Firm Scope and Spillovers from New Product Innovation: Evidence from Medical Devices

Matthew Grennan*
University of Pennsylvania, The Wharton School & NBER

Charu Gupta
University of Pennsylvania, The Wharton School

Mara Lederman
University of Toronto, Rotman School of Management

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Abstract

When firms span related product categories, spillovers across categories become central to firm strategy and industrial policy, due to their potential to foreclose competition and affect innovation incentives. We exploit major new product innovations in one medical device category, and detailed sales data across related categories, to develop a causal research design for spillovers at the customer level. We find evidence of spillovers, primarily associated with complementarities in usage. These spillovers imply large benefits to multi- vs. single-category firms, accounting for nearly one quarter of sales in the complimentary category (equivalent to four percent of revenue in the focal category).

*grennan@wharton.upenn.edu, guptac@wharton.upenn.edu, mara.lederman@utoronto.ca. Data for this research was provided by Millennium Research Group (www.mrg.net), and financial assistance was provided by the Mack Institute for Innovation Management. Thanks to Kira Fabrizio, Jon Kolstad, Robin Lee, Gabriel Natividad, Bob Town, and seminar participants at the NYU Economics of Strategy Conference, Strategy Research Forum, and Toronto Strategy Brownbag for helpful comments. Any errors are our own.

1 Introduction

When firms sell products in multiple categories (as they do in many industries including consumer electronics, automobiles, internet software, and biomedical technology), success in one product category may generate spillovers in performance to the firm's other product categories. Such spillovers arise for several reasons. On the demand side, spillovers can result from usage complementarities between products or brand preferences that extend across product categories (Cabral 2000; Chatain 2011). On the supply side, spillovers can arise if firms that are successful in one category can then exploit economies of scope in activities like advertising, sales, or R&D which improve their performance in other product categories (Panzar and Willig 1981; Teece 1982). In addition, multi-product firms may be able to create spillovers through contracting practices that offer buyers some form of benefit if they concentrate their purchases with that firm (Whinston 1990). The importance of spillovers, as well as their source, is at the heart of many recent firm strategy and industrial policy discussions, due to their potential to foreclose competition and affect innovation incentives.[1]

In this paper, we estimate the presence and magnitude of spillovers across firms' categories at the individual buyer level. Empirically identifying such spillovers is difficult for two reasons. First, it requires detailed buyer-level data on purchases of multiple products sold by the same firm. Second, actual spillovers – where success in one product category *causes* improvements in performance in others – must be disentangled from firm-specific capabilities or investments that result in a firm producing superior products across multiple categories. This requires a source of variation in the performance of a subset of the firm's products that is uncorrelated with the performance of its other products, other than through possible spillovers.

Our setting is the medical device industry – specifically, devices in the area of interventional cardiology. We use monthly data from 2005 to 2013 on a sample of hospitals' purchases of three categories of interventional cardiology devices: stents, balloons, and guidewires. These data allow us to measure each manufacturer's market share within each device category in each hospital in each month. The raw data indicate that, for firms selling in multiple categories, their shares across categories within a hospital are highly correlated with one another, with correlation coefficients at the manufacturer-hospital-month level in the US market all exceeding 0.4. The goal of this paper is to estimate the extent to which these

[1]For example, Steve Jobs termed Apple's resurgence in the computer market in the 2000s an "iPod halo effect," as their experience with the iPod influenced non-Mac users to buy their first Mac computers (Rawson 2011; Stone 2011). Recent antitrust rulings in telecommunications (Winkler 2018) and internet software (Brogan 2017) have been driven by concerns about spillovers and innovation. Scale economies and spillovers have also been central to modern biomedical technology markets for some time (Caves et al. 1991).

correlations represent spillovers, rather than firm capabilities, and to identify possible mechanisms underlying any spillovers that we measure.

Our causal research design leverages several institutional details of the market we study. We consider three devices – stents, balloons and guidewires – that are used together in angioplasty procedures that treat blockages in the arteries surrounding the heart. Stents – mesh metal tubes left in the artery to maintain open bloodflow – are the critical device in these procedures. While balloons and guidewires are used to execute the procedure, they are less directly critical to long-term patient outcomes. The stent market experiences significant innovation during our sample period with the introduction of several new drug-eluting stents (DES). DES constitute an important technological advance, improving patient outcomes over previously existing stents (Burt and Hunter 2006; Htay and Liu 2005), and their introduction resulted in movements of market share to the innovating manufacturers. Indeed, each of these entry events represents a major shock to stent market shares.[2]

Uncertainties surrounding the timing of regulatory approval (Stern 2017) mean that the precise timing of a DES's approval is unlikely to be correlated with trends in the balloon or guidewire markets (which are relatively stable technologies during this time period). Furthermore, because stents are the critical and most profitable component of an angioplasty procedure, it is unlikely that manufacturers would adjust the timing of their innovation in the stent market in response to events in the balloon or guidewire markets. As a result, we are able to combine our detailed product market data with difference-in-differences regressions that exploit this plausibly exogenous variation in stent shares to estimate whether increases in the share of stents that a hospital purchases from a given manufacturer causally influence the share of balloons and guidewires that the hospital purchases from that same manufacturer. We also shed light on some of the mechanisms underlying spillovers across categories in this setting, leveraging the fact that stents have potential usage complementarities with balloons but not with guidewires.[3]

While our setting is fruitful because it offers a source of plausibly exogenous variation in a single product's share, the medical device industry, in general, is one in which product spillovers may be economically important for several reasons. First, some medical procedures involve the use of multiple devices in combination. Manufacturers that produce both (or all) of the devices used in a procedure can design physical complementarities into their products

[2]This type of product-specific variation is relatively rare. It is analogous to observing a large shift in a search engine's market share and measuring the ensuing effect on the engine's other consumer products such as email or shopping tools.

[3]Stents and balloons are both mounted on catheters that are manipulated through a patient's blood vessels, and these catheters can share similar controls and design (e.g. the rigidity of the catheter) across the balloon and stent platforms.

such that they work better together than when used with a device from another manufacturer. Second, the success of any procedure involving a medical device depends on both the inherent quality of the device and the physician's capability and comfort level using that device.[4] Even when devices are not actually used together in a procedure, complementarities between a firm's products may arise if the products share usability features that enable a physician who is comfortable with one of the products to more easily and successfully use the other product. Third, innovation is frequent in the medical device industry and the life cycle of new devices is short, typically about 2 to 3 years. Frequent innovation means that market leadership in a given category can shift, creating the potential for changes in market share in other product categories due to spillovers, even if product offerings in those other categories remain constant. As emphasized by Teece (1986), this can have important implications for the returns to innovation and overall competitiveness of firms with a portfolio of products spanning multiple categories relative to more focused firms. Finally, medical devices are comprise a market where shared capabilities in R&D and sales are potentially important drivers of correlated success across categories, making the null hypothesis that true causal spillovers may be a negligible driver of the raw correlations in the data a viable possibility.

Our empirical analysis consists of a series of regressions that relate the share of a given manufacturer's balloons or guidewires in a given hospital in a given month to the manufacturer's share of stents in that hospital in the same month. Our data allow us to carry out this analysis for hospitals in the US and the EU. While angioplasty is performed in the same way in the EU as in the US, and provides the same benefits to patients, the regulatory barriers to entry are much lower in the EU in terms of clinical trials required. This leads to more firm entry in the EU, but also less information about product quality available upon entry, than in the US (Grennan and Town 2018). Consequently, this means that the EU market is less concentrated and has more firms with varying levels of multi-category presence, but at the same time, new stent introductions have a less pronounced impact on market shares, requiring more assumptions to validate our research design. Since our objective is to estimate a causal relationship, we focus on analysis of the US market in the body of the paper and provide results for the EU in Appendix B. We note here that the results from the EU are qualitatively and quantitatively similar to the US, suggesting the robustness of our findings.

In our preferred specification, we estimate a difference-in-differences model using seven-month windows surrounding three major DES introductions in the US. We find that a 10-percentage-point (about one third of a standard deviation) increase in a manufacturer's within-hospital stent share raises its within-hospital balloon share by 2.5 percentage points.

[4]Indeed, physicians often collaborate with device manufacturers during the design phase (Chatterji et al. 2008; Chatterji and Fabrizio 2012, 2016).

When we estimate the impact on guidewires, which do not share a usage complementarity with stents, our point estimates are much smaller and not statistically significant, suggesting that familiarity with a manufacturer's other products may be a source of the spillovers in this setting.

Given that the average multi-category device manufacturer has a stent share of 0.25 at the hospital level, our estimate implies that spillovers from stent sales to balloon sales provide the average multi-category firm in our data with a 6.25 percentage point advantage in its within-hospital balloon share, relative to a single-category firm selling only balloons. This is equivalent to a 25 percent increase in the average within-hospital manufacturer balloon share in US hospitals. With balloon prices at roughly 16 percent of stent prices, these balloon spillovers provide the average multi-category stent manufacturer the equivalent of additional 4 percent revenue boost in the US, relative to a single-product manufacturer with no such spillover benefits.

For both guidewires and balloons, we further explore the underlying mechanisms by decomposing spillovers into their extensive and intensive margins. Specifically, we investigate whether changes to a manufacturer's stent use in a hospital results in the hospital beginning to use the manufacturer's other products and/or the hospital increasing its use of those products (conditional on already using them). Consistent with the usage complementarities mechanism, we find that hospitals that increase their stent usage along the intensive margin also increase the amount of balloons used from the same manufacturer, but not the amount of guidewires used from that manufacturer. When we explore the impact of hospitals' changes in stent usage along the extensive margin, we find that hospitals which begin buying a manufacturer's stents are more likely to move on the extensive margin into buying both that manufacturer's balloons and its guidewires. This latter finding is suggestive of economies of scope in contracting costs unrelated to demand directly and adds to a growing body of literature documenting the value of buyer-supplier relationships and the frictions to developing new ones (Chatain 2011; Elfenbein and Zenger 2013; Grennan and Swanson 2018a).[5]

The spillovers we estimate imply that firms which sell products in multiple categories will reap larger rewards to innovation in a focal market than a smaller firm which operates only in the focal market and therefore cannot benefit from the additional revenue generated by such spillovers. This finding contributes empirical evidence to the debate about whether and how the profitability of innovation relates to firm size and scope (Schumpeter 1942; Teece

[5]Grennan and Swanson (2018a), in particular, find a similar extensive margin relationship at the manufacturer-hospital level in a different sample of hospitals, across a wide variety of device categories, but without a clear causal research design like the stent entry events in this study.

1986; Cohen and Levin 1989). These results also relate broadly to recent antitrust debates in the technology and telecom sectors where there has been much concern about market power in one product category affecting competition and innovation in related product categories. More specifically, they add to the growing body of research on the factors influencing innovation incentives in medical technology in particular (Chatterji and Fabrizio 2012; Nistor and Tucker 2015; Chatterji and Fabrizio 2016; Galasso and Luo 2017; Stern 2017; Grennan and Town 2018; Galasso and Luo 2018).

This paper also contributes to literatures in business strategy, industrial organization economics, and the economics of innovation on the returns to firm scope and the relationship between firm scope and innovation. In particular, we focus on issues of firm scope that arise in multi-product and multi-category industries (see Bailey and Friedlaender (1982); Teece (1982) for an overview of many relevant issues). Similar to work by Borenstein (1991) and by Lederman (2007, 2008) in the airline industry and by Chatain (2011) in legal markets, we directly measure spillovers between different products (or categories of products) offered by the same firm to the same buyer. There is a growing number of studies using a combination of detailed data and causal research designs to measure the magnitude of – and mechanisms behind – spillovers at the buyer level. These studies include: Hendricks and Sorensen (2009) which examines information shocks that spill over between new and old albums for the same musical artist; Ho et al. (2012) which studies how suppliers use contracting to "force" related DVD titles onto video rental store buyers (a mechanism suggested in theoretical work on tying, bundling, and cross-subsidization of products to deter entry by new firms (Whinston 1990; Nalebuff 2000, 2004); Cabral and Natividad (2016) which studies the combination of both information and contracting mechanisms in the retail DVD market; and Elfenbein and Zenger (2013) which studies the development of buyer-supplier relationships in the context of manufacturer commodity procurement. To our knowledge, we are the first to provide causal evidence on the primary spillover mechanism suggested by our analysis – similarities in user experience across product categories.[6]

We do not examine the advantages of preemption via product proliferation in the same category as in Schmalensee (1978) or Burton (1994), or the broader issues around corporate diversification into potentially unrelated business areas as in Montgomery and Wernerfelt (1988) and the related literatures. Our estimated causal effect also excludes advantages such as economies of scope in research and development (Henderson and Cockburn 1996; Macher and Boerner 2006) or firm-specific capabilities or focus (Siggelkow 2003) in product or sales team quality. However, comparing the magnitudes of our causal estimates to the magnitudes

[6]This result also relates to prior theoretical work on firm strategies surrounding product compatibility (Matutes and Regibeau 1988).

of the estimates obtained when we estimate less restrictive specifications suggests that, while these other mechanisms may operate, the spillovers we measure are a large component of the full set of factors underlying the observed correlations in within-firm sales across categories in our setting.

The remainder of this paper is organized as follows. Section 2 descries our empirical setting and provides relevant institutional background. Section 3 provides details regarding the dataset construction and descriptive patterns. Section 4 presents our empirical approach. Section 5 reports and discusses our results. A final section concludes.

2 Industry background

In this section, we provide relevant institutional background information on the specific medical devices we study and the procedures for which they are used, the hospital purchasing process, and the regulatory approval process for medical devices. We conclude the section with a discussion of the possible sources of spillovers in this setting.

2.1 Interventional cardiology

Interventional cardiologists focus on the treatment of coronary and vascular conditions using nonsurgical, catheter-based treatments. Interventional treatments may offer several advantages over surgical options, for example, in recovery time, patient satisfaction, lower procedural risk, and avoidance of cardio-pulmonary bypass in certain patients (Tobis and Abudayyeh 2015). The size of the global interventional cardiology market makes it an economically meaningful industry for study. One estimate valued the global market in 2013 at approximately $15 billion and forecasts it to reach more than $25 billion by 2020 (PRNewsire, 2018). In our data, we focus on the three interventional cardiology medical devices most commonly purchased by hospitals: stents, balloons, and guidewires.

Balloon angioplasty was introduced in the 1960s to relieve obstruction and narrowing of the coronary artery. A guidewire is used to guide a balloon catheter (we use the term balloon and balloon catheter interchangeably throughout the text) to a blockage in the artery, and the balloon is expanded at high pressure to push open the blockage. Stents – small, expandable mesh tubes that provides support to the artery – were approved by the FDA in 1994 and improved the effectiveness of angioplasty.

Importantly, stents are inserted into the body mounted and compressed onto a balloon catheter. The stent and balloon are then guided to the blockage (which has been previously pushed open by a high-pressure balloon), and the balloon is expanded and then released to

deploy the stent into the arterial walls. Though the balloons that deploy stents operate under different pressure than those used to push open blockages, they are constructed similarly and have similar controls. Consequently, physicians who develop experience with a given manufacturer's stents will naturally be familiar with that manufacturer's balloons. While interventional cardiologists also use guidewires during balloon angioplasty, no such usage complementarities exist between stents and guidewires.

Our empirical strategy (discussed in more detail in Section 4 below) exploits the introduction of drug-eluting stents (DES), stents that are coated with a drug that is slowly released over time to inhibit scar tissue growth. Many large randomized clinical trials showed improved outcomes from DES relative to bare-metal stents (Htay and Liu, 2005), and successive generations of DES improved to the point that angioplasty has replace coronary artery bypass graft as the most prevalent treatment for coronary artery disease.

2.2 Hospital purchasing process

It is useful to keep in mind some basic facts about the structure of decision making and the players in this market. First, hospitals generate revenue by performing a procedure (such as an angioplasty with a stent) and the price of the device is an input cost the hospital incurs. The physician who performs the procedure will typically be compensated either as a salaried employee of the hospital or on a fee-for-service basis for the procedure. Notably, in either case, the financial benefits to the physician are unrelated to the specific brand of device used. Physicians typically have strong preferences over which specific product to use for a given patient/lesion type because devices are differentiated in physical characteristics of the implanted device itself (for stents: examples are shape, strength, flexibility, and type of drug/polymer) and also characteristics that affect ease of implantation (for stents: unexpanded size and flexibility, and controls and capabilities of the catheters and balloons used in delivery). In fact, stents and other devices critical to their procedures are often referred to as "physician preference items." The supply side of the market is thus a differentiated oligopoly, and prices are typically negotiated between manufacturers and hospitals, hospital systems, or regional purchasing authorities.

There is no "search" by buyers in the conventional sense because a given brand can only be purchased directly from its manufacturer. The manufacturer holds inventory on-site at the hospital and the purchase is made when the physician pulls the product off the shelf and implants it into the patient. Stent contracts typically specify a linear price for the contract duration, often a year, but renegotiated more frequently if market conditions change. For more details on hospital purchasing, we refer the reader to Grennan and Swanson

(2018b), who find that purchasing practices via which these contracts are negotiated vary widely across organizations. Some hospitals have large materials management or purchasing departments with agents who specialize in negotiations. Sometimes a large business unit, such as a catheter lab in the case of stents, will coordinate its own purchasing separately from the rest of the hospital. Hospitals also vary in access to information on the prices other hospitals pay via GPOs, hospital system membership, or informal networks of peers.[7]

2.3 Regulatory approval process

Medical device regulation in the US mandates that the FDA determine a device "safe and effective" to grant market access. Devices fall into classes (I, II and III), based on perceived health risk. A Class III device is defined as one used in "supporting or sustaining human life, of substantial importance in preventing impairment of human health, or presents a potential unreasonable risk of illness or injury." Stents are Class III, while balloon catheters and guidewires are Class II. In the US, the approval process for a Class III device generally requires data from randomized clinical trials, involving thousands of patients and costing tens of millions of dollars to complete.

In the EU, the regulatory process is quite different, governed primarily by the Medical Devices Directive of June 1993, which has been adopted by each EU member state, and relies heavily on third parties known as "notified bodies," which are independent, commercial organizations that are designated, monitored, and audited by member states via "competent authorities." To obtain EU approval, a Class III medical device needs to demonstrate safety and performance which can usually be demonstrated with simpler and cheaper clinical trials than required in the US by the FDA. Once a device has been approved for use in one EU country, it can be marketed in any member country.

The gap between the two regulatory systems is the focus of a number of consulting and government reports and an academic study by Grennan and Town (2018) using the same stent data we use here (and to which we refer the reader for greater detail and data on these processes). For the purposes of this study, the most important differences between the two markets are: (1) the lower monetary and time costs of obtaining EU approval which results in more and earlier market entry in the EU than US (particularly for stents, where the gap in processes is largest); and (2) the lower information requirements for EU entry which leads to more gradual market adoption of new products as US trial evidence accrues. Our empirical strategy described below exploits three major DES entry events; these product

[7]Grennan and Swanson (2018b) provide a host of evidence that there is no systematic use of quantity, market share, or bundled discounts in pricing for stents, balloons, and guidewires. Appendix C.2 examines price variation in our data and finds our results unaffected.

introductions lead to gradual changes in market share in the EU whereas they lead to rapid shifts in market share in the US as the device relative quality advances are well known by that time.[8]

2.4 Potential sources of spillovers

There are several potential sources of spillovers in the medical device setting, which we aim to disentangle from firm-specific capabilities that may result in success across all categories. First, as discussed above, usage complementaries may exist between some devices, enabling physicians who use them to simultaneously become familiar with more than one device. In addition to usage complementarities, economies of scale and scope in manufacturer-physician relationships can also contribute to spillovers across categories.

These extend beyond the hospital setting to other activities which have drawn more scrutiny from policy makers. With the rapid pace of new technology development, physicians require continuous education and training. Much of this training is sponsored by device manufacturers, and larger manufacturers are able to defray the fixed costs of travel, space, and setup over a larger portfolio of product types. On the flip side, many of these physicians at the technological frontier also play an important role as developers of the next generation of technologies (Chatterji et al., 2008), and they formalize this role with consulting contracts with the manufacturers. Despite the legitimate benefits of these consulting and training relationships, they do open the door for potential conflicts of interest. While we do not speak to these conflicts of interest directly, our investigation into mechanisms does shed some light on this issue indirectly – to the extent that spillovers are driven by complementarities (concentrated in balloons vs. present across balloons and guidewires), this would seem less consistent with bias due to conflicts, at least in driving spillovers.

3 Data and descriptive statistics

3.1 Data

Our data come from Millennium Research Group's (MRG) MarketTrack survey of hospital medical device purchasing patterns. The survey is a key source of market intelligence in the medical device sector and aims to produce representative estimates of the distribution of market shares and prices of medical devices by country. Our data cover a random sample of hospitals in the US and EU, covering about ten percent of hospitals by revenue from January

[8] Appendix A.4 shows the changes in market share for innovating firms with DES product entries.

2005 through June 2013. The data contain information on the precise quantities of each interventional cardiology device purchased by a hospital in a month. We limit our sample to the three categories of devices within interventional cardiology (based on MRG's segmentation) that hospitals most often purchase: stents, balloon catheters and guidewires. Because manufacturers may produce multiple products within the same category (e.g., several different balloon catheters), we aggregate a hospital's purchases of different products from the same manufacturer in the same category. The resulting dataset is at the manufacturer-hospital-month level and includes 81,065 manufacturer-hospital-month observations in the US and 612,162 observations in the EU.[9]

Figure 1 shows the distribution of firms based on the number of categories of interventional cardiology devices in which they sell products. Averaging across firm-months in the data, 62% of firms which sell devices in one of the three device categories we consider, sell in all three. 37% of firms sell in only a single line in month. Almost no firms sell in two of the three categories. In the EU, the distribution is less bimodal. About 44% of firms sell in only a single category in the typical month while 34% sell in two and 22% sell in all three. The prevalence of firms selling in multiple categories creates the potential for spillovers to operate. The remainder of the body of the paper will focus on the US market with the corresponding analysis for the EU presented in Appendix B.

3.2 Variables and summary statistics

Our main variables of interest are the within-category shares for each manufacturer in each hospital-month. Specifically, we construct s^c_{jht} which measures the overall share of all devices in category c purchased by hospital h in month t that are produced by manufacturer j. It is calculated as the total number of units q manufacturer j sells in category c to hospital h divided by the total number of units of devices in that category that hospital h buys from all manufacturers. Our overall share measure accounts for censoring at zero by explicitly including manufacturer-category-hospital-month observations with zero units purchased ($q^c_{jht} = 0$), provided the manufacturer has a product in that category available in the market during that month. In some specifications, we distinguish changes in hospitals' usage along the intensive and extensive margin. To capture the extensive margin, we construct an indicator $\mathbb{1}_{\{s^c_{jht>0}\}}$ which equals one if hospital h purchases any quantity of devices in category c from manufacturer j during month t. The intensive margin share variable is then simply

[9]Because the MRG survey is focused first on collecting data on coronary stents, other product category data is missing in a small number of hospitals. We restrict our sample for analysis to hospital-months reporting data on all three of our categories of interest. We also account for censoring at zero by explicitly including zero-unit observations ($q^c_{jht} = 0$), provided that hospital-month is reporting data and the manufacturer has a product available in any category. More details on sample construction are available in Appendix A.

Figure 1: Number of categories across firms

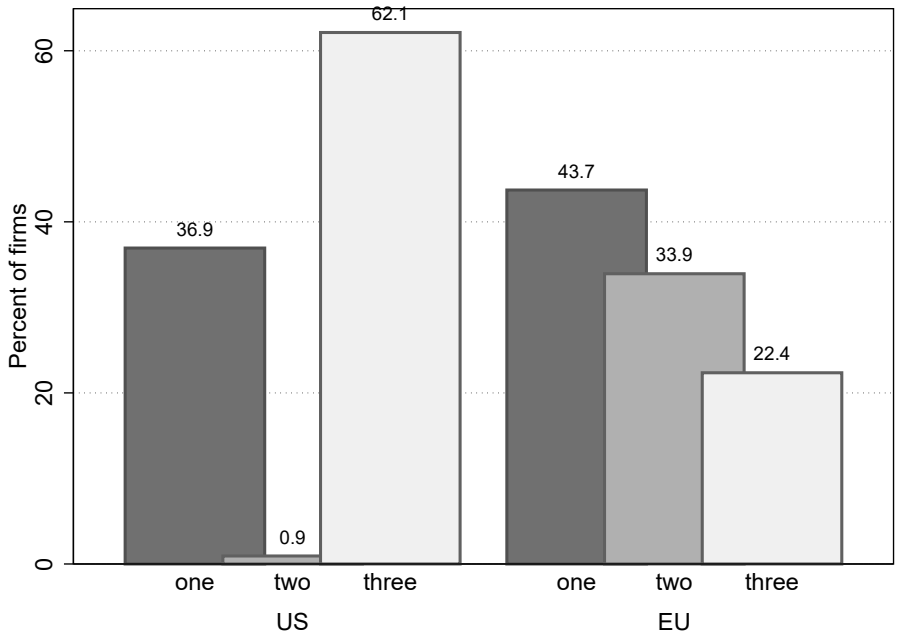


Figure depicts monthly averages across the sample period, January 2005 through June 2013. Total number of manufacturer-market-month observations is 674 in the US and 3,330 in the EU.

the conditional share $s^c_{jht}|\mathbb{1}_{\{s^c_{jht>0}\}}$. Precise variable definitions appear in Appendix A.

The first three columns of Table 1 provide means and standard deviations of the hospital-level share variables. The last two columns show the mean number of manufacturers active in a category at the market and hospital level, respectively. On average, across months in our data, there are between 3.9 and 5.9 manufacturers active in each device category and between 2 and 3 manufacturers active in each hospital, indicating that the market is more concentrated at the hospital level than country level. The means of the indicator variables reveal that, on average, in a given month, a manufacturer will sell its devices to about 30 percent of the hospitals in the market (27 percent for balloons, 30 percent for guidewires and 32 percent for stents). Conditional on selling to a hospital, on average, a manufacturer accounts for between 40 and 48 percent of the devices purchased by the hospital in the category.

To motivate our analysis, we examine the raw correlation between a manufacturer's within-hospital shares in different categories. We see a strong positive correlation between manufacturers' within-hospital stent shares and within-hospital balloon shares (0.711). We also observe a positive correlation between a manufacturer's within-hospital stent and guidewire shares (0.462) as well as between its balloon and guidewire shares (0.539), though

Table 1: Summary statistics

	s^c_{jht}	$\mathbb{1}_{\{s^c_{jht>0}\}}$	$s^c_{jht}\|\mathbb{1}_{\{s^c_{jht>0}\}}$	$\|J^c_m\|$	$\|J^c_h\|$
stents	0.128	0.321	0.398	3.95	2.53
	(0.257)	(0.467)	(0.313)	(0.22)	(0.92)
balloons	0.128	0.266	0.480	4.82	2.09
	(0.281)	(0.442)	(0.357)	(0.39)	(0.89)
guidewires	0.128	0.297	0.430	5.91	2.33
	(0.261)	(0.457)	(0.315)	(0.96)	(0.92)

Table provides mean values for the hospital-level shares by category in the typical month. Note that the overall share variable has the same mean across categories due to our inclusion of zero-quantity observations to address censoring. $|J^c|$ gives mean number of manufacturers active in the market by category, and $|J_h|$ gives mean number of manufacturers active in a given hospital by category. Standard deviations are in parentheses. Mean number of US hospitals in the sample in the typical month is 101.6, with a standard deviation of 4.3. Total number of US manufacturer-hospital-month observations is 81,065.

the magnitudes are smaller. Of course, these correlations cannot distinguish spillovers from other unobservable factors that may cause a hospital to concentrate its purchase of devices in different categories with the same manufacturer. The empirical strategy we develop below aims to do this.

4 Empirical approach

4.1 Panel regressions of cross-category spillovers

The goal of our empirical analysis is to estimate whether success in one category causes improvements in the performance of a firm's other categories. To do this, we estimate a series of regressions which relate a manufacturer's within-hospital share of either balloons or guidewires to its within-hospital share of stents, controlling for flexible time trends.[10] Our main estimating equation is the following:

$$s^{balloons/gwires}_{jht} = \beta_0 + \beta_1 s^{stents}_{jht} + \delta_{jt} + \delta_{jh} + \epsilon_{jht} \tag{1}$$

[10]We do not find evidence of meaningful effects on prices, and including price limits our sample size (price data is not reported by all hospitals, and is unavailable when usage is zero); so we focus on changes in quantities as our primary metric of success. Appendix C.2 provides results of our main specifications with price as the dependent variable, showing that prices of balloons and catheters do not change with the stent introductions we examine. It also provides extensions of our results, adding price as an independent control variable, where we find our results unchanged. This is consistent with anecdotal evidence that physician decisions about what product to use are not very responsive to price, which has been confirmed in previous studies of coronary stent demand (Grennan 2013, 2014; Grennan and Town 2018) and demand for other medical devices (Grennan and Swanson 2018a) that find very small effects of price on quantities.

The key parameter of interest is β_1 which captures how a manufacturer's within-hospital balloon (or guidewire) share changes as its within-hospital stent share changes. The primary challenge in estimating this equation is disentangling spillovers from unobservables that may influence a firm's performance in multiple categories simultaneously. For example, firms that produce higher quality products may sell more of all of their products to particular hospitals. Alternatively, firms that initiate a marketing campaign may experience increases in the sales of all of their devices.

We use several strategies to control for unobservable factors that may result in a correlation in the within-hospital shares of a manufacturer's different products. First, we include manufacturer-hospital fixed effects δ_{jh} in our models. These fixed effects control for time-invariant unobservable factors that may influence a manufacturer's sales of all three devices to a given hospital. With the inclusion of these fixed effects, our estimates are identified by changes in the shares of products that a hospital purchases from a manufacturer, rather than differences in levels across hospitals, thus controlling for the possibility that some hospitals prefer devices from particular manufacturers.

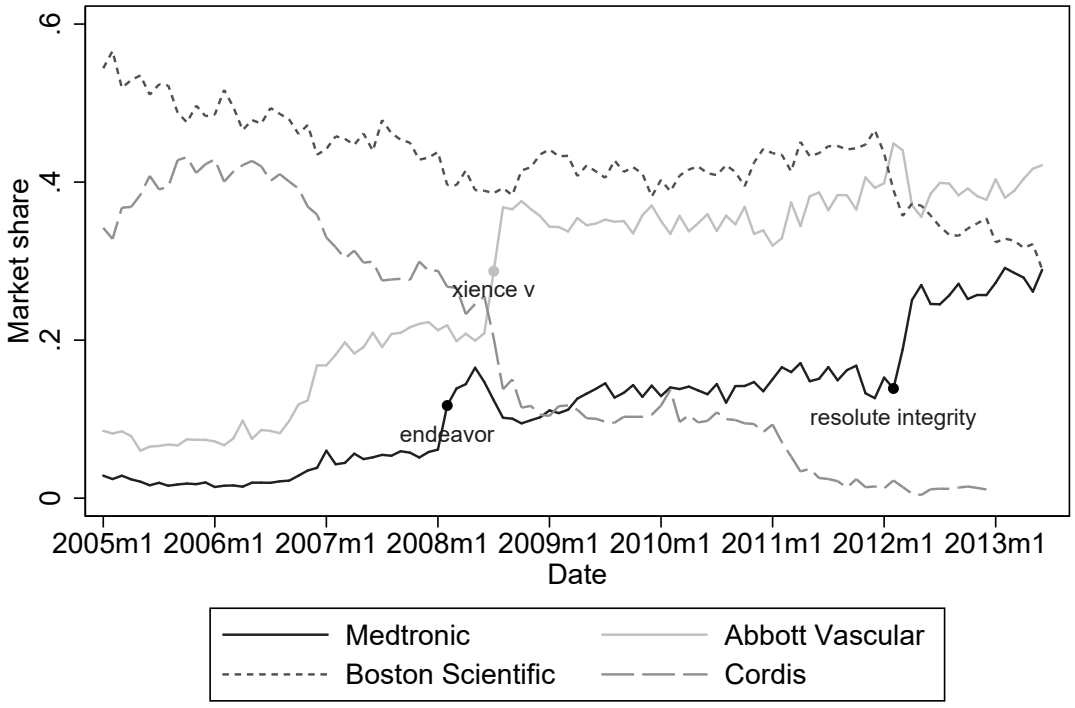
Second, we control for manufacturer-time fixed effects δ_{jt} (at the monthly level). This controls for the possibility that, over time, manufacturers may take actions that improve the attractiveness of all of their products simultaneously. For example, this could result from a new advertising campaign or from positive or negative press coverage. By including these effects, we control for such changes, and we only identify spillovers from changes in a manufacturer's stent performance in a particular hospital that is over and above any performance changes that manufacturer has in the market overall in that month. This ensures that we are estimating a hospital-level (buyer-level) relationship change.

Finally, to further eliminate the possibility of time-varying unobservables that impact the within-hospital shares of all of a manufacturer's products simultaneously, we focus on the discrete changes to stent shares that result from innovative DES product entry. The regulatory requirements for introducing a new coronary stent are expensive and time-consuming in the US, with the precise timing and outcomes of completing clinical trials and obtaining regulatory approval being uncertain (Stern 2017; Grennan and Town 2018). This uncertainty allows us to consider the stent share changes that result from new product introductions as plausibly exogenous with respect to balloon and guidewire market trends, especially within the narrow time windows we study in our tightest specification.

The three particular events that we focus on – Medtronic Endeavor, Abbott Vascular Xience V, and Medtronic Resolute Integrity – had the largest immediate impact on the innovating firm's US stent market share during our sample period.[11] Figure 2 demonstrates

[11] Appendix A.4 provides information on all DES introductions over our sample period.

Figure 2: Three major DES introductions and stent market shares



Markers indicate the three major DES introductions of interest; lines give overall market share in stents. We plot market share for the four manufacturers active in the US stent market: Boston Scientific, Abbott Vascular, Cordis, and Medtronic. Appendix Table 4 provides more details on the major manufacturers active across the stent, balloon, and guidewire device categories.

this first stage – the product introductions we exploit induce variation in stent market share. For the US, we see immediate changes in shares around all three events.

As discussed above, the introduction of these new stents is unlikely to be correlated with other changes that would (directly) impact a manufacturer's sales of balloons or guidewires. We can therefore use these three product introductions as "event studies" for estimating spillovers. Specifically, we estimate how changes in a manufacturer's within-hospital stent share after the introduction of one of these new stents influenced that manufacturer's within-hospital balloon or guidewire share and we interpret this estimate as capturing the causal effect. It is worth noting that while we focus on three introductions, these product introductions induce changes in the stent shares of both the introducing firms and competing firms, both of which serve to identify our coefficient of interest. Thus, the key identifying assumption in our event study analysis is that the new product introductions are not correlated with unobserved changes made by either the introducing firm or other firms that influence their sales of balloons and guidewires.

Finally, we note that while these three DES introductions assist with the identification of spillovers, they also share the challenges of external validity due to the fact that they necessarily limit the analysis to narrow windows around these specific events. Because of this, we also estimate spillovers using the panel regression model above and the full data. We then zero in on the event studies.

4.2 Decomposition into extensive and intensive margins

After obtaining estimates of spillovers using the major DES introductions, we decompose those spillovers into changes in the intensive and extensive margins. In particular, we estimate whether spillovers result when hospitals which already used a manufacturer's stents use them more and/or when hospitals that did not use a manufacturer's stents begin using them. We look at spillovers in terms of both the intensity of balloon (or guidewire) use and the probability of using that manufacturer's balloons (or guidewires). Characterizing the pattern over spillovers along these different margins helps shed light on which mechanisms may be causing the spillovers to exist. In particular, usage complementarities suggest that intensive margins should be linked for stents and balloons, but not for stents and guidewires.

5 Results: Spillovers across product categories

Table 2 present coefficient estimates from regressions of a firm's within-hospital share of either balloons or guidewires on that firm's within-hospital stent share. We first present the

specification with no fixed effects and then separately add manufacturer and manufacturer-hospital fixed effects to control for firm capabilities and buyer preferences which could result in certain manufacturers having a high within-hospital share for all of their devices. In the final specification of each panel, we focus on variation in stent shares that results from the three DES introductions, restricting to three-month windows around each event (for seven months total including the introduction month).

We begin our discussion with these event study specifications (Column 5 for balloons and Column 10 for guidewires), which we consider our most credible specifications for identifying causal spillovers. Looking first at spillovers from stents to balloons, we find a coefficient on the within-hospital stent share of 0.25, indicating that a 10-percentage-point increase (about one third of a standard deviation) in a manufacturer's stent share in a hospital generates a 2.5-percentage-point increase in its balloon market share in that same hospital.

This result has nontrivial implications for the performance of multi- vs. single-category firms. To quantify this, consider that the average multi-category device manufacturer offering stents and balloons has a within-hospital stent share of 25 percent, and thus enjoys an advantage over a single-category firm selling only balloons of 6 percentage points ($\beta_1 * (s_{jht}^{stents} * 100) = 0.25 \cdot 25 = 6.25$). This is 25 percent of the average within-hospital manufacturer balloon share of 25 percent in US hospitals. Thus focused balloon firms seem to be at a substantial disadvantage in the balloon market, all else equal. Relatedly, with balloon prices at roughly 16 percent of stent prices, this spillover provides the average multi-category stent manufacturer the equivalent of additional 4 percent revenue boost in the US, relative to a single-category stent manufacturer with no such spillovers.[12]

Table 2: US Spillovers

	Balloons					**Guidewires**				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
s_{jht}^{stents}	0.778***	0.540***	0.224***	0.255***	0.246***	0.469***	0.207***	0.0528**	0.0288	0.0170
	(0.0216)	(0.0273)	(0.0289)	(0.0308)	(0.0377)	(0.0261)	(0.0331)	(0.0213)	(0.0222)	(0.0271)
Observations	81,065	81,065	81,065	80,475	15,803	81,065	81,065	81,065	80,475	15,803
Adj. R^2	0.506	0.627	0.865	0.870	0.902	0.213	0.573	0.893	0.895	0.919
Mfr FE		yes					yes			
Mfr-Hosp FE			yes	yes	yes			yes	yes	yes
Mfr-Month FE				yes	yes				yes	yes

The dependent variable is $s_{jht}^{balloons}$ for balloon specifications and $s_{jht}^{guidewire}$ for guidewire specifications. Robust standard errors clustered at the hospital level are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

[12] Appendix A.3.2 provides summary stats by multi- and single-category status. Appendix C.2 provides summary statistics on prices (as well as results of regressions including price as a control variable, which has no effect on the results). Marginal costs in these medical device markets are typically thought to be very low relative to prices, with margins of 80 percent or more, making revenue a good proxy for profits (Burns 2005).

Columns (1-4), which build up to our preferred specification, provide some insight into the robustness and relative magnitude of our main spillover estimate. Column (4) uses the exact same specification but is estimated on the full dataset instead of restricting to the window around the three major entry events. The spillover estimate from the full sample is statistically indistinguishable from the estimate in the event windows, which we find reassuring in terms of external validity: It suggests that there is not some other important source of variation in stent shares with a distinct spillover on balloons that we do not capture in analyzing the entry event time periods.

Columns (1-3) build up our fixed effects.[13] Column (3) differs from (4) in that it removes the manufacturer-time fixed effects. The fact that the spillover estimate remains statistically identical between these two specifications is consistent with our understanding from qualitative analysis that there is little independent variation in the balloon market over time. Column (2) differs from (3) in that it includes only manufacturer fixed effects (rather than manufacturer-hospital fixed effects). The larger coefficient estimate – specifically, 0.54 as compared to 0.23 – indicates that there are unobserved factors at the manufacturer-hospital level – potentially preferences or sales effort – that are positively correlated across stents and balloons for the same manufacturer. The difference between these two specifications demonstrates the importance of controlling for these factors and also that our causal estimate of spillovers represents a large portion of all factors that drive these correlations across categories within a manufacturer-hospital pair. Finally, Column (1) provides a coefficient estimate of 0.78 with no controls. The positive difference between (1) and the specification with manufacturer fixed effects in (2) is indirect evidence that there are unobserved manufacturer-specific attributes – potentially R&D or sales capabilities – which result in some manufacturers having higher shares of both stents and balloons. That said, the magnitude of our causal estimate – relative to the estimate in Column (1) – suggests that within the broad class of all potential explanations of why sales might be correlated across categories within a manufacturer, the hospital-level spillovers we identify are quantitatively important.

Columns 6 through 10 present the same regressions as in the first five columns but with a manufacturer's within-hospital guidewire share as the dependent variable. As in the previous table, with the inclusion of manufacturer and manufacturer-hospital fixed effects (Columns 7 and 8), the coefficient estimates on within-hospital stent share fall relative to the specifications with no fixed effects (Column 6). Moving from the specification with no fixed effects to one which includes manufacturer-hospital fixed effects decreases the coefficient on

[13] Appendix C.1 includes robustness checks where we do not add manufacturer-month fixed effects but instead explicitly include the leave-out within-market share as a control in the regressions; our conclusions do not change.

US within-hospital stent share from 0.47 to 0.05. The large relative decline in the coefficient suggests that the raw correlation between stent and guidewire shares is to a large extent a product of fixed manufacturer and manufacturer-hospital specific factors shared across these two categories.

As Column 9 adds manufacturer-time fixed effects and Column 10 restricts to windows of time around the three stent entry events, the coefficient on stent share decreases further and is no longer statistically significant at conventional levels. Thus, in contrast to the case of balloons, we find limited evidence of within-hospital spillovers in guidewires – manufacturer-specific effects and time trends appear to play a greater role. Given that there are usage complementarities between stents and balloons but not between stents and guidewires, this pattern of results suggests these complementarities may be a cause of within-hospital spillovers in this setting.

5.1 Decomposition into extensive and intensive margins

Table 3 provides results that decompose extensive and intensive margin effects at the hospital level. This decomposition directly tests the extent to which the spillover mechanism is related to the amount of usage conditional on contracting (intensive) or related to the contracting process itself (extensive), which adds to a growing body of literature documenting evidence regarding the value of buyer-supplier relationships and the frictions to developing new ones (Chatain 2011; Elfenbein and Zenger 2013; Grennan and Swanson 2018a). It also provides further indirect evidence regarding the usage complementarity mechanism: To the extent that the strength of usage complementarities increase in the amount of usage, we would expect that mechanism to be evident primarily in the intensive but not extensive margin.

Looking first at spillovers onto balloons, Column 1 of Table 3 replicates our event study specification from the previous table. In Column 2, we decompose the spillovers we measure into the intensive and extensive margins by adding an indicator for whether or not manufacturer j sells any stents in hospital h at time t as a regressor. Once we do so, the original overall share measure now represents the intensive margin and the indicator, the extensive margin. The statistically insignificant and nearly zero coefficient on the indicator variable tells us that the increase in balloon share measured in our main specification is driven by changes in the intensive margin of stent usage. Specifically, when hospitals that already purchase stents from a given manufacturer increase their stent share, they also increase the share of balloons they purchase from that manufacturer.

Next, we explore whether changes in a hospital's stent purchases influence the probability that it purchases balloons from the same manufacturer. To capture probability of use (rather

Table 3: US Decomposition

	Balloons				**Guidewires**			
	$s_{jht}^{balloons}$		$\mathbb{1}_{\{s_{jht>0}^{balloons}\}}$		$s_{jht}^{guidewires}$		$\mathbb{1}_{\{s_{jht>0}^{guidewires}\}}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
s_{jht}^{stents}	0.246***	0.239***	0.244***	0.154***	0.0170	0.00889	0.0401	0.00338
	(0.0377)	(0.0384)	(0.0350)	(0.0339)	(0.0271)	(0.0281)	(0.0290)	(0.0356)
$\mathbb{1}_{\{s_{jht>0}^{stents}\}}$		0.0100		0.122***		0.0111		0.0499**
		(0.00933)		(0.0244)		(0.00685)		(0.0202)
Observations	15,803	15,803	15,803	15,803	15,803	15,803	15,803	15,803
Adj. R^2	0.902	0.902	0.821	0.823	0.919	0.919	0.844	0.844
Mfr-Hosp FE	yes	yes	yes	yes	yes	yes	yes	yes
Mfr-Month FE	yes	yes	yes	yes	yes	yes	yes	yes

Robust standard errors clustered at the hospital level are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

than intensity of use), we employ as the dependent variable an indicator for whether a hospital purchases balloons from a given manufacturer in a month. The results in Column 3 indicates that a 10-percentage-point increase in stent share increases the probability of a hospital purchasing balloons by the same manufacturer by 2.4 percentage points. In Column 4, we decompose this result into the intensive and extensive margins for stent purchases. For hospitals that begin to purchase stents from a particular manufacturer, after the major DES introductions, the probability that they purchase balloons from that manufacturer is 12 percentage points higher than hospitals that do not purchase the manufacturer's stents. This is a meaningful increase, equal to more than a quarter of a standard deviation and almost half the mean of hospital propensity to contract with a given balloon manufacturer. Conditional on using a manufacturer's stents, a 10-percentage-point increase in the share of stents purchased increases balloon purchases by over 1.5 percentage points. Thus changes in the probability of purchasing balloons from a given manufacturer are driven by changes in stent purchasing on both the intensive and extensive margins.

The findings that greater usage of a manufacturer's stents on the intensive margin drives greater balloon use on both the extensive and intensive margins provide further evidence consistent with usage complementarities driving spillovers from stents to balloons, for a given manufacturer at a given hospital. Interestingly, the correlation between the extensive margin of beginning to use a manufacturer's stents and beginning to use that manufacturer's balloons is suggestive that spillovers might also be driven by some contracting frictions at the buyer-supplier relationship level.

Columns 5 through 8 decompose the stent-to-guidewire spillovers. As before, Column 5 replicates our event study specification. Column 6 decomposes the spillover result by stent

intensive and extensive margins and Columns 7 and 8 repeat the same specifications, but with the extensive margin of whether or not the hospital uses the manufacturers guidewires at all as the dependent variable. We find that there is an economically and statistically significant relationship between stent and guidewire usage at the manufacturer-hospital level, but it operates entirely at the extensive margin. When a hospital begins using a manufacturer's stents, it becomes 5 percentage points more likely to begin using that manufacturer's guidewires – an 18 percent increase at the hospital propensity to contract with a given guidewire supplier.

The balloon and guidewire decomposition results provide further evidence for the primary source of demand spillovers in this setting being complementarities in usage of these products. While other mechanisms that link demand for a firm's products across categories (e.g. correlated preferences or signaling) would suggest correlations for both balloons and guidewires across all margins, the fact that intensive margin usage only moves for balloons (where usage complementarities are known to exist), and only moves as a function of intensive margin stent usage, supports the hypothesis of usage complementarities.

Finally, the relationships we estimate along the extensive margin – that when hospitals begin to contract with a manufacturer for its stents, they are also more likely to contract for its balloons and guidewires – are consistent with economies of scope in contracting costs, where hospitals and manufacturers can more easily contract with each other in other areas once they contract in one area.[14]

6 Conclusion

This paper estimates the presence and magnitude of spillovers in performance in the medical device industry, using a novel empirical strategy and detailed data set that allows spillovers to be distinguished from firm-specific capabilities. The introduction of early generations of DES, a new class of stents, generates variation in firms' within-hospital stent shares; we estimate how these changes in stent shares impact hospitals' usage of the firms' other interventional cardiology devices. Uncertainty around the timing of regulatory approval (and the profitability of the stent category relative to other product categories) means that the precise timing of the introduction of the new stents is unlikely to be correlated with other factors affecting firms' performance in the balloon or guidewire categories. The estimates from our preferred specifications indicate spillovers between stents and balloons exist. Specifically, we

[14] Although our data do not allow us to test it, this mechanism may be hospital-specific (buyer-specific) but not doctor-specific (user-specific). Using data on all hospital purchase orders in a different sample and time period, Grennan and Swanson (2018a) find similar evidence for economies of scope in contracting costs at the device manufacturer/vendor level, even for device categories that are not used by the same buyers.

find that when hospitals increase their intensive margin usage of a manufacturer's stents, they also increase their intensive margin usage of that manufacturer's balloons. They also become more likely to use that manufacturer's balloons, if they were not using them before.

These findings are consistent with the usage complementarities that exist between stents and balloons. Because stents come mounted onto a balloon, physician familiarity and comfort with a manufacturer's stents will directly translate into familiarity and comfort with that manufacturer's (stand-alone) balloon catheters. When we look at spillovers from stents to guidewires, which do not share a usage feature with stents, we only find evidence of spillovers along the extensive margins. That is, when hospitals begin using a manufacturer's stents, they also become more likely to use that manufacturer's guidewires, but there is no relation between the amount of stents used and amount of guidewires used. This relationship is suggestive of economies of scope in contracting which have been documented in other settings and in the medical device setting, using a much larger set of devices.

Our findings of economically meaningful spillovers in performance have several important implications. First, they suggest that multi-product or multi-category firms may face stronger incentives to innovate since innovation in one category may generate returns not only in the focal category but in other categories as well. This is closely related to recent policy and strategy discussions in the internet technology and telecom sectors, where spillovers across categories (and their potential effect on innovation) have been decisive. Data availability at the buyer level and exogenous variation in market share of the primary business lines (e.g. search engines) remain challenges to applying a research design similar to ours here to those contexts.

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Appendices

A Data appendix

A.1 Data construction

Our data come from Millennium Research Group's (MRG) MarketTrack survey of hospitals, tracking their medical device usage at the product-hospital-month level. The data in this paper cover a random sample of hospitals in the US and EU from January 2005 through June 2013. We limit our analysis to the three categories (based on MRG's segmentation) of interventional cardiology devices most frequently purchased by these hospitals: stents, balloon catheters, and guidewires. Because manufacturers may produce multiple products within the same category (e.g., several different balloon catheters), we aggregate a hospital's purchases of different products by the same manufacturer in the same category. Because the MRG survey is focused first on collecting data on coronary stents, other product category data is missing in a small number of hospitals. We restrict our sample for analysis to hospital-months reporting data on all three of our categories of interest. We also account for censoring at zero by explicitly including zero-unit observations ($q^c_{jht} = 0$), provided that hospital-month is reporting data and the manufacturer has a product available in category c. The resulting dataset is at the manufacturer-hospital-month level and includes 81,065 manufacturer-hospital-month observations in the US and 612,162 observations in the EU.

One challenge in the data is identifying DES products that may be recorded under different names by different hospitals but are in fact the same product. To address this issue, we first employ standard text regularization methods. We correct for capitalization inconsistencies; remove common expressions that appear in some entries and not in others; and remove excess spaces between words and leading and trailing spaces. For more complex cases, we search for information online and make deductions based on approval dates and product descriptions. For instance, we correct purchases of the DES "Sprint" from Medtronic to be "Endeavor Sprint," as Medtronic does not have a stent by the name Sprint. We also see numerous records of "Promus 2.25" in our US data; "2.25" is not part of the stent name but rather its 2.25-mm diameter. We recode these observations to "Promus" prior to November 2011 and to "Promus Element" from November 2011 and on, as the FDA approved Promus Element in November 2011 and the first US purchases of "Promus Element" appear then in our data. We similarly clean the few instances where manufacturer names are recorded inconsistently. We also recode "Guidant" as "Abbott Vascular" to account for Abbott's 2006 purchase of Guidant's vascular intervention business.

A.2 Variable definitions

Our share measures incorporate manufacturer-hospital-month observations with no units sold in that category ($q^c_{jht} = 0$), provided the manufacturer has a product available (in any category) in the market during that month. That is, we calculate these shares for every hospital $h \in \mathcal{H}_{mt}$, the set of all hospitals purchasing devices in stents, balloons, AND guidewires in market m in month t, and for every manufacturer $j \in \mathcal{J}_{mt}$, the set of all manufacturers active in market m in month t.

A.2.1 Overall share measures

Within-hospital share. Share of manufacturer j in category c in hospital h in month t (where hospital h is located in market m):

$$s^c_{jht} = \frac{q^c_{jht}}{\sum_{k \in \mathcal{J}_{mt}} q^c_{kht}} \tag{2}$$

Within-market share. Share of manufacturer j in category c in market m in month t:

$$s^c_{jmt} = \frac{q^c_{jmt}}{\sum_{k \in \mathcal{J}_{mt}} q^c_{kmt}} = \frac{\sum_{h \in \mathcal{H}_{mt}} q^c_{jht}}{\sum_{h \in \mathcal{H}_{mt}} \sum_{k \in \mathcal{J}_{mt}} q^c_{kht}} \tag{3}$$

Leave-out within-market share. Share of manufacturer j in market m excluding hospital l in month t:

$$s^c_{jm_{-l}t} = \frac{q^c_{jm_{-l}t}}{\sum_{k \in \mathcal{J}_{mt}} q^c_{km_{-l}t}} = \frac{\sum_{h \neq l \in \mathcal{H}_{mt}} q^c_{jht}}{\sum_{h \neq l \in \mathcal{H}_{mt}} \sum_{k \in \mathcal{J}_{m_{-l}t}} q^c_{kht}} \tag{4}$$

$$= \frac{\sum_{h \in \mathcal{H}_{mt}} q^c_{jht} - q^c_{jlt}}{\sum_{h \in \mathcal{H}_{mt}} \sum_{k \in J_{mt}} q^c_{kht} - \sum_{k \in J_{mt}} q^c_{klt}} \tag{5}$$

A.2.2 Extensive share measures

Whether active in hospital:

$$\mathbb{1}_{\{s^c_{jht>0}\}} = \begin{cases} 1, & \text{if manufacturer } j \text{ is actively selling in category } c \text{ in hospital } h \text{ in month } t \\ 0, & \text{otherwise} \end{cases} \tag{6}$$

where $h \in \mathcal{H}^c_{mt}$ and $j \in \mathcal{J}_{mt}$.

Whether active in market:

$$\mathbb{1}_{\{s^c_{jmt>0}\}} = \begin{cases} 1, & \text{if manufacturer } j \text{ is actively selling in category } c \text{ in market } m \text{ in month } t \\ 0, & \text{otherwise} \end{cases} \tag{7}$$

where $j \in \mathcal{J}_{mt}$.

A.2.3 Intensive (conditional) share measures

Our intensive share measures differ from the overall and extensive metrics in that we restrict the universe of manufacturers to only those manufacturers actively selling within a given category c in either hospital h or market m in month t. That is, our within-hospital intensive share is calculated for all manufacturers $j \in \mathcal{J}^c_{ht}$ and our within-market intensive share, for all manufacturers $j \in \mathcal{J}^c_{mt}$

Within-hospital share conditional on active in hospital. Share of manufacturer j in category c in hospital h in month t, conditional on manufacturer j actively selling in category c in hospital h (where hospital h is located in market m):

$$s^c_{jht} | \left[\mathbb{1}_{\{s^c_{jht>0}\}} = 1\right] = \frac{q^c_{jht}}{\sum_{k \in \mathcal{J}^c_{ht}} q^c_{kht}} \tag{8}$$

Within-market share conditional on active in market. Share of manufacturer j in category c in market m in month t, conditional on manufacturer j actively selling in category c in market m:

$$s^c_{jmt} | \left[\mathbb{1}_{\{s^c_{jmt>0}\}} = 1\right] = \frac{q^c_{jmt}}{\sum_{k \in \mathcal{J}^c_{mt}} q^c_{kmt}} = \frac{\sum_{h \in H_{mt}} q^c_{jht}}{\sum_{h \in H_{mt}} \sum_{k \in \mathcal{J}^c_{mt}} q^c_{kht}} \tag{9}$$

Leave-out within-market share conditional on active in market. Share of manufacturer j in market m excluding hospital l in month t, conditional on manufacturer j actively selling in category c in market m:

$$s^c_{jm_{-l}t} | \left[\mathbb{1}_{\{s^c_{jmt>0}\}} = 1\right] = \frac{q^c_{jm_{-l}t}}{\sum_{k \in \mathcal{J}^c_{mt}} q^c_{km_{-l}t}} = \frac{\sum_{h \neq l \in H_{mt}} q^c_{jht}}{\sum_{h \neq l \in H_{mt}} \sum_{k \in \mathcal{J}^c_{m_{-l}t}} q^c_{kht}} \tag{10}$$

$$= \frac{\sum_{h \in H_{mt}} q^c_{jht} - q^c_{jlt}}{\sum_{h \in H_{mt}} \sum_{k \in J^c_{mt}} q^c_{kht} - \sum_{k \in J^c_{mt}} q^c_{klt}} \tag{11}$$

A.2.4 Decomposition of overall within-market share

Below we decompose the overall within-market share into functions of the within-hospital share and the leave-out within-market share. For simplicity, the category c superscript is omitted.

$$s_{jmt} = \frac{q_{jmt}}{\sum_{k \in \mathcal{J}_{mt}} q_{kmt}} = \frac{\sum_{h \in H_{mt}} q_{jht}}{\sum_{h \in H_{mt}} \sum_{k \in \mathcal{J}_{mt}} q_{kht}} \tag{12}$$

$$= \frac{q_{jlt} + \sum_{h \in H_{mt}} q_{jht} - q_{jlt}}{\sum_{h \in H_{mt}} \sum_{k \in \mathcal{J}_{mt}} q_{kht}} \tag{13}$$

$$= \frac{q_{jlt}}{\sum_{h \in H_{mt}} \sum_{k \in \mathcal{J}_{mt}} q_{kht}} + \frac{\sum_{h \in H_{mt}} q_{jht} - q_{jlt}}{\sum_{h \in H_{mt}} \sum_{k \in \mathcal{J}_{mt}} q_{kht}} \tag{14}$$

$$= s_{jht} \frac{\sum_{k \in \mathcal{J}_{mt}} q_{kht}}{\sum_{h \in H_{mt}} \sum_{k \in \mathcal{J}_{mt}} q_{kht}} + s_{jm_{-l}t} \frac{\sum_{h \in H_{mt}} \sum_{k \in \mathcal{J}_{mt}} q_{kht} - \sum_{k \in \mathcal{J}_{mt}} q_{kht}}{\sum_{h \in H_{mt}} \sum_{k \in \mathcal{J}_{mt}} q_{kht}} \tag{15}$$

A.3 Manufacturer heterogeneity

A.3.1 Largest manufacturers by market share

Table 4 provides the 10 largest firms by mean market share in the US and EU across the three product categories. We notice a number of details regarding market structure. First, there are more manufacturers in the EU than in the US across all product categories. Second, the US market is more concentrated than that of the EU in all categories. Four firms are active in the US stent market: Boston Scientific, Abbott Vascular, Cordis and Medtronic. These four firms also encompass nearly 77 percent of the EU stent market share, however the EU market still has many more active firms. The same four firms account for nearly all of the US balloon market as well. Third, success across product categories is correlated. In our empirical strategy we separate such firm-specific trends from actual spillovers in innovative product success by exploiting discrete shocks to a firm's share in the stent market.

Table 4: Largest firms by market share

	US				EU			
Category	Manufacturer	$s_m\|\mathbb{1}_m$	$\mathbb{1}_h$	$s_h\|\mathbb{1}_h$	Manufacturer	$s_m\|\mathbb{1}_m$	$\mathbb{1}_h$	$s_h\|\mathbb{1}_h$
stents	boston scientific	.43	.844	.536	boston scientific	.237	.825	.317
	abbott vascular	.269	.745	.352	abbott vascular	.219	.739	.296
	cordis	.187	.459	.367	medtronic	.209	.67	.283
	medtronic	.114	.466	.219	cordis	.101	.486	.166
					biotronik	.065	.344	.187
					b. braun	.042	.209	.196
					biosensors international	.027	.146	.163
					terumo	.027	.213	.142
					cid vascular	.023	.177	.112
					hexacath	.013	.155	.106
balloons	boston scientific	.578	.875	.653	boston scientific	.485	.804	.571
	abbott vascular	.293	.596	.48	abbott vascular	.176	.473	.344
	medtronic	.095	.378	.263	medtronic	.151	.438	.352
	cordis	.027	.139	.284	terumo	.063	.289	.231
	angioscore	.009	.12	.057	cordis	.033	.191	.166
					biotronik	.024	.134	.212
					invatec	.015	.141	.107
					orbusneich	.011	.032	.153
					b. braun	.01	.106	.174
					cid vascular	.007	.056	.125
guidewires	abbott vascular	.578	.908	.624	abbott vascular	.59	.892	.693
	boston scientific	.283	.804	.377	boston scientific	.176	.574	.305
	medtronic	.07	.241	.255	biotronik	.117	.235	.402
	cordis	.039	.227	.168	terumo	.039	.185	.18
	terumo	.033	.157	.161	asahi intecc	.036	.261	.097
	argon medical	.007	.007	.405	cordis	.022	.13	.203
	other	.006	.01	1	medtronic	.015	.053	.299
	vascular solutions	.004	.01	.15	st. jude medical	.003	.008	.343
	wilson-cook	.002	.01	.153	b. braun	.002	.008	.164
	merit medical systems	.002	.005	1	spectranetics	0	.003	.057

Table gives the 10 largest firms in terms of mean intensive within-market share by device category from January 2005 through June 2013. Using a shorthand notation, $s_m|\mathbb{1}_m$ gives the mean intensive within-market share in each category, $\mathbb{1}_h$ gives the mean proportion of hospitals the manufacturer is active in (in that category), and $s_h|\mathbb{1}$ is the firm's mean share conditional on being active in a hospital (in that category). Total number of manufacturer-hospital-month observations is 81,065 in the US and 612,162 in the EU.

A.3.2 Multi- and single-category manufacturers

Tables 5 and 6 provide mean within-hospital shares for multi- and single-category manufacturers, respectively. Table 5 restricts to those manufacturer-months where the manufacturer is actively selling in all three categories of interest: stents, balloons, and guidewires. Shares are higher here relative to those seen with our full data sample for two reasons: the first being a mechanical result of our incorporating zero shares to account for censoring, and the second, that these multi-category manufacturers active in all three categories are among the largest manufacturers, including Boston Scientific, Medtronic, Cordis, and Abbott Vascular. Overall within-hospital shares in the US are about 0.25 across all three categories, with each of these firms possessing one-fourth of the interventional cardiology market. Conditional on selling in a US hospital in a given category, the typical multi-category manufacturer provides that hospital between 40 and 50 percent of its devices in that category.

Table 5: Within-hospital shares for multi-category manufacturers

	US			**EU**		
	s^c_{jht}	$\mathbb{1}_{\{s^c_{jht>0}\}}$	$s^c_{jht}\|\mathbb{1}_{\{s^c_{jht>0}\}}$	s^c_{jht}	$\mathbb{1}_{\{s^c_{jht>0}\}}$	$s^c_{jht}\|\mathbb{1}_{\{s^c_{jht>0}\}}$
stents	0.254	0.637	0.398	0.123	0.479	0.257
	(0.315)	(0.481)	0.313)	(0.197)	(0.500)	(0.215)
balloons	0.252	0.503	0.501	0.129	0.347	0.372
	(0.354)	(0.500)	(0.353)	(0.255)	(0.476)	(0.311)
guidewires	0.246	0.550	0.446	0.134	0.288	0.466
	(0.323)	(0.497)	(0.316)	(0.282)	(0.453)	(0.349)

Table provides mean values for the hospital-level shares by category in the typical month. Number of manufacturer-hospital-month observations is 40,821 in the US and 103,592 in the EU.

While Table 5 explores multi-category manufacturers, Table 6 looks at the single-category manufacturers in our sample. As such, each panel of Table 6 encompasses a different set of manufacturers. Our data do not include any manufacturers selling only stents in the US. All three within-hospital share metrics are substantially lower for the single-category firms relative to the multi-category manufacturers. In the US, single-category manufacturers in both balloons and guidewires have low within-hospital overall shares (from less than one to 1.6 percent). Conditional on selling balloons to a hospital, a balloon manufacturer will provide roughly 6.3 percent of that hospital's balloon devices in a given month. For guidewire manufacturers, this figure is higher, at 20.4 percent.

Table 6: Within-hospital shares for single-category manufacturers

	US				EU			
	s^c_{jht}	$\mathbb{1}_{\{s^c_{jht>0}\}}$	$s^c_{jht}\|\mathbb{1}_{\{s^c_{jht>0}\}}$	N	s^c_{jht}	$\mathbb{1}_{\{s^c_{jht>0}\}}$	$s^c_{jht}\|\mathbb{1}_{\{s^c_{jht>0}\}}$	N
stents	.	.	.	.	0.003	0.024	0.121	130,710
	.	.	.	.	(0.030)	(0.154)	(0.150)	
balloons	0.008	0.121	0.063	8,156	0.002	0.018	0.113	68,570
	(0.031)	(0.326)	(0.066)		(0.027)	(0.133)	(0.165)	
guidewires	0.016	0.080	0.204	18,909	0.010	0.068	0.142	20,347
	(0.080)	(0.271)	(0.206)		(0.061)	(0.251)	(0.192)	

Table provides mean values for the hospital-level shares by category in the typical month. N gives number of manufacturer-hospital-month observations.

A.4 DES entry events

Table 7 gives all DES introductions in the US during our sample period, January 2005 through June 2013, and corresponding within-hospital stent shares in the three months before and after the introductions for the innovating firm. In our empirical approach, we exploit the three entry events with the largest change to the innovating firm's stent market share: Medtronic Endeavor, Abbott Vascular Xience V, and Medtronic Resolute Integrity. Table 8 gives DES introductions in the EU for the largest 10 firms in terms of mean stent market share over the same sample period. Overall, new product introductions have less of an immediate effect on the innovating firm's market share in the EU and our three entry events of interest do not necessarily produce the largest shocks. Nonetheless, we think an EU analysis is useful given its firms have more varying levels of multi-category presence.

Table 7: US DES entry events

Date	Manufacturer	Product	Pre- s_{jht}^{stent}	Post- s_{jht}^{stent}	Diff
2008m10	boston scientific	taxus express atom	.387	.432	.044
2008m11	boston scientific	taxus liberte	.397	.436	.039
2008m11	medtronic	endeavor sprint	.099	.107	.008
2008m2	**medtronic**	**endeavor**	**.057**	**.149**	**.092**
2008m7	boston scientific	promus	.398	.397	-.001
2008m7	**abbott vascular**	**xience v**	**.205**	**.37**	**.164**
2009m6	boston scientific	taxus liberte atom	.421	.415	-.005
2011m11	abbott vascular	xience prime	.377	.413	.036
2011m11	boston scientific	promus element	.443	.431	-.013
2011m4	boston scientific	ion	.428	.438	.01
2011m6	abbott vascular	xience nano	.367	.377	.01
2012m2	**medtronic**	**resolute integrity**	**.137**	**.236**	**.099**
2013m1	abbott vascular	xience xpedition	.384	.391	.007

DES introductions in the US from during our sample period. Date refers to first instance product appears in our data.

Table 8: EU DES entry events

Date	Manufacturer	Product	Pre- s_{jht}^{stent}	Post- s_{jht}^{stent}	Diff
2005m7	**medtronic**	**endeavor**	**.163**	**.169**	**.007**
2005m9	boston scientific	taxus liberte	.332	.334	.002
2006m10	cordis	cypher select plus	.16	.148	-.012
2006m10	terumo	nobori	.016	.019	.004
2006m12	biosensors intl	biomatrix		.002	
2006m2	cid vascular	janus flex	.034	.036	.002
2006m9	b. braun	coroflex please	.036	.037	.001
2006m9	**abbott vascular**	**xience v**	**.143**	**.154**	**.011**
2007m11	medtronic	resolute	.208	.203	-.004
2007m12	boston scientific	taxus liberte long	.229	.207	-.021
2007m3	boston scientific	promus	.255	.248	-.007
2007m9	medtronic	endeavor sprint	.209	.202	-.007
2009m11	boston scientific	promus element	.201	.206	.005
2009m3	cid vascular	not classified	.026	.022	-.004
2009m8	abbott vascular	xience prime	.23	.23	0
2009m9	cid vascular	optima	.017	.013	-.003
2010m5	boston scientific	taxus element	.195	.203	.008
2010m6	**medtronic**	**resolute integrity**	**.201**	**.203**	**.002**
2011m6	biotronik	orsiro	.075	.066	-.009
2011m9	cid vascular	cre8	.008	.016	.008
2012m1	biosensors intl	biomatrix flex	.051	.061	.011
2012m11	boston scientific	synergy	.223	.226	.003
2012m8	abbott vascular	xience xpedition	.255	.283	.028
2012m8	abbott vascular	xience pro	.255	.283	.028
2013m3	boston scientific	promus premier	.226	.227	.001
2013m6	biosensors intl	biomatrix neoflex	.06		
2013m6	biosensors intl	axxess	.06		

DES introductions in the EU for top 10 firms in terms of mean stent market share. Date refers to first instance product appears in our data.

B EU analysis

In this section, we replicate the paper's analysis for the EU market. Table 9 provides means and standard deviations of the hospital-level share variables. Relative to the US, the EU market is less concentrated than in the EU. The EU has between 9.6 and 26.9 manufacturers active in each device category (relative to between 3.9 and 5.9 for the US; see Table 1). Consistent with this, EU manufacturers sell to a smaller percentage of hospitals, between 5 and 10 percent. As in the US, hospitals concentrate their sales with a small number of manufacturers per category and, on average, do not purchase from all manufacturers in a category. In the EU, conditional within-hospital shares of between 23 and 42 percent indicate that purchases are quite concentrated.

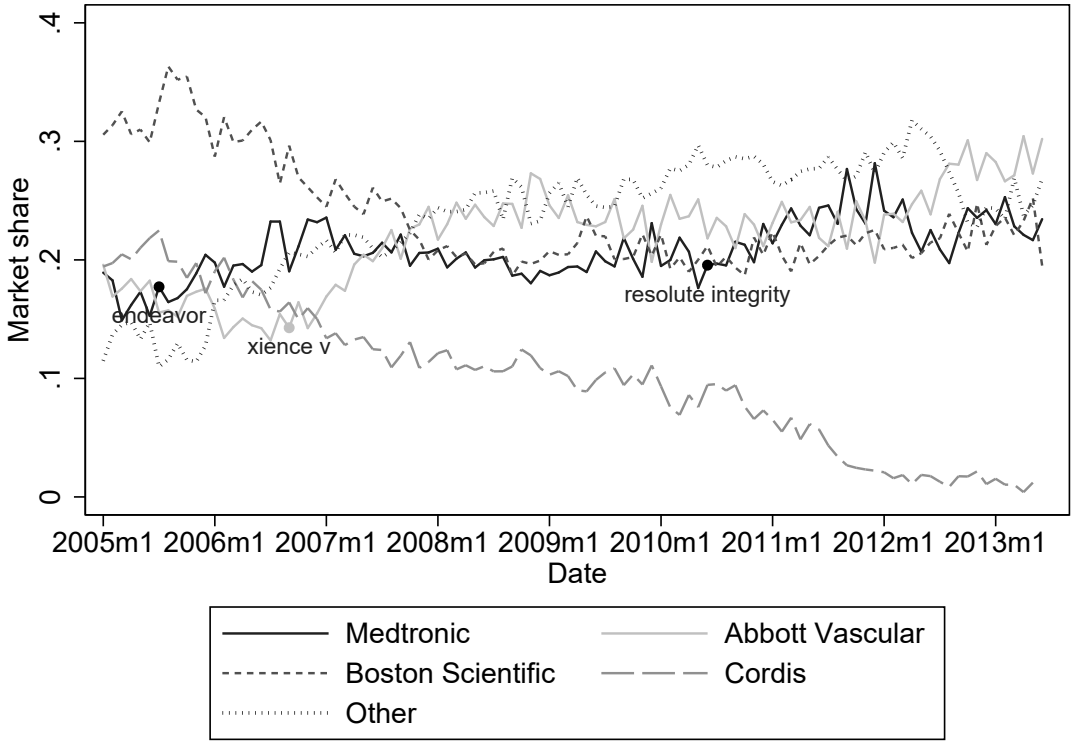
Table 9: Summary statistics

	s^c_{jht}	$\mathbb{1}_{\{s^c_{jht>0}\}}$	$s^c_{jht}\|\mathbb{1}_{\{s^c_{jht>0}\}}$	$\|J^c_m\|$	$\|J^c_h\|$
stents	0.024	0.102	0.231	26.87	4.33
	(0.097)	(0.302)	(0.209)	(3.68)	(2.00)
balloons	0.024	0.069	0.342	23.16	2.95
	(0.118)	(0.253)	(0.308)	(2.96)	(1.61)
guidewires	0.024	0.056	0.423	9.65	2.37
	(0.127)	(0.229)	(0.351)	(1.59)	(1.03)

Table provides mean values for the hospital-level shares by category in the typical month. Note that the overall share variable has the same mean across categories due to our inclusion of zero-quantity observations to address censoring. $|J^c|$ gives mean number of manufacturers active in the market by category, and $|J_h|$ gives mean number of manufacturers active in a given hospital by category. Standard deviations are in parentheses. Mean number of EU hospitals in the sample in the typical month is 147.4, with a standard deviation of 25.0. Total number of EU manufacturer-hospital-month observations is 612,162.

Figure 3 shows our entry events and corresponding stent market shares for the focal firms, other major manufacturers, and the remaining. As noted previously, changes to stent market share are more gradual in the EU for the innovating firm. Nonetheless, we think an EU analysis is useful given its firms more varying levels of multi-category presence.

Figure 3: Three major DES introductions and stent market shares in the EU



Markers indicate the three major DES introductions of interest; lines give overall market share in stents. We plot market share for the four manufacturers active in the US stent market: Boston Scientific, Abbott Vascular, Cordis, and Medtronic. These are also the four largest stent manufacturers in the EU in terms of market share; we combine all other stent manufacturers in the EU as "Other."

Table 10: EU Spillovers

	Balloons					Guidewires				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
s_{jht}^{stents}	0.651***	0.359***	0.160***	0.162***	0.125***	0.536***	0.166***	0.0360***	0.0290**	0.0116
	(0.0238)	(0.0345)	(0.0251)	(0.0247)	(0.0379)	(0.0249)	(0.0312)	(0.0114)	(0.0115)	(0.0135)
Observations	612,162	612,162	612,162	607,939	103,782	612,162	612,162	612,162	607,939	103,782
Adj. R^2	0.283	0.459	0.775	0.780	0.822	0.165	0.586	0.896	0.898	0.932
Mfr FE		yes					yes			
Mfr-Hosp FE			yes	yes	yes			yes	yes	yes
Mfr-Month FE				yes	yes				yes	yes

The dependent variable is $s_{jht}^{balloons}$ for balloon specifications and $s_{jht}^{guidewire}$ for guidewire specifications. Robust standard errors clustered at the hospital level are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

Table 11: EU Decomposition

	Balloons				Guidewires			
	$s_{jht}^{balloons}$		$\mathbb{1}_{\{s_{jht>0}^{balloons}\}}$		$s_{jht}^{guidewires}$		$\mathbb{1}_{\{s_{jht>0}^{guidewires}\}}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
s_{jht}^{stents}	0.125***	0.123***	0.220***	0.119**	0.0116	0.00199	0.0300	-0.00652
	(0.0379)	(0.0425)	(0.0454)	(0.0489)	(0.0135)	(0.0146)	(0.0223)	(0.0222)
$\mathbb{1}_{\{s_{jht>0}^{stents}\}}$		0.00126		0.0769***		0.00738*		0.0281***
		(0.00616)		(0.0132)		(0.00412)		(0.00784)
Observations	103,782	103,782	103,782	103,782	103,782	103,782	103,782	103,782
Adjusted R-squared	0.822	0.822	0.753	0.754	0.932	0.932	0.834	0.834
Mfr-Hosp FE	yes	yes	yes	yes	yes	yes	yes	yes
Mfr-Month FE	yes	yes	yes	yes	yes	yes	yes	yes

Robust standard errors clustered at the hospital level are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

In Tables 10 and 11 we replicate the paper's analysis in the EU market. Qualitatively, the EU results are similar to those of the US. In our preferred specification Column 5 of Table 10, a ten-percentage-point increase in a manufacturer's stent share in a hospital generates a 1.25-percentage-point increase in its balloon market share in that same hospital. The effect disappears in our preferred specification for guidewires (Column 10). Thus we again see strong evidence of within-hospital spillovers in balloons and limited evidence of within-hospital spillovers in guidewires. In Table 11, we again see greater usage of a manufacturer's stents driving greater balloon use on both the extensive and intensive margins while any spillovers onto guidewire use are driven entirely by the manufacturer's new stent users.

C Robustness checks

C.1 Inclusion of leave-out within-market share as a control

Tables 12 through 15 replicate our prior analyses but exclude manufacturer-month fixed effects in order to explicitly include the leave-out within-market share as a control. Doing so does not change our conclusions.

Table 12: US spillovers

	Balloons					**Guidewires**				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
s_{jht}^{stents}	0.778***	0.540***	0.224***	0.258***	0.252***	0.469***	0.207***	0.0528**	0.0314	0.0203
	(0.0216)	(0.0273)	(0.0289)	(0.0312)	(0.0404)	(0.0261)	(0.0331)	(0.0213)	(0.0229)	(0.0295)
$s_{jm_{-l}t}^{stents}$				-0.164***	-0.160***				0.106***	0.0895*
				(0.0474)	(0.0600)				(0.0372)	(0.0460)
Observations	81,065	81,065	81,065	81,065	16,300	81,065	81,065	81,065	81,065	16,300
Adj. R^2	0.506	0.627	0.865	0.866	0.899	0.213	0.573	0.893	0.894	0.918
Mfr FE		yes					yes			
Mfr-Hosp FE			yes	yes	yes			yes	yes	yes

The dependent variable is $s_{jht}^{balloons}$ for balloon specifications and $s_{jht}^{guidewire}$ for guidewire specifications. Robust standard errors clustered at the hospital level are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

Table 13: EU spillovers

	Balloons					**Guidewires**				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
s_{jht}^{stents}	0.651***	0.359***	0.160***	0.161***	0.120***	0.536***	0.166***	0.0360***	0.0307**	0.0116
	(0.0238)	(0.0345)	(0.0251)	(0.0256)	(0.0410)	(0.0249)	(0.0312)	(0.0114)	(0.0119)	(0.0146)
$s_{jm_{-l}t}^{stents}$				-0.0237	-0.0554				0.131**	0.122
				(0.0742)	(0.130)				(0.0566)	(0.0859)
Observations	612,162	612,162	612,162	612,162	105,294	612,162	612,162	612,162	612,162	105,294
Adj. R^2	0.283	0.459	0.775	0.775	0.817	0.165	0.586	0.896	0.896	0.931
Mfr FE		yes					yes			
Mfr-Hosp FE			yes	yes	yes			yes	yes	yes

The dependent variable is $s_{jht}^{balloons}$ for balloon specifications and $s_{jht}^{guidewire}$ for guidewire specifications. Robust standard errors clustered at the hospital level are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

Table 14: US Decomposition

	Balloons				**Guidewires**			
	$s_{jht}^{balloons}$		$\mathbb{1}_{\{s_{jht>0}^{balloons}\}}$		$s_{jht}^{guidewires}$		$\mathbb{1}_{\{s_{jht>0}^{guidewires}\}}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
s_{jht}^{stents}	0.252***	0.240***	0.249***	0.139***	0.0203	0.00997	0.0430	-0.00491
	(0.0404)	(0.0417)	(0.0372)	(0.0360)	(0.0295)	(0.0304)	(0.0326)	(0.0388)
$\mathbb{1}_{\{s_{jht>0}^{stents}\}}$		0.0155		0.145***		0.0136*		0.0634***
		(0.00945)		(0.0258)		(0.00753)		(0.0219)
$s_{jm_{-l}t}^{stents}$	-0.160***	-0.173***	0.00538	-0.118	0.0895*	0.0779*	0.232***	0.178**
	(0.0600)	(0.0613)	(0.0964)	(0.0996)	(0.0460)	(0.0463)	(0.0815)	(0.0806)
Observations	16,300	16,300	16,300	16,300	16,300	16,300	16,300	16,300
Adjusted R^2	0.899	0.899	0.814	0.817	0.918	0.918	0.841	0.841
Mfr-Hosp FE	yes	yes	yes	yes	yes	yes	yes	yes

Robust standard errors clustered at the hospital level are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

Table 15: EU Decomposition

	Balloons				**Guidewires**			
	$s_{jht}^{balloons}$		$\mathbb{1}_{\{s_{jht>0}^{balloons}\}}$		$s_{jht}^{guidewires}$		$\mathbb{1}_{\{s_{jht>0}^{guidewires}\}}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
s_{jht}^{stents}	0.120***	0.112**	0.214***	0.0993*	0.0116	0.00242	0.0347	-0.00387
	(0.0410)	(0.0456)	(0.0500)	(0.0534)	(0.0146)	(0.0158)	(0.0240)	(0.0243)
$\mathbb{1}_{\{s_{jht>0}^{stents}\}}$		0.00568		0.0875***		0.00701		0.0294***
		(0.00669)		(0.0144)		(0.00443)		(0.00867)
$s_{jm_{-l}t}^{stents}$	-0.0554	-0.0577	-0.0808	-0.116	0.122	0.119	0.497***	0.485***
	(0.130)	(0.130)	(0.188)	(0.187)	(0.0859)	(0.0867)	(0.112)	(0.112)
Observations	105,294	105,294	105,294	105,294	105,294	105,294	105,294	105,294
Adjusted R^2	0.817	0.817	0.746	0.748	0.931	0.931	0.831	0.831
Mfr-Hosp FE	yes	yes	yes	yes	yes	yes	yes	yes

Robust standard errors clustered at the hospital level are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

C.2 Price impacts

Including prices in the paper's analysis is made difficult by the lack of reporting on price data for the vast majority of hospitals in the survey. An analysis including price would also prevent us from exploring changes on the extensive margin. Below we restrict to those hospital-months reporting price data on stents, balloons, and guidewires. Doing so limits the sample to 2,850 manufacturer-hospital-month observations in the US and 2,923 in the EU. Table 16 presents summary statistics on the intensive hospital-level price and share variables. We calculate a manufacturer's monthly price for category for a hospital as a weighted average of all products they sell to that hospital in that category. Tables 17 and 18 show that the prices do not drive our results. Looking at Columns 4 (and 8) of both tables shows that the prices of a manufacturer's balloons (guidewires) have no effect on the shares of balloons (guidewires), and thus prices are not driving our spillover results.

Table 16: Summary statistics

variable	US	EU
p_{jht}^{stents}	1518.8	1189.2
	(460.1)	(622.8)
$p_{jht}^{balloons}$	238.8	321.8
	(86.3)	(288)
p_{jht}^{gwires}	82.6	101.1
	(16.3)	(67.3)
$s_{jht}^{stents} \vert \mathbb{1}_{\{s_{jht>0}^{stents}\}}$	.457	.293
	(.299)	(.22)
$s_{jht}^{balloons} \vert \mathbb{1}_{\{s_{jht>0}^{balloons}\}}$	.544	.445
	(.353)	(.307)
$s_{jht}^{gwires} \vert \mathbb{1}_{\{s_{jht>0}^{gwires}\}}$	.473	.454
	(.318)	(.351)

Table provides mean values for hospital-level prices and intensive shares in the typical month. We restrict to those hospital-months reporting price data on stents, balloons, AND guidewires. Standard deviations are in parentheses. Total number of manufacturer-hospital-month observations is 2,850 in the US and 2,923 in the EU.

Table 17: Price impacts for balloons

	US				EU			
	p^{stents}_{jht}	$p^{balloons}_{jht}$	$s^{balloons}_{jht}$	$s^{balloons}_{jht}$	p^{stents}_{jht}	$p^{balloons}_{jht}$	$s^{balloons}_{jht}$	$s^{balloons}_{jht}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
s^{stents}_{jht}	385.4***	-10.07	0.244***	0.241***	-15.52	17.55	0.0918	0.0918
	(56.46)	(10.21)	(0.0432)	(0.0425)	(72.84)	(44.13)	(0.0611)	(0.0608)
$p^{balloons}_{jht}$				-0.000294**				6.35e-07
				(0.000124)				(9.58e-05)
Observations	2,773	2,773	2,773	2,773	2,798	2,798	2,798	2,798
Adj. R^2	0.790	0.756	0.871	0.873	0.873	0.898	0.799	0.799
Mfr-Hosp FE	yes	yes	yes	yes	yes	yes	yes	yes
Mfr-Month FE	yes	yes	yes	yes	yes	yes	yes	yes

Robust standard errors clustered at the hospital level are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

Table 18: Price impacts for guidewires

	US				EU			
	p^{stents}_{jht}	$p^{guidewires}_{jht}$	$s^{guidewires}_{jht}$	$s^{guidewires}_{jht}$	p^{stents}_{jht}	$p^{guidewires}_{jht}$	$s^{guidewires}_{jht}$	$s^{guidewires}_{jht}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
s^{stents}_{jht}	385.4***	0.625	0.0417**	0.0422**	-15.52	53.86	0.000693	-0.00123
	(56.46)	(1.542)	(0.0199)	(0.0202)	(72.84)	(51.59)	(0.0317)	(0.0322)
$p^{guidewires}_{jht}$				-0.000894**				3.57e-05
				(0.000441)				(4.01e-05)
Observations	2,773	2,773	2,773	2,773	2,798	2,798	2,798	2,798
Adj. R^2	0.790	0.733	0.902	0.902	0.873	0.590	0.910	0.910
Mfr-Hosp FE	yes	yes	yes	yes	yes	yes	yes	yes
Mfr-Month FE	yes	yes	yes	yes	yes	yes	yes	yes

Robust standard errors clustered at the hospital level are in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.