has witnessed significant advancements, thereby allowing us to identify how changes, exogenous to the hospital and physician, affect how and when stents are used. The exogeneity stems from the fact that the FDA had to approve usage of BMSs and DESs before they could be adopted by hospitals. Similarly, the guideline recommending stents not be used for low-severity SCAD patients was, for legal and practical reasons, constructed under strict confidentiality rules. As a result, for the purposes of identification, the introduction of BMSs presents hospitals with an opportunity to adopt new technology, the release of DESs allows us to observe hospital abandonment of the inferior BMSs, and the release of the guideline is a trigger for technology abandonment when efficacy of the underlying technology is questioned. The ability to study both abandonment triggers within the same technology provides a unique context that permits us to control for technology- and disease-related contextual heterogeneity. Thus, we are able to hold all else constant while contrasting adoption and abandonment decisions stemming from the underlying triggers. Importantly, the fact that the guideline release questioning efficacy only applies to a certain class of patients allows us to rule out the fact that stents are unsafe and permits us to focus on abandonment when use is not cost-effective. Specifically, although the guideline release implies that significant cost savings can be realized for the treatment of low-severity SCAD at a societal level, each hospital may have private incentives to continue use, e.g., higher revenues, without affecting its vulnerability to malpractice concerns.

Data
To quantify how different hospital types react to the triggers for abandonment, we draw data from multiple sources to create a longitudinal sample of physician decisions for the treatment of SCAD over the 13-year time period of the study. The primary data source is the Florida Agency for Healthcare Administration (AHCA); their data have been used extensively in prior research (Burke et al. 2003, 2007; Greenwood and Agarwal 2015). These data capture a census of approximately two million patients admitted to hospitals in the state of Florida as well as their diagnoses, comorbidities (i.e., International Classification of Diseases, Ninth Revision (ICD-9 codes)), the attending physician, and the hospital where they were admitted. We merge the AHCA data with information from the Council of Teaching Hospitals to identify hospitals in Florida associated with AMCs.

We apply two restrictions to the data sets. First, given our focus on stable, rather than unstable, coronary arterial disease, we drop all patients suffering an acute myocardial infarction, i.e., heart attacks. Second, because the more invasive procedure of coronary artery bypass grafts (CABGs) is generally associated with advanced cases of SCAD where a stent may not be appropriate, we drop these patients from our analysis.

The richness of these data notwithstanding, we note two limitations stemming from patient privacy considerations. First, we are unable to track patients over...
time. Although this may introduce unobserved heterogeneity into the data set, there is no reason, a priori, to believe that patient differences are correlated with the changes to the technological regimes. Second, the patient data are aggregated to the quarter level; i.e., within a given quarter, all stenting decisions are treated as contemporaneous. However, because we are interested in studying aggregate stent use over time across hospital types, aggregating to the quarter allows us to estimate these effects without having to specifically consider intraquarter variations.

Figure 1 presents a visual representation of the stenting rate, i.e., the percentage of SCAD patients in Florida treated with a stent over time. The trend clearly documents adoption and abandonment. From inception through 2002, the light grey line depicts the adoption of BMSs. Its abandonment after 2002 reflects the corresponding increasing adoption of DESs (dark grey line), which occurs at a much faster pace than the first generation of the technology. The guideline release in late 2005 then creates a decline in overall stenting rates, attributable to the abandonment of the treatment for low-severity SCAD patients (in our detailed analyses, high-severity SCAD patients serve as a suitable control group to gauge the effect of this event on the responses from physicians). Figure 1 also identifies the three periods surrounding the introductions of the technologies and guideline release, where we use a uniform time window that includes a single quarter before the change and six quarters after the change (18 months). The use of these periods in our subsequent econometric analysis help limit the effect of omitted variable bias, i.e., other confounding incidents in the environment. We refer to the time period surrounding the adoption of BMSs as Period 1, that around adoption of DESs and the simultaneous abandonment of BMSs as Period 2, and the final one around the guideline release as Period 3.7

Variable Definitions
We define our variables and conduct our analysis at the bed level (a single in-patient admittance recorded in the AHCA data) for each time quarter, consistent with prior empirical work in cardiology (Huckman and Pisano 2006). While we are primarily interested in variations across organizations, the analysis at the bed-level permits us to control for the underlying patient-level heterogeneity such as age, race, gender, and severity of SCAD (as determined by the patient’s ICD-9 codes). Furthermore, it also allows us to control for unobserved physician heterogeneity, such as the propensity to stent, through physician fixed effects. Finally, it avoids the potential of a Yule–Simpson effect (Simpson 1951) due to aggregation across groups of different sizes for the various patient and physician-level characteristics.

Dependent Variable. We construct three different indicators of the 0/1 stenting decision at the bed level. For Period 1, the dependent variable is 1 for the decision to implant a BMS in the focal SCAD patient 0 otherwise. For Period 2, the dependent variable is 1 for the decision to implant a BMS in the

7 It should be noted that the temporary increase in BMS utilization late in Period 3 (which partially substitutes for DES usage) is likely the result of several controversial papers that linked DES stents to clotting problems for patients (Daemen et al. 2009, Lüscher et al. 2007), and not the AHA/ACC Guideline.
focal SCAD patient, capturing the decision to substitute away from BMSs in the presence of a superior alternative. For Period 3, the dependent variable is 1 for the decision to implant either type of stent (BMS or DES) in the focal low-severity SCAD patient, capturing the decision to abandon stenting, consistent with the guidelines.

**Independent Variables.** The key independent variable in our analysis, hospital type, is operationalized as a set of indicators for the hospital’s organizational mission: Not-For-Profit, For-Profit, and AMC, each of which is mutually exclusive and coded dichotomously. We use Not-For-Profit hospitals as the base case in our analysis, unless noted otherwise. The second set of independent variables, Time, is a series of linear splines that capture the variation in the stenting rate over time after each of the exogenous changes in the technological regime, i.e., the release of BMSs, the release of DESs, and the release of the guideline, which questions the efficacy of stents for low-severity SCAD. Although the spline variables clearly impose a linearity assumption on the change of stent utilization over time, we run additional analyses using squared and cubed splines. The results (available upon request) indicate that there is no significant curvilinear structure to the relationship. We further address this concern by replicating our analysis using quarter dummies and graphing the results (Figures 2–10), all of which depict quarter-by-quarter change.

**Control Variables.** To account for the effect of other forms of heterogeneity that may influence the rate of stent implantation, we include a robust series of controls. For patients, we include dummies for their age (ages 3–108), race (e.g., African American, Caucasian, Latino, etc.), and gender. We also use fixed effects for the type of SCAD the patient has been diagnosed with. Furthermore, to decrease the effect of unobserved physician- and hospital-level heterogeneity, we include hospital and physician fixed effects. Because these fixed effects often perfectly predict the independent variables of interest, we introduce the fixed effects sequentially into our econometric specifications to increase the interpretability of the results. Finally, in our robustness tests, we use two physician-level variables, based on information provided within the Florida AHCA data set. Faculty is a dichotomous variable indicating whether or not the physician has a faculty appointment at any of the universities in the State of Florida. Furthermore, to test robustness within physicians across organizational types, we use the variable Freelancer, which identifies all physicians who have treated at least one SCAD patient in two different hospital types in the same quarter.

Table 1 provides summary statistics for the three periods in our analysis, and a further breakdown of the population of patients and physicians at each type of hospital is in Table 2. As can be seen from this table, although AMCs are larger on average and more likely to be in rural locations, patients are of roughly the same age and are equally likely to be suffering from high-severity SCAD.

**Empirical Strategy**

Formally, we model the probability that a patient receives a stent as

\[
P(y_{ijt} = 1) = \beta_i \text{AMC}_i + \gamma_i \text{For} - \text{Profit}_i + \theta_i \text{Time}_t + \eta_i (\text{Time}_t \times \text{AMC}_j) + \rho_i (\text{Time}_t \times \text{For} - \text{Profit}_j) + X' \delta_i + \varepsilon, \tag{1}
\]

where \(y_{ijt}\) is an indicator equal to one if physician \(i\) implants a stent in hospital \(j\) during time \(t\) and zero otherwise, \(AMC\) and \(For\)-\(Profit\) indicate the hospital type, \(Time\) is the calendar time spline, and \(X\) is the vector of patient characteristics. The terms \(\{\beta_j, \gamma_j, \eta_j, \rho_j, \delta_j, \theta_i\}\) are parameters to be estimated, and \(\varepsilon\) represents the error term. Our primary econometric specification for estimating the change in stenting is a fixed effect linear probability model (LPM). As discussed

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\(^8\)We only focus on differences in freelance physicians who treat patients across more than one hospital type. For example, a physician who treats patients at both Jacksonville Memorial Hospital and Baptist Medical Center in Jacksonville in the same quarter would be classified as a freelancer because one institution is for profit and the other is not. Conversely, a physician who treats patients only at Tampa General Hospital and UF Health Shands in Gainesville is excluded, because both hospitals are associated with AMCs.


\(^10\)A one-way analysis of variance comparison of means show that the populations across hospital types are significantly different (underscoring the need for hospital, physician, and patient characteristic fixed effects). Some of the significance in the statistics could be driven by large sample sizes (over one million observations). In any case, adding hospital and patient controls becomes critical in this analysis.

\(^11\)We use the LPM, in lieu of a logit or probit model, for two reasons. First, as noted by King and Zeng (2001), the rarity of stent implantation (often less than 5% of the time in our sample) can lead to a biased estimation of the standard errors. Second, the interpretation of interaction terms (the primary coefficients of interest in our estimations) is difficult and requires the simulation of the marginal effects after estimation (Ai and Norton 2003, Zelner 2009). This is notably problematic for our analysis because the statistical tools...
above, after the estimation of Equation (1), we reestimate the equation with hospital fixed effects (thereby omitting \( \beta_1, \gamma_1 \)) and then with hospital and physician fixed effects.

We note that though the LPM provides benefits in terms of computation and interpretation, it also introduces heteroscedasticity into the model and may yield predicted values outside the \([0, 1]\) interval. To mitigate the first concern, we use heteroscedastic consistent Huber–White standard errors clustered on the hospital and time.\(^\text{13}\) Regarding the second limitation, a postestimation inspection of the data set shows that the predicted probability of stenting is consistently within the \([0, 1]\) bound across all models.

### Results

We first consider results relating to how hospital incentives influence the adoption of emerging technologies (columns (1)–(3) of Table 3). From the Period 1 analysis, we see that for-profit hospitals adopt the use of BMSs significantly faster than not-for-profit hospitals, as indicated by the positive and significant interactions For-Profit and Time in columns (1)–(3). Furthermore, as indicated in columns (1)–(3), we see that AMCs adopt stents even faster than for-profit hospitals (an average increase of 1.09% versus 0.59% per quarter). Economically, for-profit hospitals adopt the use of BMSs 39.3% faster than not-for-profit hospitals, whereas AMCs adopt the use of BMSs a striking 157.1% faster than not-for-profit hospitals (and 84.5% faster than for-profit hospitals). To visualize these results (Figure 2), we convert the linear time splines to time dummies and graph the results. As seen, the adoption of BMSs by AMCs is the fastest, followed by that by for-profit hospitals (FP), and finally by not-for-profit hospitals (NFP), which are the slowest.

Given our focus on the abandonment of technology when triggered by different underlying causes, we...
Table 2 Breakdown of Patient and Physician Characteristics by Hospital Type

<table>
<thead>
<tr>
<th></th>
<th>AMC</th>
<th>For-profit</th>
<th>Not-for-profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of hospitals</td>
<td>14</td>
<td>112</td>
<td>113</td>
</tr>
<tr>
<td>No. of rural</td>
<td>3</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Percent rural (%)</td>
<td>21.43</td>
<td>9.82</td>
<td>15.04</td>
</tr>
<tr>
<td>Avg. beds</td>
<td>504</td>
<td>181</td>
<td>265</td>
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Patient characteristics

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<tr>
<th></th>
<th>AMC</th>
<th>For-profit</th>
<th>Not-for-profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. SCAD patients (per quarter)</td>
<td>6,259</td>
<td>52,337</td>
<td>36,844</td>
</tr>
<tr>
<td>Avg. high severity</td>
<td>956</td>
<td>8,453</td>
<td>5,955</td>
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<tr>
<td>Percent high severity (%)</td>
<td>15.27</td>
<td>16.15</td>
<td>16.16</td>
</tr>
<tr>
<td>Avg. patient age</td>
<td>66,724</td>
<td>70,902</td>
<td>72,569</td>
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<tr>
<td>Patient age std. dev.</td>
<td>13,446</td>
<td>12,668</td>
<td>12,657</td>
</tr>
<tr>
<td>Percent Medicare (%)</td>
<td>9.06</td>
<td>3.50</td>
<td>3.66</td>
</tr>
<tr>
<td>Percent private insurance (%)</td>
<td>19.13</td>
<td>18.00</td>
<td>16.74</td>
</tr>
<tr>
<td>Percent Medicare (%)</td>
<td>60.24</td>
<td>73.09</td>
<td>75.17</td>
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Physician hospital characteristics

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<th>AMC</th>
<th>For-profit</th>
<th>Not-for-profit</th>
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<tr>
<td>No. of attendings</td>
<td>3,676</td>
<td>16,281</td>
<td>11,524</td>
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<tr>
<td>Attendings per hospital</td>
<td>262,571</td>
<td>143,366,071</td>
<td>101,923,009</td>
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<tr>
<td>No. of faculty</td>
<td>1,724</td>
<td>3,268</td>
<td>1,915</td>
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<tr>
<td>Percent faculty (%)</td>
<td>46.90</td>
<td>20.07</td>
<td>16.62</td>
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Freelancer characteristics

<table>
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<th></th>
<th>AMC</th>
<th>For-profit</th>
<th>Not-for-profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of freelancers</td>
<td>2,116</td>
<td>6,498</td>
<td>6,098</td>
</tr>
<tr>
<td>Percent freelancers (%)</td>
<td>75.56</td>
<td>39.91</td>
<td>52.92</td>
</tr>
<tr>
<td>No. of freelancers at AMCs also at</td>
<td>n/a</td>
<td>1,258</td>
<td>858</td>
</tr>
<tr>
<td>No. of freelancers at</td>
<td>1,258</td>
<td>n/a</td>
<td>5,240</td>
</tr>
<tr>
<td>for-profits also at</td>
<td></td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>No. of freelancers at</td>
<td>858</td>
<td>5,240</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Table 3 LPM Estimation of Change in Stenting Over Time; Comparison of AMCs, For-Profit Hospitals, and Not-For-Profit Hospitals

<table>
<thead>
<tr>
<th>Phenomenon</th>
<th>(1) Release of BMS</th>
<th>(2) Abandonment of BMS after release of DES</th>
<th>(3) Abandonment of stents after release of guideline for low-severity SCAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMC</td>
<td>0.00990</td>
<td>0.0311*</td>
<td>0.0308*</td>
</tr>
<tr>
<td>For-Profit</td>
<td>0.0126***</td>
<td>0.0296**</td>
<td>0.0146</td>
</tr>
<tr>
<td>Time</td>
<td>0.00397***</td>
<td>-0.00102***</td>
<td>-0.00107***</td>
</tr>
<tr>
<td>AMC × Time</td>
<td>0.00547**</td>
<td>-0.00642***</td>
<td>-0.00754***</td>
</tr>
<tr>
<td>For-Profit × Time</td>
<td>0.000880</td>
<td>-0.00462***</td>
<td>-0.00499***</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.0471***</td>
<td>-0.00606</td>
<td>-0.250***</td>
</tr>
</tbody>
</table>

Notes. The dependent variables are as follows: columns (1)–(6), bare metal stent utilization; columns (7)–(9), utilization of any kind of stent. Beta coefficients for age, SCAD severity, race, and hospital were estimated but are not displayed in the interest of space. Robust standard errors are in parentheses (clustered on the union of hospital and time).

*p < 0.1, **p < 0.05, ***p < 0.01.
Finally, results for the abandonment of stents due to the release of the guideline questioning efficacy for low-severity SCAD patients are provided in columns (7)–(9) of Table 3. We first note that, on the margin, there is a decrease in stent utilization for low-severity SCAD patients in each hospital type, despite the fact that the guideline is nonbinding on this patient class. However, as indicated by the interaction between For-Profit and Time in column (9), for-profit hospitals abandon the use of stents slower than all other hospitals (although the coefficient is not statistically different from Not-For-Profits). Furthermore, AMCs abandon the use of stents significantly faster than all other hospitals (122.3% faster than not-for-profit hospitals). As before, the dummy time graphs shown in Figure 4 corroborate these results.

It is important to note that, unlike the regime changes in Periods 1 and 2, the guideline release in Period 3 impacts only the low-severity SCAD patients. Thus, high-severity SCAD patients serve as a natural control group for whom we can test differences in responses and provide a first-order identification check. For example, it is possible that stents are being abandoned for all patients, which would undermine our argument that the observed change is the result of the guideline (because the guideline applies only to low-severity SCAD patients). We further note that the traditional difference-in-difference method for testing across treatment and control groups is less applicable in our context, given that the groups have a different ex ante trend in propensity to receive a stent, thereby violating a key assumption of the difference-in-difference model (Angrist and Pischke 2008). Therefore, we choose the strategy of estimating similar models of physician stenting decisions for high-severity SCAD patients. We construct a sample consisting of only severe SCAD patients and reexecute our analysis for Period 3. Results in Table 4 show that there is no significant change in the stenting rate for this group after guideline release, establishing that the application of the guideline is indeed the driving force for abandonment in the case of low-severity SCAD patients.14

To summarize, the regressions as well as graphical representations provide support that the different types of organizations differ in their adoption and abandonment responses due to the different triggers.

14 Although the point estimates for the change in stenting for high- and low-severity patients across the hospitals (i.e., across Tables 3 and 4) are not significantly different, it is important to note that such a comparison is inappropriate because of the significantly higher probability of a high-severity SCAD patient receiving a stent (41% versus 8.2%). Furthermore, an extension of the time window for Period 3 reveals a long, steady, decrease in stenting for low-severity patients and almost no change for high severity (results available upon request). We thank an anonymous reviewer for bringing this point to our attention.
failures in For-Profit hospitals, respectively, have faculty appointments. Furthermore, 17% and 20% of physicians at not-for-profit and for-profit hospitals, respectively, have faculty appointments. Accordingly, there is sufficient variation across hospitals to examine whether physician faculty status has any impact on the change in stenting. To execute these estimations, we interact the dichotomous indicator Faculty affiliation with Time and hospital type (i.e., AMC and For-Profit status) and reestimate our models. Results are in Table 5, and the associated graphs are shown in Figures 5–7.

Results from Table 5 replicate the organizational-level differences observed in Table 3 and suggest no significant difference between faculty and nonfaculty physicians’ response to the triggers for abandonment across hospital types. In each of the three periods, independent Chow’s tests confirm that changes in the marginal stenting rates for faculty and nonfaculty members are statistically indistinguishable within hospital type (with the exception of marginally significant ($p < 0.1$) differences of faculty in AMCs during the abandonment of BMSs). Figures 5–7 confirm these findings graphically; the lines for faculty and nonfaculty physicians are almost identical to each other. For abandonment decisions, although the estimated coefficients in Table 5 suggest that faculty members at AMCs abandon the use of BMSs slower than nonfaculty members, the graph shown in Figure 5 shows this to be effectively negligible. In summary, the results from Table 5 indicate continued strong support for organizational differences, but limited indication of variation within organizations that can be explained by individual-level differences.

Freelancer Physicians. To account for potential differences arising from physician sorting into organizations that reflect their preferences (Agarwal and Ohyama 2013), we next examine whether the same physicians operating in different hospitals respond differently to the abandonment triggers. The presence of freelance physicians, i.e., physicians simultaneously practicing at multiple types of hospitals (Huckman and Pisano 2006), allows us to test this alternative explanation. If physicians adhere to the norms of where they are practicing, as opposed to maintaining consistent behavior across institutional settings, it lends further credence to the argument that the observed changes are to the result of organizational—rather than individual-level effects.

To investigate how these physicians react to the different impetuses for abandonment, we take two approaches. In both approaches, we include only freewheeling physicians, i.e., physicians who are operating...
in multiple organizational settings simultaneously. In the first, we replicate our baseline estimations and include an additional control (physician change in stenting \( t - 1 \) to \( t - 0 \) ) that captures the physician’s idiosyncratic change in stenting over time. In principle, the inclusion of this control accounts for the possibility that the physician may be distributed across the hospital settings unevenly (i.e., perform a significantly larger proportion of her decisions in AMCs rather than for-profit hospitals). Furthermore, it allows us to observe the overall change in stenting in each hospital type after each shock. In the second,

more stringent model, we replicate our estimations and include the physician fixed effect interacted with the time spline (with the base time spline omitted). Intuitively, what this model allows us to do is isolate the individual physician’s idiosyncratic trend and capture the extent to which decisions taken within an AMC or for-profit hospital deviate from this physician-specific trend. One drawback of this more stringent specification is that we cannot estimate the change in stenting specific to the base condition, i.e., stringent specification is that we cannot estimate the phenomenon adoption abandonment of BMS after release of DES guideline for low-severity SCAD.

We thank the anonymous reviewer for the suggestion of this test

Note that the inclusion of the idiosyncratic physician change in stenting causes the pretreatment period to be omitted from the estimation. We thank an anonymous reviewer for this suggestion. Results are consistent in the presence and absence of this control.

15 Note that the inclusion of the idiosyncratic physician change in stenting causes the pretreatment period to be omitted from the estimation. We thank an anonymous reviewer for this suggestion. Results are consistent in the presence and absence of this control.

16 We thank the anonymous reviewer for the suggestion of this test as well.
from \( t - 1 \) to \( t - 0 \) and a physician-specific time trend, we are able to provide a more detailed understanding of freelancer physician behavior. Results are in Table 6. In the interest of space, we present only the fully interacted models.

Consistent with previous results, freelance physicians practicing at AMCs and for-profit hospitals adopt the use of BMSs faster (columns (1) and (3) of Table 6) than they do when practicing at not-for-profit hospitals. Moreover, during periods of abandonment characterized by the presence of a superior technology (columns (2) and (5)), we find that when freelancer physicians practice in AMCs, they abandon the use

### Table 6 LPM Estimation of Change in Stenting Over Time For Freelance Physicians; Comparison of AMCs, For-Profit Hospitals, and Not-For-Profit Hospitals

<table>
<thead>
<tr>
<th>Sample</th>
<th>Abandon of BMS after release of guideline for low-severity SCAD</th>
<th>Abandon of BMS after release of DES</th>
<th>Abandon of BMS after release of guideline for low-severity SCAD</th>
<th>Abandon of BMS after release of DES</th>
<th>Abandon of BMS after release of guideline for low-severity SCAD</th>
<th>Abandon of BMS after release of DES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician change in stenting ( t - 1 ) to ( t - 0 )</td>
<td>0.469*** (0.0205)</td>
<td>0.441*** (0.0184)</td>
<td>0.358*** (0.0118)</td>
<td>[Omitted]</td>
<td>0.00248 (0.00672)</td>
<td>0.000735 (0.000240)</td>
</tr>
<tr>
<td>Time</td>
<td>0.00459*** (0.000685)</td>
<td>-0.0131*** (0.00132)</td>
<td>-0.00248*** (0.0000672)</td>
<td>0.00830*** (0.00198)</td>
<td>-0.0113*** (0.00278)</td>
<td>-0.000735 (0.000240)</td>
</tr>
<tr>
<td>AMC \times Time</td>
<td>0.0127*** (0.00341)</td>
<td>-0.0226*** (0.00533)</td>
<td>-2.39e-05 (0.00152)</td>
<td>0.00198 (0.00091)</td>
<td>0.0018*** (0.000787)</td>
<td>0.00194* (0.000078)</td>
</tr>
<tr>
<td>For-Profit \times Time</td>
<td>0.000147 (0.000975)</td>
<td>-0.00275 (0.00215)</td>
<td>0.00169 (0.000911)</td>
<td>0.00169 (0.000977)</td>
<td>-0.00194* (0.000078)</td>
<td>0.00178** (0.000078)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0566 (0.0673)</td>
<td>-0.739*** (0.0709)</td>
<td>-0.0342 (0.0463)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Physician fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Physician fixed effects \times Time</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>117,347</td>
<td>174,698</td>
<td>169,952</td>
<td>136,266</td>
<td>204,336</td>
<td>192,601</td>
</tr>
<tr>
<td>( R )-squared</td>
<td>0.181</td>
<td>0.237</td>
<td>0.326</td>
<td>0.194</td>
<td>0.279</td>
<td>0.345</td>
</tr>
</tbody>
</table>

**Notes.** The dependent variables are as follows: columns (1) and (2), bare metal stent utilization; column (3), utilization of any kind of stent; columns (4) and (5), bare metal stent utilization; column (6), utilization of any kind of stent. Beta coefficients for age, SCAD severity, race, and hospital were estimated but are not displayed in the interest of space. Physician change in stenting \( t - 1 \) to \( t - 0 \) indicates the physician’s individual change in stenting to account for imbalanced opportunities to stent across different hospital settings. Physician fixed effects \times Time indicate the inclusion of another set of controls where the physicians idiosyncratic trend is controlled for. Robust standard errors are in parentheses (clustered on the union of hospital and time).

\( *p < 0.1; **p < 0.05; ***p < 0.01.\)
of stents significantly faster. Freelance physicians in for-profit hospitals similarly abandon faster, although the difference between for-profits and not-for-profits is insignificant. Finally, these same freelance physicians, when reacting to the guideline questioning the efficacy of stents (columns (3) and (6)), abandon the use of stents slower at for-profit hospitals and significantly faster at AMCs. In summary, the results support the argument that organizational norms and incentives explain stenting decisions, even in the presence of individual heterogeneity. A graphical representation of the results, shown in Figures 8–10, confirms these findings.

**Additional Robustness Tests**

We further conduct tests to ensure that our modeling approach is not subject to specification errors (either from omitted variables or though contextual ambiguity). Results from these unreported tests are available upon request but are summarized in brief in Table 7. We first consider the role of CABG treatment and the possibility that abandonment of stents may be associated with a concomitant change in the utilization of CABGs. To rule out this possibility, we replicate our estimations including both patients receiving CABGs as well as a control variable indicating whether a CABG treatment was used for the patient. The inclusion of CABG patients does not affect the base coefficients we estimate, and the results remain consistent. Furthermore, we consider whether change in CABG use, within hospital type, is correlated with our three changes in stenting. To execute this test, we replicate our models replacing CABG use as the dependent variable (with 1 for CABG use, 0 otherwise). We see no significant correlations between hospital types and the use of CABG treatment, indicating that CABG as an option does not systematically bias the results we obtain on the focal stenting decisions. Finally, we eliminate all patients likely to receive CABGs, i.e., high-severity SCAD patients, from Periods 1 and 2 and replicate our estimations. Results remain consistent.

It is also possible that patients are self-selecting into different hospital types, i.e., certain hospitals with superior reputations are chosen by patients, thereby leading to biased estimates of the coefficients. One method to eliminate this source of bias is to consider patients admitted through the emergency department, where the patient’s ability to select hospitals is arguably low or absent. We therefore estimate our models using only such patients. Results are consistent. Finally, many hospitals were observed to invest in cardiac catheterization labs late in Period 1 of our analysis, thereby incurring a fixed cost that would systematically lead to greater financial incentives for stenting, all else being equal. This would affect the analysis of the adoption of BMSs, creating an alternative reason for adoption. We therefore estimate models where later quarters during the adoption of BMSs are truncated. Additionally, we eliminate hospitals where these investments in labs were noted. Here too, results are consistent.\(^\text{17}\)

\(^\text{17}\) We thank the two anonymous reviewers for many of these suggestions.
tial mechanisms underlying the observed effects. The

Discussion
In this study we asked, do the two different triggers for abandonment (superior technology versus questionable efficacy) result in different patterns of abandonment? If so, what organizational factors influence the observed patterns? Results in the empirical context of the use of stents in hospitals suggest that, in the presence of a superior technology, rates of abandonment mirror rates at which the original technology was adopted: academic medical centers adopt and abandon technologies fastest, followed by for-profit hospitals, and then not-for-profit hospitals. However, there are notable differences in observed patterns of abandonment when a technology’s efficacy is questioned. The response from AMCs remains similar under both contexts of abandonment, but abandonment in for-profit hospitals is not necessarily faster than that observed in not-for-profit hospitals. Importantly, results indicate that these patterns of abandonment cannot be attributed to individual differences—tests indicate that both faculty and freelancing physicians adhere to the norms of the organization where they practice, their own preferences notwithstanding.

This pattern of results offers insights into the potential mechanisms underlying the observed effects. The substantial variation in behavior across different organizational types and the two abandonment triggers may be related to the nature of incentives these organizations face. When financial incentives dominate, as is the case for for-profit hospitals, organizations respond with alacrity when revenue-enhancing alternatives (such as superior technologies) are introduced. However, these hospitals are slow to abandon more lucrative technological alternatives when their efficacy is questioned. In sharp contrast, the response of organizations with incentives to remain at the vanguard of science is distinctly different. AMCs instead adhere more closely to Mertonian (Merton 1973) norms of science. To the extent that the production of original research is of the utmost importance at AMCs (Wartman 2008, 2010), continuing to use the stents after their limitations had been identified would be inconsistent with the inherent “Skepticism” required of the scientific community.

Our robustness tests further allowed us to rule out alternative explanations that it is individual preferences, rather than organizational differences, that cause these adoption and abandonment decisions. Even in fields like medicine, where physicians are experts with significant autonomy in decision making (Freidson 1988), their behavior is circumscribed by the organization within which they work. A practicing
physician made the following observation regarding differences in freelancers’ behavior across hospitals:

They are immensely busy practitioners who have little excess time to involve themselves in the often intricate and difficult institutional decision-making which governs the purchase of or abandonment of technologies, especially at more than one hospital. Therefore, being pragmatic problem-solvers, they probably “go with the flow” most of the time in order to provide their patients with the best of what is available at each hospital to whose staff they belong.

Our study also suggests useful directions for theory development in the domain of technology diffusion. First, there is a clear need for deeper theorizing about how organizations respond to differences in the underlying triggers for abandonment and the interplay of these responses with different organizational types. Second, it would be useful to explore how organizational types could be conceptualized to better understand their adoption and abandonment responses. We alluded to the notion of organizational identity as a key factor in determining the behavior of AMCs, with the dominant incentives that characterize the organization constituting the basis for that identity. If AMCs’ science-based identity ensures that when confronted with a trade-off they are likely to abandon, even if it means financial losses, there is a clear need to investigate other influences that moderate organizational responses to technological regime change.

We note several limitations of this study, some of which offer fruitful avenues for future research. First, the AHA/ACC guideline was released into a vibrant environment of research on treatment for SCAD. However, because these studies, which either substantiate or refute the guideline (Boden et al. 2007, Lüscher et al. 2007, Tu et al. 2007), were released after the guideline we do not believe they contaminate our analysis. Second, we are unable to rule out some alternate explanations, such as selection into the hospital or agency on the part of the patient in demanding stenting as a treatment, though our robustness check using patients who arrive through the emergency department suggests this is not an issue. Finally, care should be taken when generalizing the findings to alternate settings where different sets of norms may operate. However, as most professionalized organizations experience some levels of conflict between the broader mission that the organization is created to address and the financial objectives and social norms underlying their day-to-day activities, the broad thrust of our argument should hold even outside the medical context.

Our study makes several contributions to existing literature. First, we investigate an understudied yet critical organizational process—the abandonment of technology—and shed further light on equivocal results found thus far in the literature. It is widely understood in the management and economics literatures that technology innovation occurs with regularity, thereby necessitating organizations to adopt new technology on an ongoing basis or face the risk of competitive disadvantage. However, arguably, the need to discard old technology when its efficacy is called into question is an equally important organizational and societal imperative. Our analysis allows us to illuminate the drivers of these organizational processes in a richer and more detailed way than prior research. Moreover, to the degree that researchers in management (Burns and Wholey 1993, Finkelstein and Gilbert 1985) and medicine (Greer 1981, Howard and Shen 2012) have found divergent results regarding the abandonment of technology and practices, our study suggests that these may be the result of underlying heterogeneity in triggers for technology abandonment, and in organizational types. Second, our work adds interesting nuance to existing knowledge regarding firm-specific human capital in medicine. Although prior research (Huckman and Pisano 2006) has shown little correlation in the performance of physicians across organizations, our results indicate that this may be a result of pursuing different treatment options across organizational settings, where organizational norms appear to carry primacy. This finding highlights the importance of future work devoted not only to how physicians choose their treatments based on organizational factors, but also to how these treatment choices influence patient care outcomes.

Finally, this study answers the call for research (Horwitz 2005) examining understudied or unresolved differences across hospitals. By showing that AMCs, for-profit, and nonprofit hospitals differ in their adoption and abandonment rates of new technologies and information, we add to the empirical literature addressing similarities and differences across hospitals. Our findings underscore the point that differences in the mix of vanguard technologies do exist, due to both norms of science and corporate ownership status. These differences may help identify potential obstacles policy makers may face during the transformation of the U.S. healthcare system as envisioned in the Patient Protection and Affordable Care Act of 2010. Although comparative effectiveness of treatments is a critical cornerstone of this legislation, in an effort to curb the escalating costs of medical treatment in the United States (Agarwal et al. 2010, Iglehart 1999), many scholars have highlighted barriers to effectively implementing these protocols (Timbie et al. 2012). Our results suggest that the strategic utilization of coherent social incentives operating in organizations, alongside targeted incentives aimed at individual physicians, may be a
more effective and cost-effective to ensure compliance across the medical community.

Acknowledgments
All authors contributed equally. The authors thank the department editor, the associate editor, and the anonymous reviewers for the many suggestions that improved this paper. This research also benefitted from feedback received at the Utah Winter Conference on Business Intelligence, the Workshop on Information Systems Economics, the Workshop on Health IT Economics, and the Smith Entrepreneurship Research Conference. The authors thank the Maryland Reading Group, Gordon Gao, Jeff McCullough, William Miller, Kislaya Prasad, and Curtiss Stinis for their comments on earlier versions. This research was partially funded by the University of Maryland’s Center for Health and Information Decision Systems. All remaining errors are the authors’ responsibility.

Appendix A. Coronary Arterial Disease
Coronary arterial disease is a condition where plaque builds up in patients’ arteries, causing a restriction of blood to the heart, thereby reducing the amount of oxygen the muscle receives. Left untreated, arterial disease can lead to a variety of negative patient care outcomes, ranging from a reduced ability to perform everyday tasks as a result of angina, i.e., chest pain, to death as a result of acute myocardial infarction, i.e., heart attack. At present, it is the leading cause of death in the United States, with roughly 40% of the American population suffering some form of the disease over the course of their lifetime (Rosamond 2007).

Not surprisingly, given the length of time required for plaque buildup to become life threatening, many classifications of the disease have been developed, with varying medical treatments existing at each degree of severity. At present, the dominant classification comes from the CCS (see Cassar et al. 2009, Table 1, for a formal definition of CCS Class I-IV angina), which is referenced explicitly in the 2005 AHA/ACC guideline (Smith et al. 2006). According to the newly released guideline, stents should no longer be used as a treatment for CCS Class I and CCS Class II arterial disease.

We therefore classify patients suffering from the following medical conditions as severe SCAD patients based on their ICD-9 codes: intermediate coronary syndrome, an acute coronary occlusion without myocardial infarction, or angina decubitus.18 Acute coronary occlusion without myocardial infarction is a complete blockage of one of the arteries that supplies the heart with blood, thereby making it severe by definition. Angina decubitus is CCS Class III based on the descriptions in Cassar et al. (2009), because it is resting chest pain. Finally, intermediate coronary syndrome is severe SCAD according to the ICD-9 description.

Appendix B. Adoption of Drug-Eluting Stents
Although the empirical estimations in Table 3 (as well as the subsequent robustness checks) examine the abandonment pattern of BMSs after the release of DESs, it is possible that the adoption patterns of DESs do not follow the initial adoption patterns observed for BMSs. Because idiosyncratic differences in the technologies may lead to different outcomes, such as different patterns of adoption for the second generation technology, with different theoretical implications, we investigate the initial adoption patterns of DESs in this appendix. Therefore, to ensure that abandonment of BMSs in the presence of DESs is an appropriate empirical corollary to initial BMS adoption, we replicate our analysis using DES adoption patterns. To estimate these results, we estimate Equation (1) again with the dependent

---

18 Recall that all patients suffering from a heart attack are dropped from the sample.
variable of DES utilization during Period 2. Results can be found in Table B.1, and output of the dummy regressions can be found in Figure B.1. Results suggest consistent adoption patterns between initial BMS adoption and subsequent DES adoption. To the degree that AMCs adopt the use of DESs significantly faster and not-for-profit hospitals adopt the usage of DESs significantly slower, we conclude that the emergence of DESs is an appropriate counterfactual for studying the abandonment of an antiquated technology, viz., BMSs, in the presence of a superior technology, viz., DESs. Graphical output from the time dummy regressions confirms this intuition. Replication of these results using freelancer and faculty specifications are consistent and are available from the authors upon request.

References

Greenwood et al.: Organizational Differences in Medical Technology Life Cycles Management Science, Articles in Advance, pp. 1–19, © 2016 INFORMS