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Alice Chen
Seth M. Freedman
Elizabeth L. Munnich
Michael R. Richards

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ABSTRACT

Technological innovation in medical services can improve health, but its ability to reach patients often depends on price signals for downstream providers, which can also be discordant across production inputs. We examine such a context when Medicare sharply revises facility fees—while holding physician fees constant—for advanced surgical care performed within certain outpatient settings. Industry-wide output for impacted cases increases via market expansion, and indirectly affected physicians devote more labor supply to these cases by sacrificing other outpatient and inpatient surgical volumes. Government price setting for healthcare facilities spills over onto physicians—impacting their technology utilization and time allocations.

Alice Chen
Schaeffer Center for Health Policy
and Economics
University of Southern California
635 Downey Way
Los Angeles, CA 90089-3333
alicejc@usc.edu

Seth M. Freedman
O'Neill School of Public
and Environmental Affairs
Indiana University
1315 E. 10th St.
Bloomington, IN 47405
freedmas@indiana.edu

Elizabeth L. Munnich
Department of Economics
University of Louisville
Louisville, KY 40292
United States
beth.munnich@louisville.edu

Michael R. Richards
Jeb E. Brooks School of Public Policy
Cornell University
3301 MVR Hall
Ithaca, NY 14853
and NBER
michael.richards@cornell.edu

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Technology is a clear contributor to productivity and economic growth and holds the potential to improve the quality of goods and services available. Technological advancements in medical service delivery are no exception: they can have profound implications for consumers through better care experiences and improved health outcomes, as well as implications for overall healthcare spending and social welfare (Smith, Newhouse, and Freeland 2009; Chandra and Skinner 2012). However, the diffusion and application of new medical technology will depend on the incentives facing providers within the US healthcare mixed economy. Sellers of medical services, much like those supplying a variety of other goods and services (e.g., agricultural products, military and national security products and services, and information technology), often rely on the US government as a major purchaser and are therefore exposed to government payment policy. Importantly, the risk of mispricing a new treatment is perhaps greater in the context of government procurement where prices can be more regulated and rigid, instead of reflecting market forces. Government payments can also abruptly change with the introduction of a new policy or a reversal of a previous policy decision.

It is currently known that manufacturers' research and development (R&D) expenditures devoted to healthcare innovations as well as eventual adoption by firms supplying care are shaped by demand expectations and public financing (Acemoglu and Linn 2004; Finkelstein 2004; Acemoglu *et al*. 2006; Acemoglu and Finkelstein 2008; Blume-Kohout and Sood 2013; Budish, Roin, and Williams 2015; Dubois *et al*. 2015; Freedman 2016; Clemens and Rogers 2020).[1] Public and/or private payers may also overprice or underprice the use of an advanced medical treatment following its market debut, which can translate to overuse or under-provision by providers (Currie and Gruber 1997; Baker 2001; Baker and Phibbs 2002; Freedman, Lin, and Simon 2015; Yurukoglu, Liebman, and Ridley 2017; Horn, Sacarny, and Zhou 2022).[2] To further complicate matters, common

[1] Such dynamics have also been documented outside of the healthcare sector—e.g., in the energy sector (Newell, Jaffe, and Stavins (1999) and Popp (2002) are just a couple of many examples).

[2] Of note, Clemens and Gottlieb (2014) also demonstrate evidence consistent with greater physician practice investment in medical imagining technology in response to higher Medicare reimbursements—though this was not the primary focus of their study. Horn, Sacarny, and Zhou

reimbursement structures pay different production factors (e.g., healthcare facilities and physicians) separately and may not offer commensurate incentives to each component of what is often jointly produced care. In other words, even when some production inputs (e.g., physicians) have strong incentives to utilize new technologies for patient care, the overall supply of advanced medical services can be suppressed by weak or absent incentives for a complementary input to production (e.g., healthcare facilities). Price signals are therefore important, not only for upstream R&D, but also downstream technology diffusion and utilization so that care delivery innovations reach the intended patients.

In this paper, we focus on how exogenous changes in the price for surgical technologies affect the utilization of such technologies in a market novel to the existing literature: outpatient surgical care. Surgery is a field rife with ongoing technological innovation and subsequent enhancements to care delivery, including those facilitating the transition away from the traditional inpatient hospital settings toward outpatient settings for many procedures. However, healthcare facilities and physicians must coordinate to ultimately adopt and deploy the relevant technology to impact patients. Incorporating advancements in surgical care may require significant upfront capital investments (i.e., increasing fixed costs of production) and/or the use of higher cost inputs when performing the marginal surgery (i.e., increasing variable costs of production). The incidence of these costs and supplier willingness to bear them will be determined, at least in part, by the prevailing payments from patients and their third-party insurers for the surgical services using these innovations.

A prominent example of surgical advancement requiring provider capital investment is the spread of minimally invasive (i.e., laparoscopic) surgery that began in earnest during the 1980s. This family of surgical techniques requires the installation of sophisticated and costly equipment within a given operating room, but it also allows for faster operating times, quicker recoveries, and improved patient outcomes when compared to traditional (i.e., "open") surgical approaches,

(2022) remark that Medicare does not differentially reimburse for robotic assisted surgery, which could discourage take-up.

which have led to greater demand for laparoscopic delivery over time. Likewise, an important class of surgical advancements that require higher variable input costs involves the physical implantation of medical devices within the human body (e.g., to regulate pain sensations or cardiac function). These "device intensive" treatments can facilitate better and more sustained health improvements than other care options as well as alleviate the burden of external monitoring and intervention that could be necessary in the absence of an implantable device.

Despite the medical appeal of these advancements, the financial incentives from a dominant payer (i.e., Medicare) to use a laparoscopic technique or administer a device intensive treatment have been widely unequal across outpatient surgery production factors. More specifically, Ambulatory Surgery Centers (ASCs) and Hospital Outpatient Departments (HOPDs) each provide the facility-based infrastructure necessary for physicians (i.e., surgeons) to perform the relevant surgical interventions. They are also rival firms that directly compete in outpatient procedure markets, especially for Medicare and commercial (i.e., private, non-Medicare) referrals from local physicians.[3] Prior to 2008, Medicare paid ASCs a small fraction of what hospitals would receive for an identical laparoscopic or device-intensive procedure. The pay disparity radically shrank after 2008 when Medicare's fee reforms for ASCs (discussed in Section IB) mechanically induced large upward price revisions for laparoscopic as well as device intensive cases performed within the ASC setting. The policy-driven price shocks more than doubled the ASC reimbursement rate for common laparoscopic surgeries and raised ASC reimbursements for common device intensive procedures by roughly tenfold (i.e., increased by 1,000% or more). Medicare fees in the HOPD settings remained on their pre-existing trend, and physicians continued to receive an undifferentiated payment—and hence incentive—to perform the accompanying surgeries within either facility type (i.e., site-neutral physician reimbursement).[4]

[3] While HOPDs are owned by hospitals and typically attached to a hospital, ASCs are most often independently owned, standalone facilities. We discuss ASCs in greater detail in Section IA.

[4] When a physician performs a service, she receives a Medicare payment for the procedure while the facility where she administered the service receives a separate Medicare facility-based

We leverage this unique policy context to implement a series of difference-in-differences (DD) research designs to explore how the supply of care responds to enormous increases in financial incentives for one key production factor from a dominant payer, and crucially, how such payment reforms transmit to other untargeted, but indispensable, production factors—namely physicians. Our analytic setting allows us to explicitly test the sensitivity of medical joint production to pricing policies that only directly affect certain suppliers (e.g., ASCs) but can nevertheless narrow or expand the overall flow of technologically advanced services by restraining or enhancing care delivery opportunities for other, indirectly affected, contributing suppliers (e.g., physicians). It is also our impression that the ability of separate price signals to coordinate treatment availability across production factors has not been frequently examined in the existing literature, despite the potentially wide scope for misaligned incentives between healthcare facilities and front-line clinicians within public and private healthcare markets.[5]

Our empirical analyses primarily rely on the universe of outpatient surgery discharge records across all payers (i.e., Medicare and non-Medicare) from the state of Florida between 2004 and 2011. These historical all-payer data are ideal for our purposes because they not only allow us to track the supply of care to the Medicare market by firms within each industry (i.e., ASCs versus HOPDs), but the data also facilitate the construction of cleaner treatment and control groups within our DD analyses and make feasible estimations of spillover effects (i.e., externalities) onto other patients and payer groups. Neither would be possible in the absence of sufficiently historical, all-payer data. Moreover, tracking both the Medicare and non-Medicare markets allows us to test for the importance of capacity constraints for physician labor supply as their treatment opportunities expand. If physicians—who do not directly experience any changes in Medicare incentives—had excess capacity at baseline or are capable of expanding their own capacity in the short-run,

payment. The physician payment amount from the public insurer is independent of the facility chosen.

[5] For example, recent work by Geruso and Richards (2022) investigates the own- and cross-market effects on physician behavior from increasing physicians' facility choice set for a particular surgery for a particular payer through a facility-targeted policy intervention.

then their aggregate output could simply increase to accommodate new Medicare device intensive and laparoscopic surgeries following the targeted facility-level payment shocks. However, if capacity constraints bind, physicians will have to trade off other cases—implying that the facility-focused payment reforms can impact at least two physician-specific supply margins: (1) Medicare device intensive and laparoscopic surgical volumes and (2) all other surgical volumes (i.e., non-device intensive and non-laparoscopic cases within the Medicare market and all case volumes belonging to other payer markets).

We also supplement our rich outpatient care delivery data with detailed information on ASCs' equity investments by physicians (see Munnich *et al*. 2021) and Medicare beneficiaries' inpatient and emergency department utilization over this same period. The former allows us to examine if public market payment policies influence physicians' willingness to hold ASC equity positions, while the latter data can speak to broader spillovers and downstream health impacts from increasing the supply of the policy-affected outpatient surgical services for Medicare beneficiaries.

We ultimately find that ASCs' provision of more technologically advanced care is strongly sensitive to Medicare pricing. Device intensive and laparoscopic procedure volumes for Medicare beneficiaries were low and stable in the lead up to 2008. However, once the payment reforms were fully phased in, the ASC industry had increased its laparoscopic case output nearly threefold and its device intensive output nearly thirteenfold. The implied industry-wide price elasticities are 1.4 and 0.6, respectively. Incumbent ASCs (i.e., those established before the policy change) are overwhelmingly responsible for the greater supply of device intensive Medicare procedures after 2008, but firms newly entering the market after the introduction of the fee reforms supply 35% of Medicare laparoscopic procedures by the end of our study period. This pattern, coupled with the fact that incumbent firms do not increase their extensive margin use of laparoscopic technology following the price shocks, highlights the importance of market entry among ASCs when it comes to making costly (fixed) capital investments tied to treatment technology. Such capital commitments seem to be made when these "focused factories" are considering

which medical specializations (often just one) and corresponding services to offer at the time of entry, rather than dynamically adjusting to market conditions over time.[6] Interestingly, the ASC industry ramps up service provision without obviously stealing business from hospitals. In fact, the HOPD industry, which does not experience a direct price shock, increases aggregate Medicare device intensive and laparoscopic procedure volumes as the ASC industry is doing likewise. This response is consistent with strategic complementarities across the two industries when it comes to utilizing advanced surgical care opportunities and leads to an overall market expansion of 78% and 49% for Medicare device intensive and laparoscopic procedures, respectively. These large changes also sharply contrast with all other Medicare outpatient surgery activity over this same period.

Our primary DD strategy for spillover effects onto physicians shows that the indirectly affected surgeons substitute away from other procedures and payers as more outpatient facilities are incentivized to accommodate Medicare device intensive and laparoscopic surgeries into their caseloads. The physicians' outpatient surgical volumes for commercial and all other non-Medicare payers decline by approximately 10%, and physicians perform 8-13% fewer inpatient surgical cases across all payers—indicating a labor supply shift away from inpatient care delivery. Capacity constraints appear to bind and thus force them to trade off other cases when performing more Medicare surgeries directly impacted by the facility fee reforms. At the same time, their case mix complexity rises for their Medicare surgeries as well as for the non-Medicare surgical cases they retain following the outward shift in the supply of advanced surgical care. More complex surgeries are likely to be tied to higher physician reimbursement levels, which suggests that these physicians are maximizing earnings subject to their available surgical time that can be allocated to the public and private markets. Taken together, incentivizing facilities to devote more capacity to more technologically advanced Medicare surgeries has the additional effect of allowing physicians to devote more of their

[6] See Casalino, Devers, and Brewster (2003) and Carey and Mitchell (2019) for detailed descriptions of the "focused factory" business model pertaining to the ASC industry.

scarce time to these same cases at the expense of other procedure-payer combinations as well as inpatient procedure volumes across payers (i.e., generating negative externalities along these margins). Medicare payment policy for facilities thus strongly shapes beneficiaries' access to medical care innovations and, through its downstream impact on provider diffusion and application, indirectly affects the returns to the intellectual property held by technology manufacturers.

Supplementary findings demonstrate that the subset of physicians that perform the relevant advanced surgical care prior to the Medicare payment changes are also approximately 30% more likely to invest in the ASC industry once the new ASC facility payments are rolled out. This finding suggests that ASCs can further benefit from a more attractive public payer fee schedule via subsequent infusions of private capital from outside investors (i.e., a positive externality for ASCs). Additionally, as far as we are aware, this represents the first causal connection between Medicare reimbursement policy and physicians' (controversial) ownership of ASC facilities.[7] We also find that the impacted surgeons expand their Medicare pool of patients by performing more device intensive and laparoscopic outpatient surgeries for relatively younger beneficiaries—a 1-3% reduction in the average age relative to the pre-period. However, we find no evidence that Medicare beneficiaries are more likely to be hospitalized or present to an emergency department with surgical complications, despite the aggressive market-wide expansions in technologically advanced surgeries—including among firms with limited previous experience with these cases for an elderly patient population. These data patterns at least indicate that ASCs are a safe setting to perform these procedures for Medicare beneficiaries.

Beyond adding to an influential body of literature on the utilization of medical technologies, our findings also extend a strand of economics research devoted to Medicare's spillover effects on provider treatment decisions and supply of care for non-Medicare patients (e.g., Sloan, Morrisey, and Valvona 1988; Yip

[7] For example, Munnich *et al*. (2021) are the first to credibly estimate physician behavior changes following an ASC ownership transition, and Geruso and Richards (2022) use pre-existing physician ownership status to demonstrate a heterogeneous response to an ASC regulatory change. However, neither study focuses on the effect of policy on the actual physician ownership decision.

1998; He and Mellor 2012; Baicker, Chernew, and Robbins 2013; White 2013, 2014; Barnett, Olenski, and Sacarny 2020; Richards, Seward, and Whaley 2021; Chen *et al*. 2022; Geruso and Richards 2022). Our estimates further underscore the importance of quantifying behavior change across different medical production inputs (e.g., physicians) and all payers to better understand the full influence of Medicare policymaking, which may be narrow in its design (e.g., targeting specific procedures and/or specific facilities) but still generate a variety of externalities. Additionally, a small theoretical and empirical literature documents the presence of strategic complements, whereby strategies among players mutually reinforce one another (Dubey *et al*. 2006). Strategic complementarities have been identified through arrangements such as joint ventures, research and development agreements, and buyer-supplier relationships (e.g., Das and Teng 1999; Guo and Wang 2020); yet, they have not been regularly demonstrated within healthcare contexts—despite the presence of many competing entities and large sums at stake (i.e., a roughly $4 trillion sector of the US economy).[8] We observe both the ASC and HOPD industries expanding their Medicare technologically advanced surgical caseloads even though only the former was the recipient of the positive price shocks. We therefore view our work as making a variety of novel contributions that are relevant to ongoing economic policy and health policy debates—including the Medicare program's looming choices over its provider fee schedules and related incentive structures for suppliers.

I. Background

A. *Brief Background on Outpatient Surgery Markets*

A long running trend in US healthcare is the shift toward more outpatient delivery of medical services, including surgical and other procedural treatments. ASCs have been a key contributor to this movement and currently number nearly 6,000 across the US. These firms are highly specialized and most often involve just a single

[8] Dafny (2019) offers a recent example when examining premium setting behavior among rival insurers.

physician specialty and a subset of procedures performed within the relevant specialty. The ASC industry also has the unusual characteristic that most firms have full or partial ownership by physicians, and in the aggregate, the industry captures approximately $5 billion in Medicare-specific revenue per year (MedPAC 2021).

The ASC value proposition typically involves greater consumer convenience and lower care delivery costs (e.g., Paquette *et al*. 2008; Grisel *et al*. 2009; Munnich and Parente 2014; Weber 2014; Munnich and Parente 2018; Aouad, Brown, and Whaley 2019; Sood and Whaley 2019). Relatedly, hospitals facing greater ASC competition can experience outpatient procedure business stealing by proximate ASCs as well as worsening finances and stronger pressure to lower prices for competing services (Bian and Morrisey 2007; Courtemanche and Plotzke 2010; Carey, Burgess, and Young 2011; Koeing and Gu 2013; Hollenbeck *et al*. 2015; Carey 2017; Whaley and Brown 2018; Baker, Bundorf, and Kessler 2019; Munnich *et al*. 2021). Hospitals also appear keen to blunt further ASC market penetration through strategic responses, including vertically integrating with referring physicians (Richards, Seward, and Whaley 2022).

B. *Medicare ASC Facility Fee Reform*

Medicare payments for outpatient surgeries primarily consist of a facility fee and a physician fee. While physicians receive a site neutral payment that is the same regardless of whether a procedure was performed in an ASC or a hospital, facility payments differ across settings. In general, reimbursements for outpatient procedures in hospitals are set higher than ASCs because hospitals must meet additional regulatory requirements and treat patients who are more medically complex (MedPAC 2003). For example, in 2007, the national rate for a common colonoscopy performed in an ASC was $446, whereas HOPDs received 22% more ($543) for the identical service.

Differences in the way ASC and HOPD payments are set, and the relative payment rates between the two types of facilities, have also varied over time. When Medicare first started covering outpatient procedures in 1982, HOPD procedures were reimbursed using a cost-based system whereas ASC procedures were grouped

into one of four payment categories based on cost and clinical similarity, with every procedure in a particular category reimbursed the same amount. Across both settings, facility payments did not vary with case mix (i.e., underlying health of the patient population) and were updated annually for inflation. They were not otherwise adjusted until Medicare expanded to eight ASC payment groups in 1990, and nine in 1991 (MedPAC 2010).

In 2000, Medicare's traditional cost-based reimbursement system for outpatient care in HOPDs was replaced with the Outpatient Prospective Payment System (OPPS). OPPS established 200 Ambulatory Payment Classifications (APCs) for hospital outpatient procedures.[9] This change harmonized the ambulatory procedure reimbursement structures across HOPDs and ASCs; however, payment levels were still set independently. In fact, because little was known historically about costs for outpatient procedures, Centers for Medicare and Medicaid Services (CMS) administrators lacked confidence in the resulting price schedules and typically adjusted payment rates in part based on perceived imbalances in ASC and HOPD supply (Scully 2/26/03, p. 46).[10]

"*I've got a third of my staff in hospitals, a third in the outpatient side, and some guy setting ASC rates, and they never talk to each other…"*—Thomas Scully, CMS Administrator (2001-2004), FTC health care market hearing 2/26/2003.

Responding to rapid ASC growth and federal agency concerns over the current fee schedule, the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 froze ASC payment updates and directed the Government Accountability Office (GAO) to examine the relative costs of procedures performed in ASCs and HOPDs and to inform implementation of a new

[9] Of note, prior research has examined how the introduction of OPPS influenced hospital behavior—including shifts in care setting as well as service delivery devoted to non-Medicare patients (He and Mellor 2012, 2013).

[10] Thomas Scully, the former Administrator for the Center of Medicare and Medicaid Services (CMS) from 2001-2004, testimony at a 2003 Federal Trade Commission (FTC) Health Care and Competition Law hearing. The transcript from the 2/26/2003 hearing is available at https://www.ftc.gov/sites/default/files/documents/public_events/health-care-competition-law-policy-hearings/030226trans.pdf

fee schedule (GAO 2006). Announced in 2007, Medicare began rolling out a new reimbursement system for ASCs starting January 1, 2008. Between 2008 and 2011, ASC payments were based on the 200 APCs in the OPPS as well as expanded the number of covered ASC procedures (MedPAC 2010). Importantly, under the new policy, the ASC facility fee for any procedure would be benchmarked against the corresponding HOPD fee for the first time and could be no greater than 59% of the facility fee paid to a HOPD. Any subsequent fee adjustments to satisfy this condition would be phased in fully by 2011—i.e., 25% of the payment change would take place in each year from 2008 through 2011.

With the resulting mechanical linkage between the two prices, initial conditions became important. ASC facility fees set higher than the 0.59 ratio with respect to the corresponding HOPD fee would have to be adjusted downward; yet, those below the ratio could be adjusted upward. Existing work argues that the ASC industry was financially disadvantaged by this reformulation overall, at least in some respects (Munnich and Parente 2018; Munnich and Richards 2022). However, unlike prior works which have limited their focus to the most common ASC procedures or aggregate trends in ASC entry behavior, the collection of technologically advanced surgical services that we focus on here had a markedly different experience.[11]

Previously wide gaps between ASC and HOPD facility fees were dramatically narrowed via large and positive price revisions by Medicare for advanced surgical care (see Figure 1). For example, the Medicare reimbursement for the highly common outpatient procedure, laparoscopic inguinal hernia repair, increased by 194% once the fee reforms were fully implemented in 2011.[12] Prior to the 2008 ASC fee reforms, Medicare only paid ASCs 24% of what they would have paid a HOPD for performing an identical hernia repair using laparoscopic

[11] We provide a list of these procedures in Appendix Table A1. Only a handful of codes were newly added codes. Dropping these newly added codes does not change any of the inference presented in the manuscript. Results available upon request.

[12] Inguinal hernias occur when tissue "protrudes through a weak spot in the abdominal muscle." About 25% of males and 2% of females will develop an inguinal hernia in their lifetime. See https://my.clevelandclinic.org/health/diseases/16266-inguinal-hernia for more information.

technology. The price shocks were even larger for device intensive procedures. Among the unique procedures belonging to this set of surgical treatments, the median 2007-to-2011 price change was a positive 1,225%, and the changes ranged from 364% to as much as 3,510% (Panel A, Figure 1). These unusual price increases that localized to advanced surgical care performed within ASCs ultimately allow us to assess how healthcare providers' joint production for medical care responds to aggressive Medicare payment policy adjustments for a single key input (i.e., surgical facility space), with downstream implications for beneficiary access to innovative surgical care.

II. Data and Industry Level Output

A. *Data*

Our primary analytic data come from the Florida Agency for Health Care Administration (AHCA). AHCA collects and maintains the universe (i.e., all-payer, including self-pay) of outpatient discharge records for all ASCs and HOPDs licensed and operating in the state of Florida. The data span 2004 through 2011 and are collected quarterly, which we aggregate to the half-year level. Our analytic window allows us to observe industry and firm behavior three years before the Medicare fee reforms for ASCs are announced, the year of announcement (2007), the initial implementation of the reforms in 2008, and their conclusion by 2011. We observe 22.9 million discharge records during this period, and each discharge record captures standard patient information (e.g., demographic and health characteristics), clinical provider information (e.g., physician administering care and what treatments are performed), as well as information on the precise facility setting used. As previously noted, a key feature of these outpatient surgery market data is their all-payer nature, which is crucial for our subsequent DD research designs and the ability to estimate Medicare policy spillover effects onto other payer-procedure combinations. It would not be possible to accomplish either empirical task in commonly used alternative data, such as Medicare claims data.

B. *Trends in Medicare Case Volumes*

Before implementing our DD empirical estimations, we first generate a series of descriptive, industry-level trends to document some important facts relevant to these medical markets and to motivate our subsequent analyses focused on physician behavior. We tally the aggregate output within the traditional Medicare (i.e., excluding Medicare Advantage) market for the two domains of advanced surgical care separately. The laparoscopic procedures are comprised of 41 unique Current Procedural Terminology (CPT) codes while the devise intensive procedures involve 48 unique CPTs in total.[13]

Figure 2 demonstrates the total output among all ASCs operating in Florida in a given half-year period. From 2004 through 2007, typically less than 100 Medicare device intensive procedures are performed in an ASC per half-year (Panel A). The ASC industry volume sharply increases with the introduction of the higher Medicare facility fees for ASCs in 2008 and continues to increase as the price increases are fully phased in. ASCs supply Medicare beneficiaries with approximately 1,000 device intensive surgeries per half-year by 2011. Panel B of Figure 2 shows a similar pattern for laparoscopic surgeries performed for Medicare beneficiaries. The entire ASC industry supplies only around 100-150 such cases per half-year when prices are lower; however, output increases to as much as 450 cases per half-year when the much more attractive reimbursements for ASCs are available.

Figure 3 allows us to benchmark the rapid increase in these advanced surgical procedures within the Medicare market against other industry-level output during this period. Consistent with the patterns from Figure 2, device intensive procedure volumes (Panel A) are as much as thirteenfold higher by 2011 relative to just before the fee reforms were announced (second half of 2006), and laparoscopic

[13] Of note, a minority of the CPTs belonging to each domain were newly introduced after the fee reforms (i.e., they were not reimbursable by Medicare prior to 2008). These specific procedures consequently start at the higher (i.e., reformed) price point. For the device intensive procedures, the newly introduced codes make up a vanishingly small share of the total Medicare device intensive procedure volume over time. New codes are more important for laparoscopic procedures; however, we have confirmed that ASCs increase their Medicare case volumes for new and old CPTs involving laparoscopic technology.

procedure volumes (Panel B) have nearly tripled by end of our study period. These trends sharply contrast with those representing all other outpatient procedures performed in either the ASC or HOPD setting. In both ASC and HOPD settings, the volumes of other procedures (in relative terms) do not show an analogous and sharp increase during 2008-2011 and are largely unremarkable over time. We can also translate the increase in ASC industry supply of device intensive and laparoscopic procedures into price elasticities by constructing a relative price change for these technologically advanced surgical cases. We do so by calculating a volume-weighted average price for the basket of relevant outpatient procedures in 2007 first using the 2007 Medicare facility fees and then imposing the 2011 Medicare facility fees (i.e., the final post-reform prices) on the same basket of procedures (weighted by 2007 volumes). The resulting ASC industry-wide implied elasticities are 0.6 and 1.4 for device intensive Medicare surgeries and laparoscopic Medicare surgeries, respectively.[14]

Interestingly, despite experiencing no Medicare price shocks of its own, the HOPD industry increases its supply of device intensive and laparoscopic surgeries for the Medicare market just as the ASC industry is doing likewise (Figure 3). There are even indications that HOPDs begin dialing up their supply of these Medicare surgeries once the ASC price shocks are announced (2007). The evidence therefore suggests that ASC output increases via market expansion, rather than stealing business from hospitals. The patterns are also consistent with strategic complementarity behavior whereby HOPDs increase their use of these surgical innovations. If true, such HOPD behavior could be an attempt to preempt downstream losses in market share through weaker patient demand and/or changes in physician referral behavior now that competing ASCs are provided with an incentive to perform more of these specific procedures for Medicare beneficiaries. The seemingly lockstep increases across the two industries translate to 78% more

[14] Of note, we place no restriction on the site of care (i.e., ASC or HOPD) for the 2007 Medicare device intensive and laparoscopic procedure volumes used to create the volume-weighted price change measure. In this way, the calculated relative price change reflects the full potential Medicare market for these outpatient cases prior to the fee reform implementation.

total Medicare device intensive surgeries and 49% more total Medicare laparoscopic surgeries performed in 2011 relative to 2007.

Our final descriptive exercise in Figure 4 involves a simple decomposition of the ASC industry output according to firms' timing of entry into the Florida healthcare landscape. Specifically, we stratify all ASCs into three mutually exclusive groups: incumbent firms (i.e., present in Florida by 2004), new market entrants during 2005-2007, and new market entrants during 2008-2011. Panel A of Figure 4 reveals that the bulk of the Medicare volume increases over time are driven by incumbent ASCs. These firms are consistently responsible for approximately 70-80% of industry-wide output during the post-policy period. Firms entering the market during the post-policy period provide only a small share of cases per half-year. The pattern in Panel B of Figure 4 departs from Panel A, however. While incumbent firms increase their aggregate output by nearly two-thirds and perform roughly half of all laparoscopic Medicare surgeries by the end of our study period, new market entrants play a much larger role for these surgeries—especially among firms establishing themselves after Medicare has introduced the generous fee reforms. The differences across the two domains of technologically advanced surgical care are perhaps unsurprising, given that the former (device intensive) is primarily about higher variable costs of production while the latter (laparoscopic) is primarily about higher fixed costs of production. Relatedly, the prevalence of laparoscopic technology adoption among established ASCs does not increase following the introduction of more generous Medicare payments (Appendix Figure A1).

III. Physician Level Empirical Strategy and Results

A. *Data and Estimation*

Given the striking industry level trends observed in Section II, we next implement our DD empirical strategy to examine how these Medicare facility price shocks and subsequent surgical supply expansions indirectly shape individual physician behavior. We also emphasize that, throughout our study period, physicians continue to receive the same payment for services, regardless of whether they perform those

services at an ASC or HOPD. However, due to ASC and HOPD willingness to accommodate more device intensive and laparoscopic services (Figures 2 and 3), physicians now have more opportunities to perform these technologically advanced procedures. We are subsequently interested in evaluating whether physicians then trade off other payer-procedure combinations to accommodate an increase in their surgical activity tied to device intensive and laparoscopic Medicare outpatient cases.

Physicians are highly specialized due to their specific human capital investments spanning many years (e.g., residency training and board certification typically within a single specialty). As a result, the treatment and control demarcation is relatively simple across physicians. Among physicians observed consistently from 2004 through 2011, we determine if a given physician performs these technologically advanced surgeries (at least once in every half-year across any payer market and outpatient treatment setting) during the pre-period years (2004-2007) versus if they *never* perform these cases for any patient in any outpatient setting over the pre-period years. The former comprises the treatment group, and the latter comprises the control group. 25% of physicians consistently performing outpatient cases in Florida over our full 16 half-year periods from 2004-2011 meet our requirement to be designated as a treated unit.

The DD estimating equations for our balanced panel of physicians belong to Equation (1) and Equation (2). Both equations include physician fixed effects (λ) and half-year time (τ) fixed effects, and all standard errors are clustered at the physician level.

$$Y_{pt} = \delta(Treated \times Post)_{pt} + \lambda_p + \tau_t + \varepsilon_{pt} \quad (1)$$

$$Y_{pt} = \sum_{\substack{n=-8 \\ n\neq -1}}^{7} \delta_n \big(Treated \times 1(t+n)\big)_{pt} + \lambda_p + \tau_t + \varepsilon_{pt} \quad (2)$$

The *Treated* indicator variable is equal to one for physicians consistently supplying these technologically advanced surgeries to one or more markets and equal to zero for physicians that are never observed performing one of these outpatient surgeries in any context during the pre-period years (2004-2007). Our key physician-level outcomes (*Y*) specifically examine physicians' total outpatient surgery productivity as well as non-device intensive and non-laparoscopic procedures across three mutually exclusive payer groups: traditional Medicare, commercial (private, non-Medicare), and a composite group of all other (much smaller) payers (e.g., Medicaid, Medicare Advantage, self-pay, TRICARE, etc.). These outcomes can inform if, and to what degree, physicians substitute away from other outpatient surgical cases as they devote more scarce time to device intensive and laparoscopic Medicare surgeries. Of note, the vast majority (70-80%) of ASC services in a given half-year are supplied to the commercial and traditional Medicare markets over our analytic time period.

With the known importance of physician ownership in ASCs (e.g., see Munnich *et al*. 2021; Geruso and Richards 2022), we extend these analyses into a triple differences framework that allows for heterogeneity in the Medicare price shock spillover effects according to pre-policy ASC ownership status at the physician level. Physician equity stakes, including the precise timing and duration of the ASC ownership investment, comes from a FOIA request to CMS (see Munnich *et al*. (2021) for a full description of the ASC ownership data).[15] 5% of our policy exposed physicians have an active ASC ownership stake at the time of Medicare fee reform implementation in 2008. The estimating equation is consequently a slight adaptation of Equation (1) that allows for the pre-policy ownership (i.e., *ASCOwner*) interaction with the main DD variable:

[15] Linking individual physicians to the FOIA data is accomplished via the National Provider Identification (NPI) number. AHCA began recording NPIs in 2010, so it is necessary to construct a crosswalk between 2010 NPIs and Florida physician licenses (recorded in all years of data), which results in a small loss of analytic sample among physicians where a confident 1:1 mapping cannot be made between the recorded license and a unique NPI.

$$Y_{pt} = \delta(Treated \times Post)_{pt} + \gamma(Treated \times Post \times ASCOwner)_{pt} + \lambda_p + \tau_t + \varepsilon_{pt} \quad (3)$$

The delta parameter identifies the policy effect among non-owners as of the start of 2008, while the gamma parameter formally tests for any statistically different heterogeneity among the ASC owner subgroup. The rest of the specification and analytic sample mirrors Equation (1).

Our final surgical volume related analyses combine our primary analytic outpatient data with the Florida AHCA universe of inpatient discharge records over the 2004-2011 period. We then construct physician-half-year measures of total inpatient surgical volume by payer group—mirroring the same three mutually exclusive payer markets described above. A given hospitalization counts toward the physician's inpatient surgical volume measure when the specific physician is listed as the operating physician on the discharge record (via the Florida license number). Not all of our physicians from the main DD analytic sample have inpatient procedures attributed to them and are therefore excluded from these supplementary estimations. However, among our treatment group physicians belonging to the main analytic sample, only 1.7% lack any inpatient surgical cases during our analytic period.[16]

B. *Results for Outpatient Volumes*

Table 1 shows the expected increase in Medicare device intensive (column 1, Panel A) and laparoscopic (column 2, Panel A) surgeries within ASC settings among the (indirectly) policy exposed physicians. In the pre-period, the average treatment group physician performed nearly zero of these cases for Medicare beneficiaries in an ASC. However, as ASCs incorporate more device intensive and laparoscopic cases into their business lines after the Medicare facility price shocks, our treatment group physicians begin performing more of these cases in ASCs—averaging

[16] Most of the analytic sample reduction is from the control group where just under 19% of physicians are without any inpatient surgeries during this 8-year period.

around a tenth of a case per half-year for each of the two families of advanced surgeries. The corresponding event study estimates (Figure 5) also show level shifts and dynamic growth in the size of the increase over time that aligns with the four-year phase-in of the Medicare ASC facility fee reforms.[17] Appendix Figure A2 demonstrates a qualitatively similar pattern for these procedures performed within HOPDs, with the exceptions that the increases begin during the ASC fee reform announcement period (2007) and that the changes are not as sharp for Medicare laparoscopic surgical cases in HOPDs.

Panel B of Table 1 examines changes in physician-level outpatient procedure productivity by procedure type and payer type. Total volume for policy exposed physicians is not obviously affected (column 1, Panel B); however, procedures outside of the device intensive and laparoscopic domains witness a nearly 10% decline among the commercial and all other payer groups (columns 3 and 4 in Panel B of Table 1). Medicare case volumes for other procedures are not clearly affected by these physicians devoting more surgical time to Medicare device intensive and laparoscopic surgeries (column 2, Panel B in Table 1). The approximately 10% decrease for other procedure types supplied to non-Medicare payers also represent 5 and 2 less of these procedures, on average, for the commercial and all other payer markets, respectively. The event study estimates in Figure 6 align with the findings from Table 1 and demonstrate sharp and increasing reductions in the supply of procedures outside of the policy's direct reach. The findings in Figures 5 and 6 further imply that capacity constraints bind for physicians—leading new Medicare device intensive and laparoscopic surgeries to crowd out other cases for impacted physicians. Put differently, when Medicare changes its *facility* payments for device intensive and laparoscopic procedures at ASCs, *physicians* respond to the increased opportunity to perform these procedures by reducing their provision of non-device intensive and non-laparoscopic procedures among their non-Medicare populations.

[17] Note, the purpose of Panel A in Table 1 and the corresponding event study results in Figure 5 is to demonstrate the 'first-stage' among the treatment group of physicians. By construction, these outcomes are virtually stable zeros for the control group physicians.

In Table 2, we reexamine these results when allowing for a heterogeneous response among physicians already holding an ASC ownership stake at the time of the reimbursement changes. Panel A indicates that pre-policy owners were more responsive in terms of increasing their ASC surgery volumes, especially with respect to laparoscopic Medicare surgeries (column 2). Yet, across columns 1-4 in Panel B of Table 2, we see no clear evidence of a heterogeneous response in the externality effects among this subset of physicians—if anything, the coefficients are oppositely signed, albeit imprecise, which implies an attenuated spillover effect. In Appendix Table A2, we go farther and re-estimate the findings from Table 1 when excluding from the treatment group any physicians with a pre-policy ASC ownership stake *or* a post-policy (2008-2011) ownership stake (only 4% of non-owners become ASC owners at any point during the post-period). The results and inferences from Table 1 hold with this additional analytic sample restriction.

Given that even non-owners demonstrate volume reductions, the results in Table 2 suggest that physicians who are not residual claimants on facility profits and hence would not directly benefit from higher Medicare facility fees flowing to ASCs are still indirectly and substantively affected by the market expansion in these specific Medicare surgeries. A plausible explanation for this Medicare policy spillover effect is that the targeted procedures (i.e., device intensive and laparoscopic surgeries) offer a physician payment rate that is higher than what was tied to the marginal case they chose to trade off. We bolster this interpretation in the following subsection.

C. *Supplementary Results for Case Mix and Inpatient Volumes*

We cannot observe physician reimbursement amounts for a given procedure outside of the traditional Medicare market, which relies on administratively set and publicly known prices. However, to strengthen our inferences from Section IIIB, we conduct a supplementary exercise that examines the average case complexity belonging to the Medicare and the two non-Medicare payer markets for these same surgeons.

To do so, we leverage publicly available 2008 Medicare information that maps each procedure (i.e., CPT code) to a predetermined number of physician work

Relative Value Units (RVUs). RVUs are designed to approximate the relative complexity—and hence physician effort—belonging to a given medical service provided to a Medicare beneficiary and forms the basis of the traditional Medicare physician fee schedule. We use the corresponding, procedure-level Medicare assigned RVUs to create a proxy measure of case complexity for all Medicare and non-Medicare procedures performed by the physicians belonging to our analytic sample in Table 1 (Section IIIB).[18] Once we have assigned the procedure-specific work RVUs to all of the physician's cases in a given half-year for the relevant payer market, we then average over all of these cases to generate a physician-half-year measure of average case complexity by payer.

This empirical exercise implicitly assumes that the relative ranking of procedures (in terms of expected physician effort) by the Medicare program is a sufficient approximation for how other payers would rank them as well and thus a reasonable ordering of their corresponding reimbursement levels (assuming that complexity and payments are positively correlated), even though we do not observe the actual transaction prices in the encounter data. Of note, we also fix the assigned Medicare work RVUs at their 2008 levels so that we can interpret any observed changes at the physician-time level as solely stemming from changes in the physician's case mix (i.e., collection of procedures), rather than fluctuations in Medicare RVU calculations over time. We then apply Equation (1) and Equation (2) to test whether the overall mix of procedures shifts among the new set of Medicare cases as well as the retained non-Medicare cases after the Medicare reimbursement shocks for ASCs are implemented.

Table 3 shows that the average case complexity for the indirectly impacted physicians from Tables 1 and 2 increases by 8%, 7%, and 5% for the Medicare, commercial, and all other payer markets, respectively, when averaged over the full post-policy period (columns 1-3, Table 3). All three DD estimates are precisely estimated as well. Moreover, in Figure 7, the change is increasing over time (growing to more than a 10-15% increase relative to pre-policy levels), and the

[18] For cases where more than one procedure is performed, we consider the highest work RVU procedure to be the main procedure and resulting RVUs for that particular case.

pattern is in alignment with the dynamics observed in Figures 5 and 6 as well. Namely, as more Medicare device intensive and laparoscopic procedures are able to take place, physicians performing these new Medicare cases further substitute away from cases performed within the non-Medicare markets, with the remaining cases for non-Medicare patients being higher complexity, and hence, more likely to be associated with a higher physician payment rate (i.e., the professional fee).

Turning to inpatient surgical volumes among physicians performing both outpatient and inpatient cases, we find that our treatment group physicians are producing approximately 9-13% less inpatient surgical output (i.e., 2-4 less cases per half-year) across each of the three payer group markets (Table 4). The effect sizes also seem to grow over time (Figure 8), as observed for the previous care quantity outcomes.[19] The results from Table 4 and Figure 8 indicate that indirectly affected physicians shift more of their labor supply toward outpatient surgical settings.

One interpretation is that physicians, on average, prefer outpatient surgical cases and will devote more time to such cases so long as outpatient facilities are willing to absorb more, higher complexity procedures. Moving away from inpatient delivery is also financially damaging to the hospital. Even if the relevant case is recaptured (e.g., redirected to the hospital's own outpatient surgery facility), it is likely that the total reimbursement will fall short of what would have been received had the procedure been performed on an inpatient basis. And if there is "leakage" (e.g., cases being diverted to competing ASCs or other local HOPDs), then the hospital will lose out on the potential revenue in its entirety. And while the declines in Table 4 and Figure 8 could reflect substitution (i.e., trading inpatient delivery for outpatient delivery of the same surgery for the same patient), Tables 1 and 2 reveal

[19] Admittedly, the event studies are not as well-behaved for the inpatient surgical volumes, with the exception of the Medicare results (panel (a) in Figure 8). The pre-2008 coefficients for the Medicare market oscillate around zero and then become progressively negative as the positive price shocks are being phased in. The commercial and 'all others' case groups demonstrate noisier trends; however, the general pattern is evident and is consistent with a spillover effect interpretation.

that aggregate outpatient volumes for affected physicians fall among the commercial and 'all other' composite payer groups during this period.

IV. Physician Equity Stakes in ASCs

A. *Data and Estimation*

We next examine physician willingness to personally invest in ASC ownership with the advent of more favorable Medicare facility fees for ASCs. To do so, we return to our FOIA acquired information on physician equity holdings in ASCs; however, we now construct a binary and time-varying outcome variable at the physician-half-year level, rather than the fixed indicator (based on pre-policy data) used in the previous triple differences estimation. Equations (1) and (2) are repurposed for these analyses as well. The only departures are the analytic sample inclusion criteria. Specifically, we first relax and then progressively tighten the criteria to allow for dynamics in the physician market (e.g., entry and exit), given that we observe important dynamics in the ASC industry in relation to expanding supply of these Medicare surgeries (Section II).

We define a treatment group physician as one that is present in the data and performing a device intensive and/or laparoscopic outpatient surgery at any point before 2008 for any payer. Control group physicians are those that never perform such cases over the entire 2004-2007 time frame. We first estimate Equation (1) as a pooled DD regression (i.e., excluding the physician fixed effects), followed by imposing physician fixed effects for within-physician estimation, and lastly requiring that a given physician is present for at least 10 half-years in the analytic data. The latter restriction guarantees that all physicians in the sample will be observed at least once in both the pre- and post-periods. We are then able to assess how sensitive the results and interpretations are to the analytic sample construction as well as to ensure that we do not inadvertently mask a policy effect due to physician sample restrictions.

B. *Results*

Table 5 presents the corresponding ASC ownership results. Just under 4% of physicians in the treatment as well as the control group hold an ASC equity stake prior to 2008. Across all three columns of Table 5, there is a substantive and statistically significant increase in ASC ownership for physicians that perform device intensive and laparoscopic surgeries. The DD estimate's magnitude is reduced by half when imposing physician fixed effects (column 2); however, it is qualitatively the same when requiring a minimum panel length of at least 10 half-years (column 3).[20] Figure 9 offers the event study results corresponding to column 2 of Table 5 (Appendix Figure A3 does likewise for column 3). The observed physician behavior change is both sharp and persistent over the post-policy period. Using the more conservative estimates from Table 5 and Figure 9, indirectly affected physicians are roughly 25-30% more likely to invest in an ASC after Medicare has radically increased its facility fees for device intensive and laparoscopic surgeries.

V. Market Expansions, Patient Mix, and Quality of Care

A. *Data and Estimation*

We conclude our empirics by examining the Medicare beneficiary patient mix as well as downstream adverse health events tied to these substantive market expansions in the supply of technologically advanced surgeries. The former allows us to better understand the marginal patient impacted by the Medicare facility fee change, and the latter element can speak to another potential externality from the fee reforms as it relates to care quality (i.e., surgical complication rates).

We are specifically interested in the age, the likelihood that the patient identifies as non-Hispanic white, and the likelihood the patient needs to be transferred to an acute care inpatient hospital among Medicare beneficiaries receiving a device intensive or laparoscopic outpatient surgery. Looking across the

[20] We do note that the differential change in the likelihood of ASC ownership is not evident among our Section III analytic sample that fully restricts to a balanced panel of physicians over the 16 half-years. This could indicate that dynamics in the physician market and/or other correlated characteristics, such as time point in the working life course, influence the ownership decision in relation to the policy change.

full Medicare population, we are then interested in the rate of Medicare beneficiaries presenting to an emergency department or being hospitalized for medical and surgical care complications (ICD-9 codes 996-999) before and after the significant ramp up of advanced technology surgeries being supplied to the Medicare market. The rationale for this analysis is that with a many-fold increase in these procedures being performed by ASCs (Figure 2 and Figure 3) it is possible that affected ASCs could be performing a great deal more of these cases than before and/or performing them for a relatively novel patient group (i.e., elderly Medicare beneficiaries). If "learning by doing" is important to these specific surgical cases (i.e., if there is a positive correlation between payer-specific case volume and performance quality), then it would suggest that the rapid and large outward shift in the industry-wide supply curve could translate to more adverse events for Medicare beneficiaries, at least in the short-run as ASCs adjust to this new line of business within the Medicare market.

To undertake each of these final analyses, we leverage supplementary AHCA data that provide the universe of inpatient hospital stays (2004-2011) and emergency department (ED) visits from 2005-2011.[21] We again use a DD research design but define treatment and control categories based on the two most prominent payers in outpatient procedure markets during this time period: traditional Medicare and the non-Medicare commercially insured groups. The differential experience in the quantity of advanced surgeries supplied to these two markets (in relative terms) is made clear from the raw aggregate data in Figure 10. Medicare and commercial device intensive and laparoscopic procedures are trending in parallel prior to the fee reform announcement, and then begin to diverge following the fee reform announcement in 2007, with a growing gap as the payments are fully phased in.[22] We consequently compare the patient characteristics among those receiving the relevant surgeries across the two payer groups as well as the inpatient and ED

[21] The ED discharge database is restricted specifically to ED encounters that do not result in an inpatient admission at the hospital. The database is only available starting in 2005.

[22] Of note, the divergence during the announcement period is driven by HOPD delivered surgeries (suggesting anticipatory behavior by the rival firms), rather than that of ASCs.

utilization behavior of these two payer groups for patients residing in the same geographic area (i.e., county of residence).

We operationalize this Medicare-to-commercial patient comparison by estimating discharge record-level DD and event study specifications that are similar in spirit to those described in Section III. The only exceptions are that the estimation is at the patient discharge record (i) level, we include patient county of residence fixed effects (η) instead of physician fixed effects, and we cluster standard errors at the county level.

$$Y_{ict} = \delta(Treated \times Post)_{ict} + \eta_c + \tau_t + \varepsilon_{ict} \quad (4)$$

$$Y_{ict} = \sum_{\substack{n=-8 \\ n\neq -1}}^{7} \delta_n \big(Treated \times 1(t+n)\big)_{ict} + \eta_c + \tau_t + \varepsilon_{ict} \quad (5)$$

The omitted time period for Equation (5) is again the second half of 2006, and the series of DD coefficients allows us to test for differential changes before, during, and beyond the extensive Medicare price shocks for the ASC industry. Besides the relevant outcomes (Y) of interest, the only other departure between these two analytic looks (one focused on marginal patients and the other focused on the risk of complications) is the subset of discharge records examined. The former restricts to traditional Medicare and commercially insured patients receiving either a device intensive or laparoscopic surgery. The latter includes all discharge records from each payer group. By capturing changes in the probability (or rate) of presenting to the ED or hospital with surgical complications, we avoid conflating a change in the absolute number of episodes with general changes in ED and/or hospital utilization among Medicare beneficiaries or commercial insurance enrollees in these areas and over time.

B. *Results*

Table 6 provides the results tied to patient mix for our technologically advanced surgeries of interest. Compared to the commercially insured population, Medicare beneficiaries are no more or less likely to identify as non-Hispanic white or need to be transferred to an acute care hospital (a very rare event in the data) when receiving a device intensive or laparoscopic surgery. They are, however, becoming differentially younger on average by roughly 1 year (column 1, Table 6). The event study estimates for changes in the average age among the mix of Medicare beneficiaries are also compelling (Figure 11). There is a sharp and growing decline as the number of these surgeries is dramatically expanding (Figures 2, 3, and 10). Yet, the relative magnitude is only a 1-3% decline when compared to the pre-policy average age of this specific patient population.

Within Table 7 and Appendix Figure A4, we find no evidence that Medicare beneficiaries are more likely to experience a complication after outpatient facilities are supplying more of these advanced surgeries to the Medicare market. Approximately 1% and 4% of ED visits and inpatient admissions, respectively, for Medicare beneficiaries are due to medical/surgical complications during the pre-period, but these rates are virtually unchanged in the post-period. The coefficients are vanishingly small in Table 7, and even negatively signed for ED visits (suggesting a slightly lower likelihood of an adverse event). Admittedly, our data assets do not allow us to definitively rule out all possible adverse events, such as those that might be more subtle and hence captured in general outpatient care, pharmaceutical utilization, or other care settings. However, we at least document that there is no increase in emergent care or hospitalization, which could otherwise indicate that care quality is sacrificed as the ASC and HOPD industries expand the Medicare market for device intensive and laparoscopic surgery.

VI. Discussion

Medicare is a large and influential component of the US healthcare system. Previous work has shown that price signals from Medicare can influence R&D, capital equipment, and treatment decisions among a variety of healthcare firms. We

show that this is also true for the adoption and utilization of surgical care innovations. Following the extensive price revisions for ASCs performing technologically advanced surgeries, the ASC industry substantially increases its relevant case volumes for Medicare beneficiaries—with an implied elasticity of between 0.6 and 1.4 across the two sets of surgical services we examine. Additionally, the low reimbursements from Medicare for device intensive and laparoscopic surgeries performed in ASCs prior to 2008 not only limited output among ASCs treating Medicare beneficiaries but also may have blunted broader surgical innovation use among ASC competitors (i.e., hospitals) in the Medicare market.

What is more, the behavior of healthcare facilities in response to government pricing decisions has important spillover effects on the surgical care supplied by individual physicians. A variety of medical services, especially those with greater technical requirements, need to take place within designated and equipped healthcare facilities. Physicians possess the requisite human capital, but they often will not own or control the complementary inputs (i.e., physical capital), such as augmenting technologies, that are necessary to deliver certain services. Price signals from payers that separately target physicians and the relevant healthcare facilities will consequently determine if, and to what degree, medical joint production takes place. Disparate or misaligned incentives across these two production inputs can substantively restrain the supply of care. In our study's context, outpatient healthcare facilities provide the necessary venue for device intensive and laparoscopic surgeries, but Medicare's unfavorable pricing led the ASC industry to avoid these cases—which perhaps created a perverse incentive for HOPDs to limit their availability as well. The upshot is a bottleneck, if not barrier, to physicians being able to perform these surgeries for Medicare beneficiaries.

Once more physical capital (i.e., operating space and involved surgical technologies) is accessible following the positive Medicare price shocks, the indirectly affected physicians devote more labor supply to these Medicare outpatient cases and simultaneously substitute away from outpatient cases tied to non-Medicare payers as well as inpatient surgical cases across the board. These

outcomes reflect negative externalities from the perspective of non-Medicare patients who receive less care and/or are forced to seek out alternative physicians, as well as from the perspective of hospital managers losing inpatient revenue. At the same time, the complexity of these physicians' outpatient surgical case mix is strongly increasing within each of their payer markets. These findings indicate that capacity constraints bind for these physicians—meaning that they must forgo some cases to accommodate others—and their preferences over their case mix as well as delivery setting (i.e., outpatient versus inpatient) appear to have been distorted by the lack of opportunities to perform Medicare device intensive and laparoscopic surgeries prior to 2008. The observed reallocation of their operating time across settings and cases suggests a positive externality for physicians most exposed to the Medicare-induced facility behavior changes. Physicians performing the relevant procedures also exhibit a greater willingness to invest in ASCs following the facility fee reforms, which is both a novel empirical finding and indicative of a potentially important positive externality for the ASC industry insofar as these firms attract more outside investors and needed capital with a more favorable public insurer price schedule.

Taken together, government price setting for healthcare facilities spills over onto physicians' facility options, technology use, case mix, and payer mix. In other words, physician labor supply and time allocations—and hence earnings—are not solely determined by prevailing professional fees. The set of services they can perform is also shaped by the incentives facing other key production inputs, such as healthcare facilities. Facilities' willingness to bear the additional costs (fixed or variable) to incorporate more surgical innovations into their available medical services affects the returns on upstream innovators' intellectual property as well as the returns on downstream physicians' human capital. Subsequent physician changes in physician behavior have direct implications for patients and other healthcare market participants—creating a mix of positive and negative externalities from these otherwise narrow and largely overlooked facility payment shocks.

While our data assets cannot speak to the normative social welfare question as to whether these additional Medicare procedures are worth their costs, they demonstrate a variety of indirect effects on physicians.[23] The reach—and hence externalities—of these public payer policy decisions targeting one input is often underappreciated. But in a context of medical joint production within a mixed economy (i.e., public and private payers contracting with a common provider), these choices can have cascading effects that dramatically influence the overall medical care output observed in the market. Recent and complementary research (e.g., Richards, Seward, and Whaley (2021); Geruso and Richards (2022)) has likewise shown various spillover effects from Medicare policymaking within the outpatient surgery space. Future legislative and administrative efforts devoted to this expanding domain of US healthcare delivery should be more cognizant of the full reach of associated Medicare policy and include expected spillovers into any cost-benefit considerations. Our collection of findings also implies an important role for policymakers to promote and preserve dynamic firm entry and competition to facilitate greater surgical innovation adoption and utilization. New firms may be better positioned to make needed fixed cost investments, and incumbent firms may feel more pressure to embrace innovation if existing competitors have done so and/or there is a credible threat of new competitors doing so. Interestingly, Munnich and Richards (2022) note a sharp decline in ASC entry behavior, specifically, over the last 10-15 years. Weaker entry could consequently restrain the uptake of important medical advancements within a healthcare setting of rapidly growing significance.

[23] For instance, our data cannot track patients over time and do not include all medical care contexts and associated utilization. Consequently, the data are also unable to capture subtle changes in health status (e.g., reported improvements in self-assessed health or disability adjusted life years), which are important for consumer welfare considerations.

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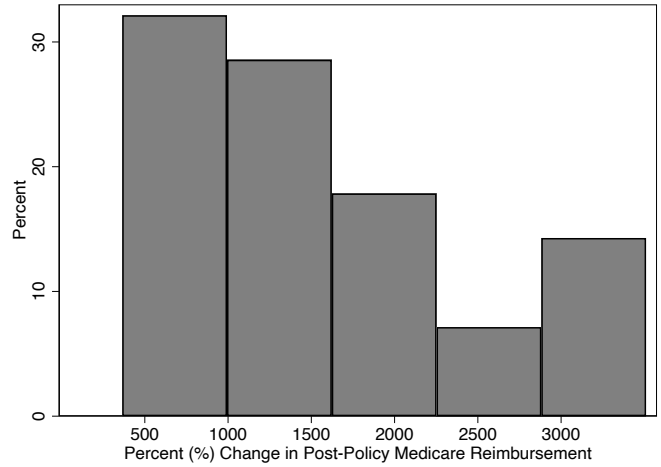
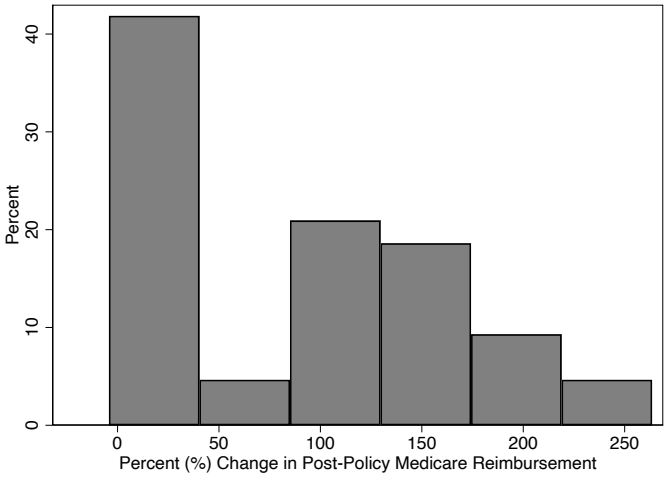


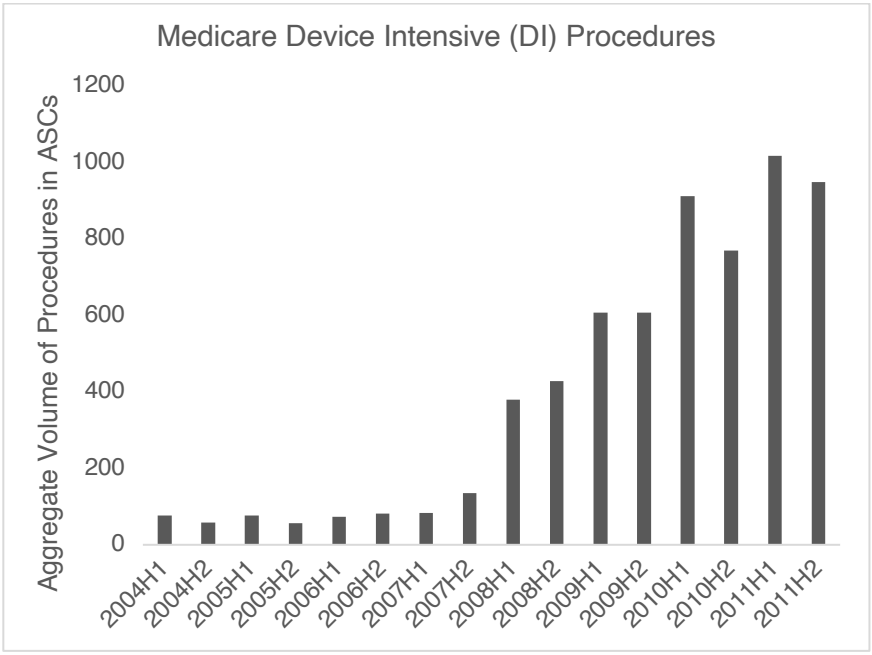
(a) Device Intensive Procedures



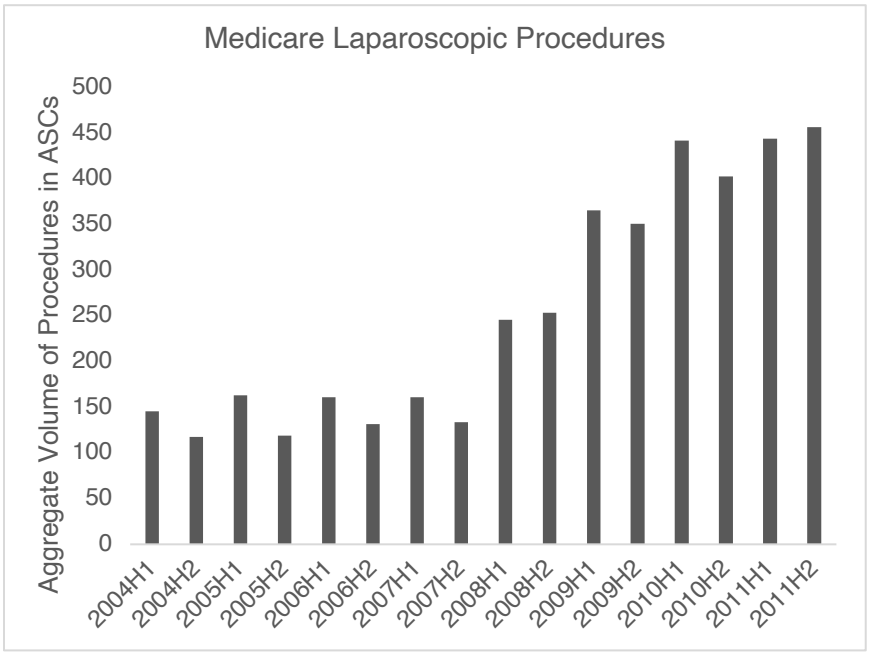
(b) Laparoscopic Procedures

FIG 1. DISTRIBUTION OF MEDICARE FACILITY FEE CHANGES BETWEEN 2007 AND 2011 FOR CASES PERFORMED IN ASCS

Notes: Relative change (in percentage terms) in the procedure-level Medicare ASC facility fee between 2007 and 2011.



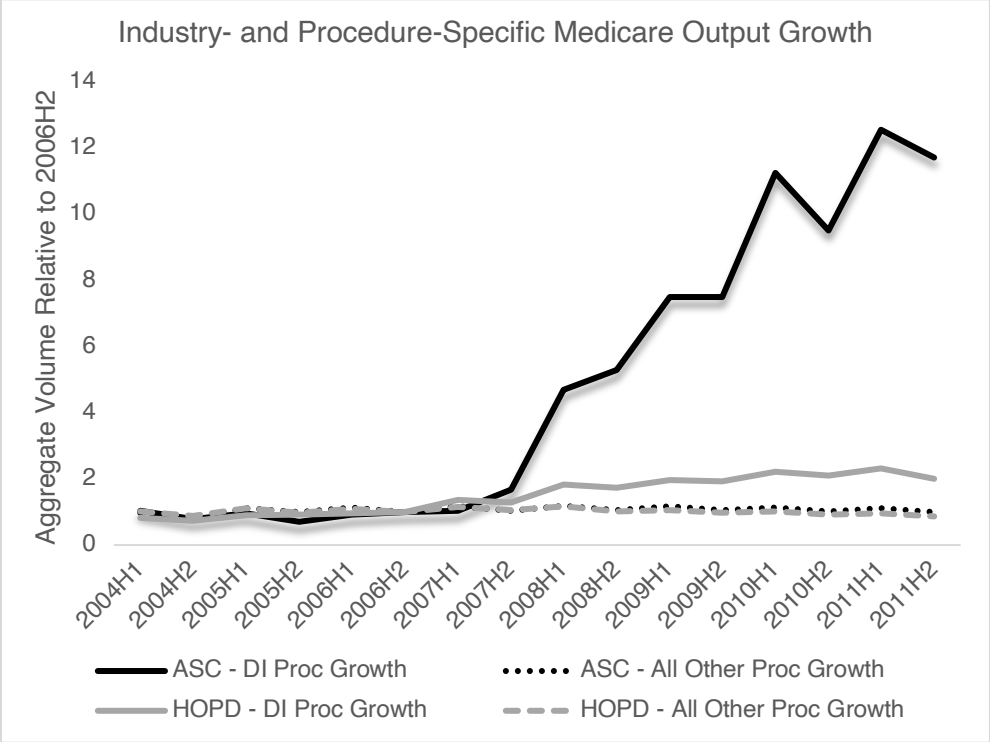
(a) Device Intensive Outpatient Procedures



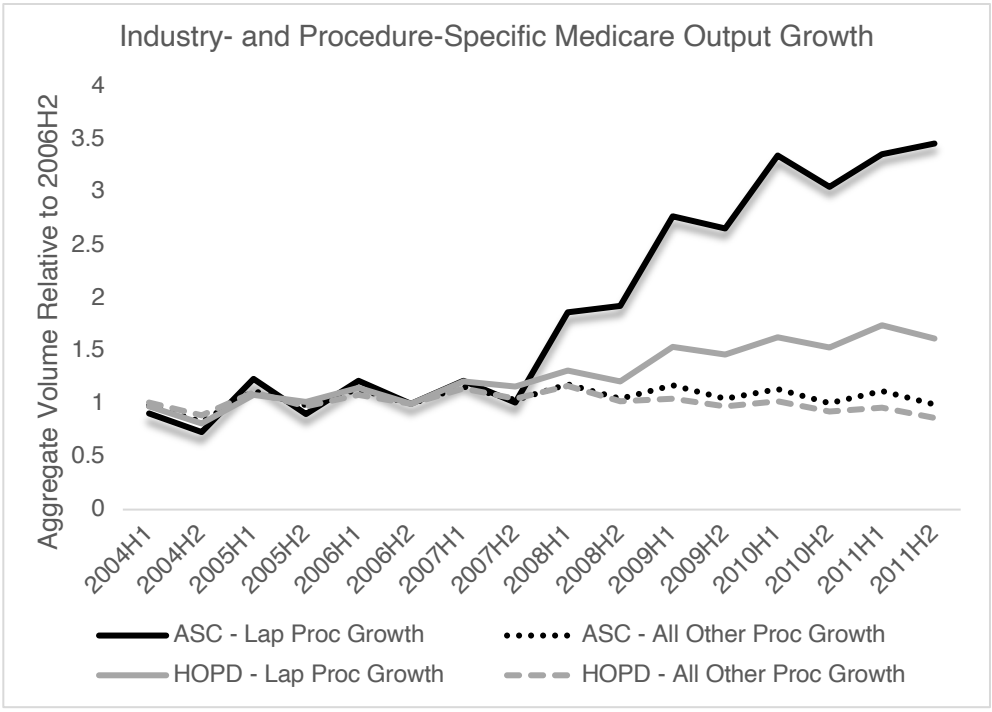
(b) Outpatient Procedures Using Laparoscopic Technology

FIG 2. ASC INDUSTRY OUTPUT FOR PROCEDURES RECEIVING LARGE MEDICARE PRICE INCREASES

Notes: Data are from the universe of outpatient surgery discharge records from Florida (2004-2011). Cases are restricted to those performed within Ambulatory Surgery Center (ASC) settings.



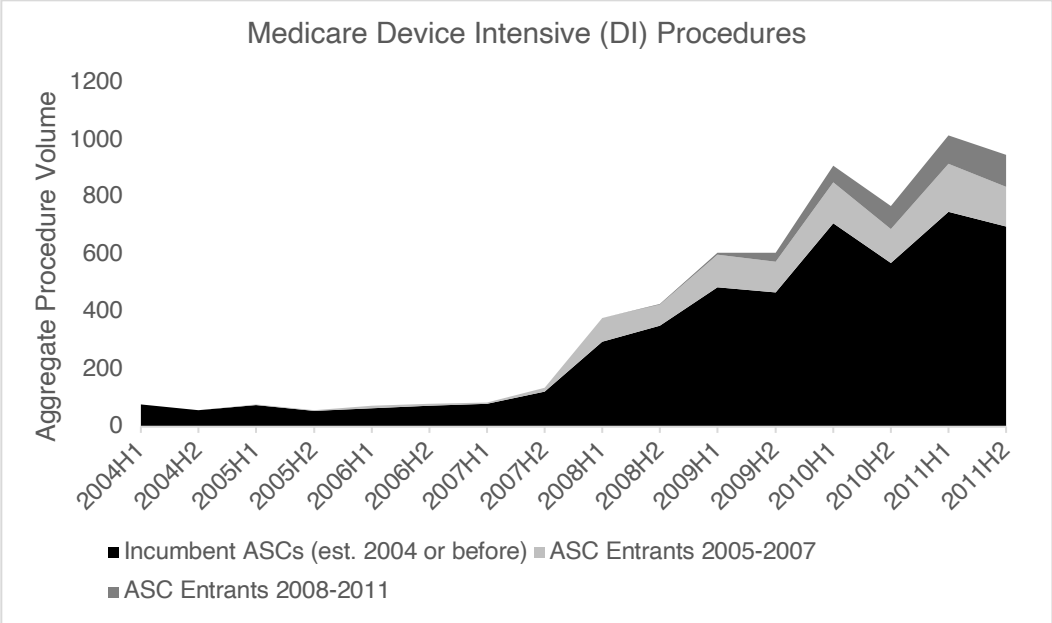
(a) Device Intensive Outpatient Procedures



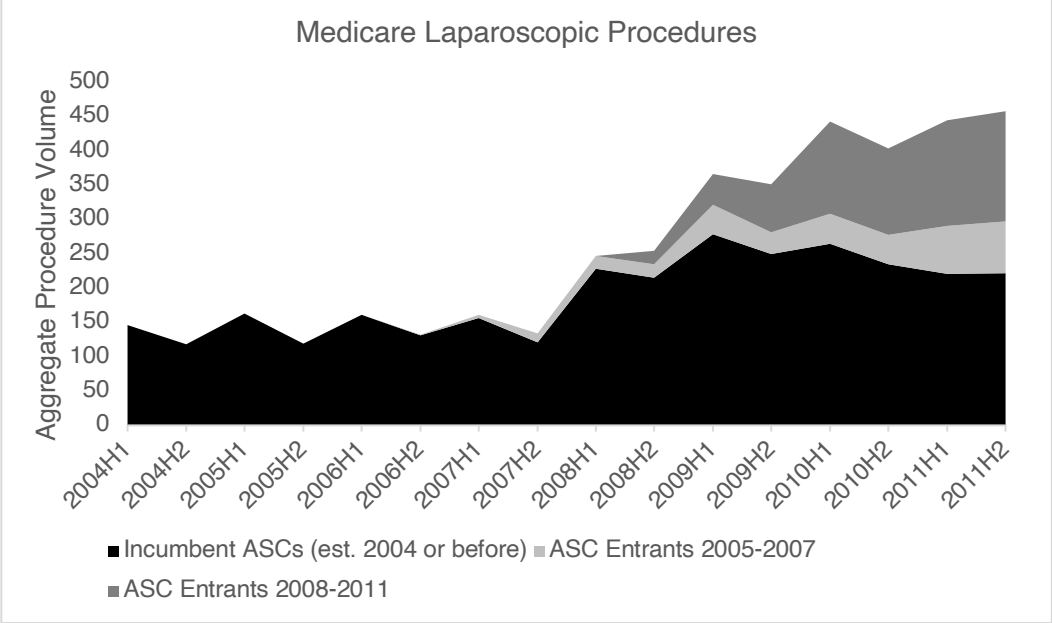
(b) Outpatient Procedures Using Laparoscopic Technology

FIG 3. GROWTH IN MEDICARE PRICE AFFECTED PROCEDURES RELATIVE TO ALL OTHER MEDICARE PROCEDURES BY INDUSTRY

Notes: Data are from the universe of outpatient surgery discharge records from Florida (2004-2011). Volumes have been normalized relative to those in the second half of 2006. "All Other Proc" are identical trends in both panel (a) and panel (b)—i.e., these represent all non-DI *and* non-laparoscopic procedures for Medicare beneficiaries.



(a) Device Intensive Outpatient Procedures



(b) Outpatient Procedures Using Laparoscopic Technology

FIG 4. STRATIFYING AGGREGATE OUTPUT CONTRIBUTIONS BY ASC FIRM ENTRY TIMING

Notes: Data are from the universe of outpatient surgery discharge records from Florida (2004-2011). Cases are restricted to those performed within Ambulatory Surgery Center (ASC) settings and stratified according to a given ASC's timing of entry into the Florida market.

TABLE 1—DIFF-IN-DIFF ESTIMATES FOR MEDICARE PRICING EFFECTS AT THE PHYSICIAN LEVEL

PANEL A

	Device Intensive (DI) Medicare Procedures in ASCs	Laparoscopic Medicare Procedures in ASCs
	(1)	(2)
Treated Physician x Post	0.132***	0.102***
	(0.026)	(0.017)
Physician fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Unique Physicians	6,367	6,367
Observations (N)	101,872	101,872
Treated Physicians Pre-Period Mean	0.03	0.07

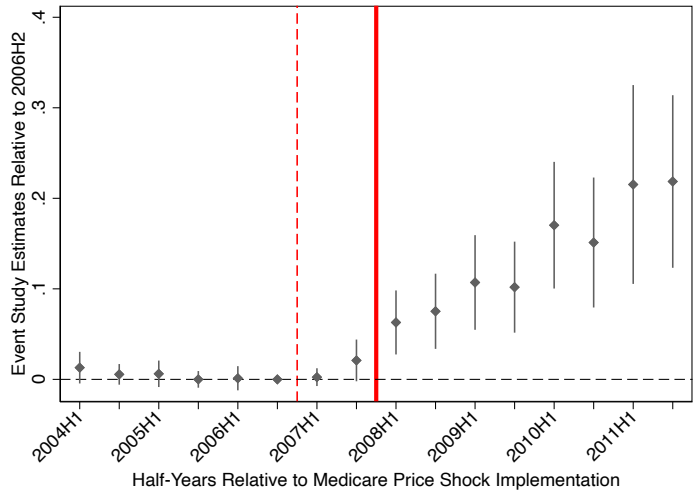
PANEL B

		Non-DI Non-Lap Procedure Volume		
	Total Procedure Volume (in logs)	Medicare (in logs)	Commercial (in logs)	All Others (in logs)
	(1)	(2)	(3)	(4)
Treated Physician x Post	–0.026	–0.023	–0.096***	–0.106***
	(0.016)	(0.015)	(0.015)	(0.020)
Physician fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Unique Physicians	6,367	6,367	6,367	6,367
Observations (N)	101,872	101,872	101,872	101,872

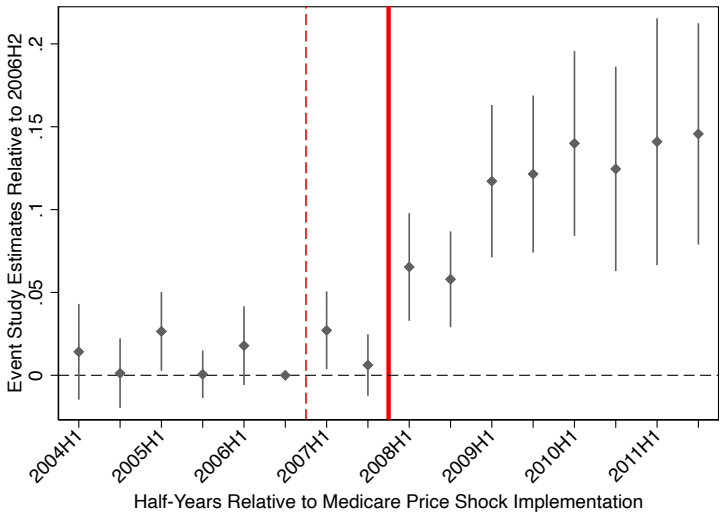
Notes: During the pre-period, treatment group physicians averaged 117 total procedures and 101 non-DI, non-Lap procedures in a given half year across all payers (26, 53, and 22 for Medicare, commercial, and all other payers, respectively, for non-DI, non-Lap procedures). All included physicians are consistently observed from the first half of 2004 through the second half of 2011. Time fixed effects capture half-years.

Standard errors clustered at the individual physician level.

*** P value at 0.01 ** P value at 0.05



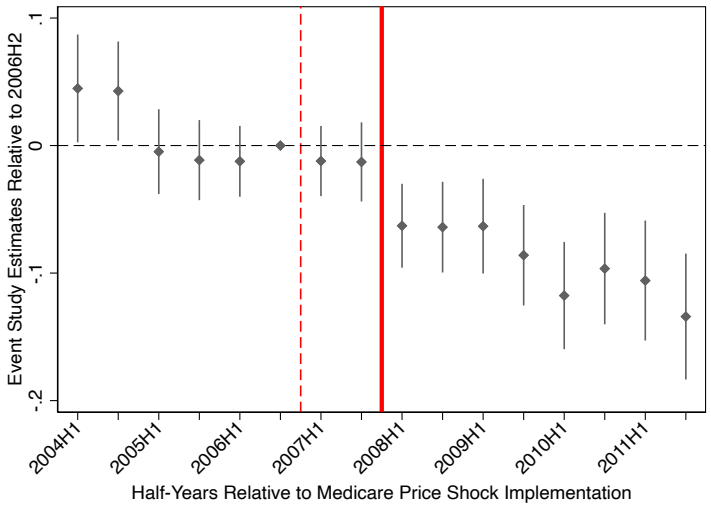
(a) Device Intensive (DI) Medicare Procedures in ASCs



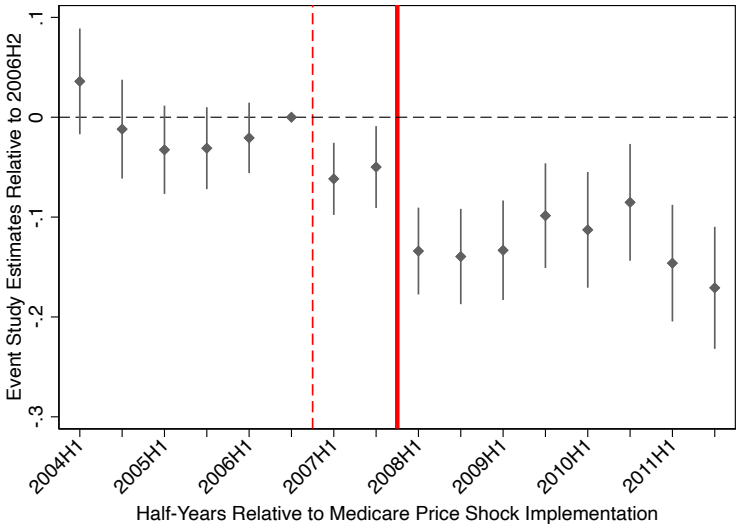
(b) Laparoscopic Medicare Procedures in ASCs

FIG 5. MEDICARE ASC PRICE SHOCK EFFECTS ON PHYSICIAN LEVEL MEDICARE PROCEDURE OUTPUT

Notes: Analytic samples are identical to those in Table 1, and the specification is that of Equation (2). Solid vertical line indicates the beginning of the fee reforms; dashed line indicates policy announcement period.



(a) Non-DI Non-Lap Commercial Procedure Volumes (in logs)



(b) Non-DI Non-Lap All Other (non-Medicare) Procedure Volumes (in logs)

FIG 6. MEDICARE ASC PRICE SHOCK SPILLOVER EFFECTS ON UNTARGETED PROCEDURES BY PAYER AND AT THE PHYSICIAN LEVEL

Notes: Analytic samples are identical to those in Table 1, and the specification is that of Equation (2). There is no restriction on the outpatient setting (i.e., these reflect total procedures by payer). Solid vertical line indicates the beginning of the fee reforms; dashed line indicates policy announcement period.

TABLE 2—TRIPLE DIFF ESTIMATES FOR MEDICARE PRICING EFFECTS AT THE PHYSICIAN LEVEL

PANEL A

	Device Intensive (DI) Medicare Procedures in ASCs	Laparoscopic Medicare Procedures in ASCs
	(1)	(2)
Treated Physician x	0.125***	0.088***
Post	(0.027)	(0.019)
Treated Physician x	0.131	0.293***
Post x ASC Owner	(0.150)	(0.117)
Physician fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Unique Physicians	6,367	6,367
Observations (N)	101,872	101,872

PANEL B

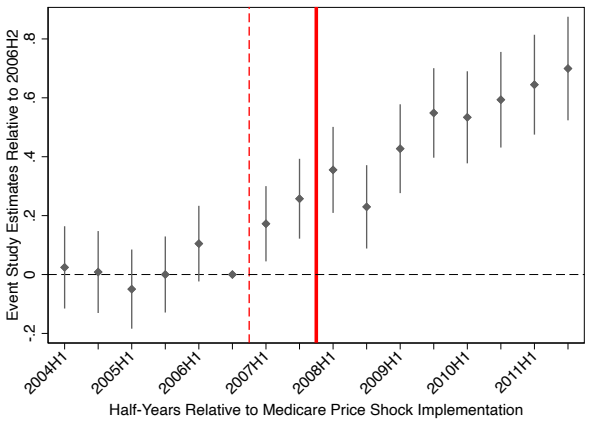
		Non-DI Non-Lap Procedure Volume		
	Total Procedure Volume (in logs)	Medicare (in logs)	Commercial (in logs)	All Others (in logs)
	(1)	(2)	(3)	(4)
Treated Physician x	–0.026	–0.024	–0.097***	–0.107***
Post	(0.016)	(0.015)	(0.015)	(0.020)
Treated Physician x	–0.006	0.029	0.039	0.027
Post x ASC Owner	(0.050)	(0.062)	(0.049)	(0.068)
Physician fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Unique Physicians	6,367	6,367	6,367	6,367
Observations (N)	101,872	101,872	101,872	101,872

Notes: All included physicians are consistently observed from the first half of 2004 through the second half of 2011. "ASC Owner" is equal to one for any physician with ASC ownership active at the time of the Medicare price reforms (start of 2008) and zero otherwise. 5% of the treatment group physicians had a qualifying ASC ownership stake. Time fixed effects capture half-years.
Standard errors clustered at the individual physician level.
*** P value at 0.01 ** P value at 0.05

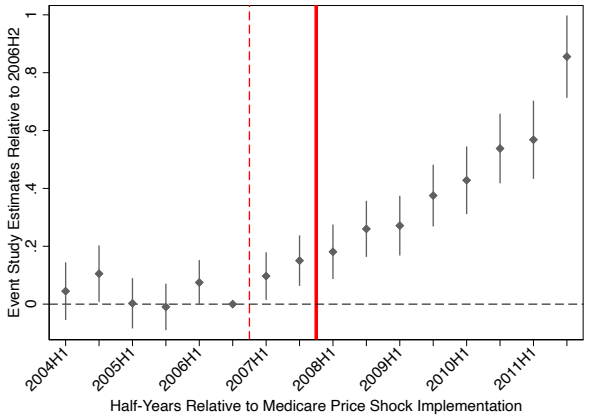
TABLE 3— DIFF-IN-DIFF ESTIMATES FOR MEDICARE ASC PRICING EFFECTS ON OUTPATIENT PROCEDURE CASE MIX COMPLEXITY AT THE PHYSICIAN LEVEL

	Avg. Work RVUs Medicare	Avg. Work RVUs Commercial	Avg. Work RVUs All Others
	(1)	(2)	(3)
Treated Physician x Post	0.439***	0.374***	0.266***
	(0.042)	(0.038)	(0.045)
Physician fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Unique Physicians	6,248	6,363	6,344
Observations (N)	90,594	96,283	90,430
Treated Physicians Pre-Period Mean	5.6	5.7	5.2

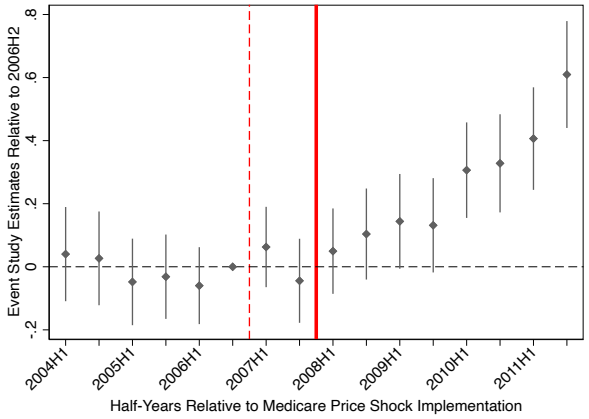
Notes: All included physicians are from the analytic sample belonging to Table 1. Slight differences in the number of physicians and number of observations reported in Table 1 are due to a small minority of the analytic sample not having a matchable case for the relevant payer in all half-years. RVUs (relative value units) are from the 2008 Medicare Physician Fee Schedule and are at the CPT code level. Time fixed effects capture half-years.
Standard errors clustered at the individual physician level.
*** P value at 0.01 ** P value at 0.05



(a) Medicare



(b) Commercial



(c) All Others

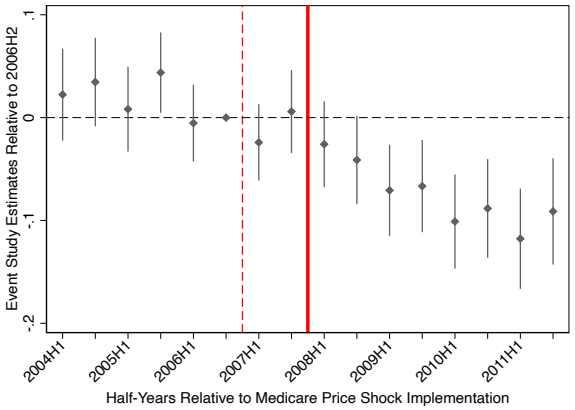
FIG 7. MEDICARE ASC PRICING EFFECTS ON CASE MIX COMPLEXITY AT THE PHYSICIAN LEVEL

Notes: Analytic samples are identical to those in Table 3, and the specification is that of Equation (2). There is no restriction on the outpatient setting (i.e., these reflect total procedures by payer). Solid vertical line indicates the beginning of the fee reforms; dashed line indicates policy announcement period.

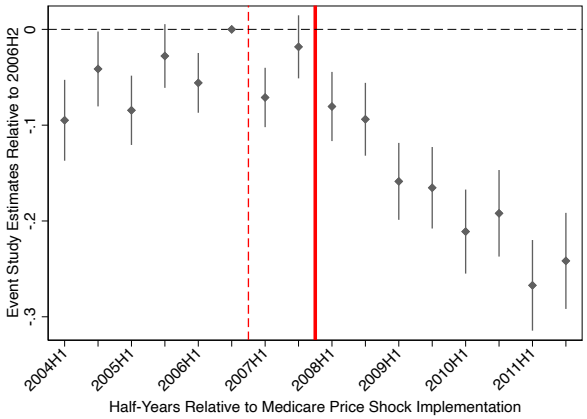
TABLE 4— DIFF-IN-DIFF ESTIMATES FOR MEDICARE ASC PRICING EFFECTS ON INPATIENT SURGICAL VOLUME AT THE PHYSICIAN LEVEL

	Inpatient Volume (in logs) Medicare	Inpatient Volume (in logs) Commercial	Inpatient Volume (in logs) All Others
	(1)	(2)	(3)
Treated Physician x Post	–0.085***	–0.125***	–0.118***
	(0.015)	(0.015)	(0.018)
Physician fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Unique Physicians	5,700	5,761	5,788
Observations (N)	71,261	74,009	72,924

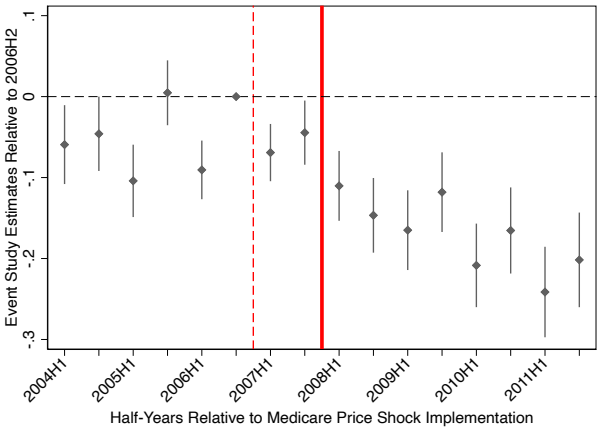
Notes: All included physicians are from the analytic sample belonging to Table 1. Differences in the number of physicians and number of observations reported in Table 1 are due to some physicians not having any inpatient surgical/procedural cases during the analytic time period (1.7% of the treated group and 18.8% of the control group). Prior to the payment reforms, treatment group physicians averaged 23, 43, and 33 inpatient procedures per half-year for Medicare, commercial, and all other payers, respectively. Time fixed effects capture half-years.
Standard errors clustered at the individual physician level.
*** P value at 0.01 ** P value at 0.05



(a) Medicare



(b) Commercial



(c) All Others

FIG 8. MEDICARE ASC PRICING SPILLOVER EFFECTS ON INPATIENT SURGICAL VOLUME AT THE PHYSICIAN LEVEL

Notes: Analytic samples are identical to those in Table 4, and the specification is that of Equation (2). There is no restriction on the outpatient setting (i.e., these reflect total procedures by payer). Solid vertical line indicates the beginning of the fee reforms; dashed line indicates policy announcement period.

TABLE 5— DIFF-IN-DIFF ESTIMATES FOR MEDICARE ASC PRICING EFFECTS ON PHYSICIAN EQUITY STAKES IN ASCs

	(1)	(2)	(3)
Treated Physician x Post	0.024***	0.012***	0.010***
	(0.004)	(0.003)	(0.003)
Physician fixed effects	No	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Restrict to >=10 half-years in analytic data	No	No	Yes
Unique Physicians	22,595	22,595	5,788
Observations (N)	255,096	255,096	72,924

Notes: Physician included in the treatment group are those that perform at least one device intensive of laparoscopic surgery prior to 2008 (for any payer type). Controls are those with zero such procedures across all payers from 2004-2007. Columns 1 and 2 place no restrictions on a given physician's panel length in the data while column 3 requires at least 10 half-years of contributing data to part of the estimation. 3.7% of physicians in the treatment as well as the control group have ASC ownership stakes at baseline (i.e., prior to 2008). Time fixed effects capture half-years. Standard errors clustered at the individual physician level.
*** P value at 0.01 ** P value at 0.05

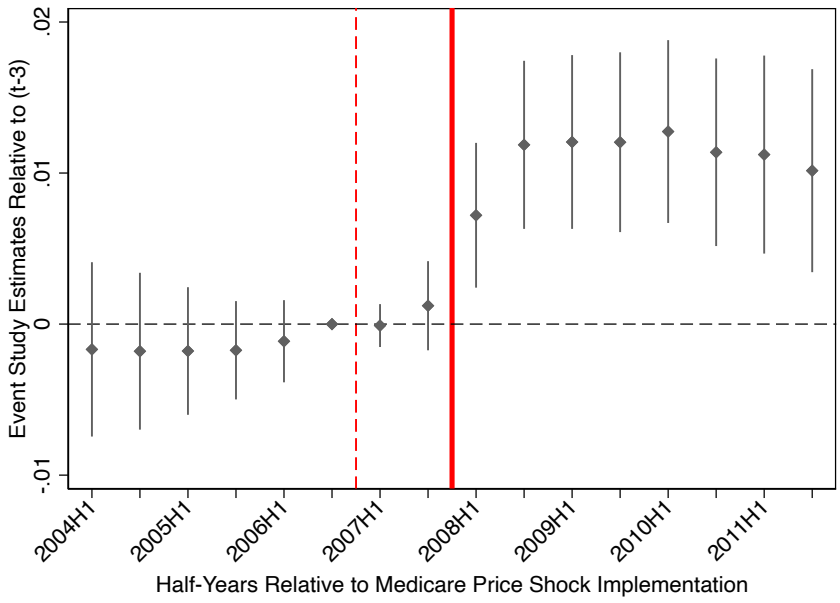


FIG 9. MEDICARE ASC PRICE SHOCK EFFECTS ON PHYSICIAN EQUITY STAKES IN ASCs

Notes: Analytic samples are identical to those in Table 5, and the specification is that of Equation (2). Solid vertical line indicates the beginning of the fee reforms; dashed line indicates policy announcement period.

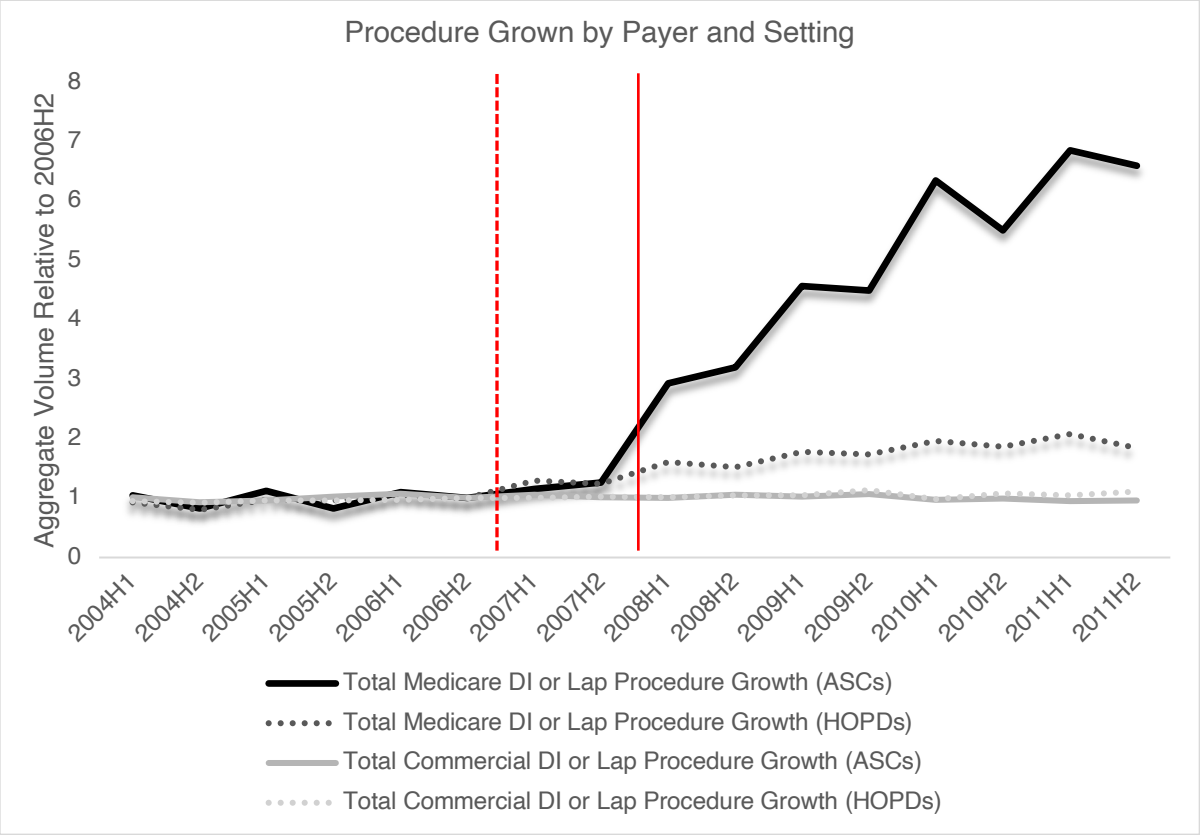


FIG 10. GROWTH IN MEDICARE PRICE AFFECTED PROCEDURES BY PAYER

Notes: Outpatient surgery discharge records from 2004-2011 and aggregated to the payer-procedure group level. Volumes have been normalized relative to those in the second half of 2006.. Dashed vertical line represents Medicare ASC pricing policy announcement.

TABLE 6—DIFF-IN-DIFF ESTIMATES FOR MEDICARE PRICING EFFECTS ON MEDICARE BENEFICIARY DEMOGRAPHICS AND DISCHARGE STATUS AMONG THOSE RECEIVING A DEVICE INTENSIVE OR LAPAROSCOPIC PROCEDURE

	Age	White	Transferred to Hospital
	(1)	(2)	(3)
Medicare x Post	–1.394***	–0.001	–0.00008
	(0.215)	(0.007)	(0.00016)
Patient county of residence fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Observations (N)	515,199	515,199	515,199
Medicare Pre-Period Mean	72.5	0.88	0.0007

Notes: Analytic sample restricts to discharge records belonging to traditional Medicare (treatment) and commercially insured (control) patients receiving a device intensive or laparoscopic surgery between 2004 and 2011, inclusive. Time fixed effects capture half-years.
Standard errors clustered on patient county of residence.
*** P value at 0.01 ** P value at 0.05

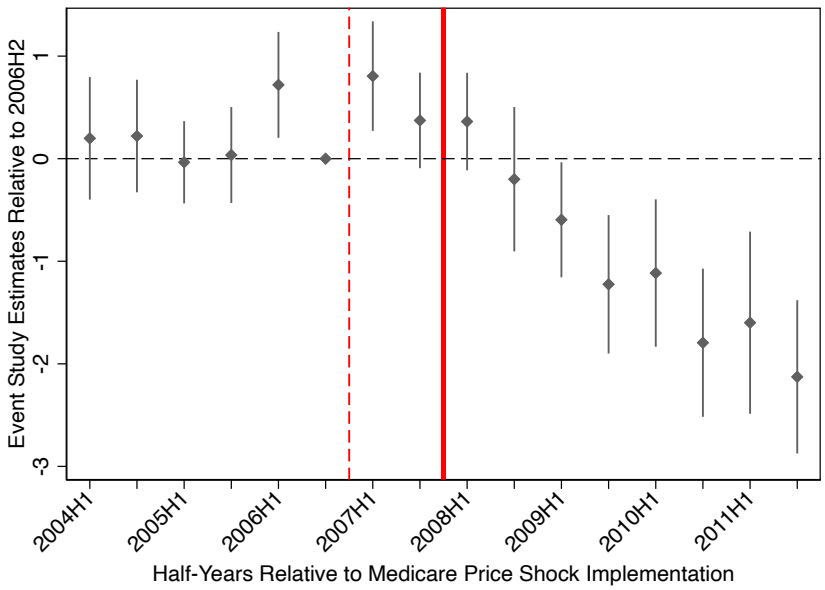


FIG 11. MEDICARE ASC PRICE SHOCK EFFECTS ON MEDICARE BENEFICIARY AGE AMONG THOSE RECEIVING A DEVICE INTENSIVE OR LAPAROSCOPIC PROCEDURE

Notes: Analytic samples are identical to those in Table 6, and the specification is that of Equation (4). Solid vertical line indicates the beginning of the fee reforms; dashed line indicates policy announcement period.

TABLE 7—DIFF-IN-DIFF ESTIMATES FOR MEDICARE PRICING EFFECTS ON MEDICARE BENEFICIARY EMERGENCY DEPARTMENT AND INPATIENT UTILIZATION FOR SURGICAL-RELATED COMPLICATIONS

	Emergency Department Visits	Inpatient Stays
	(1)	(2)
Medicare x Post	–0.00052**	0.0005
	(0.00022)	(0.0004)
Patient county of residence fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Observations (N)	17,176,960	11,946,009
Medicare Pre-Period Mean	0.013	0.037

Notes: Both panels restrict to discharge records belonging to traditional Medicare (treatment) and commercially insured (control) patients. Emergency department (ED) span 2005-2011; inpatient data span 2004-2011. Time fixed effects capture half-years.
Standard errors clustered on patient county of residence.
*** P value at 0.01 ** P value at 0.05