ABSTRACT

Title of dissertation: Hospital Responses to Superior Competitors And Societal Valuation of Surgical Procedures.

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Chapters 1 and 2 of this dissertation explore the evergrowing outpatient surgical market and how hospitals respond to specialized competitors, Ambulatory Surgical Centers (ASCs). ASCs are providers of surgical procedures that occur in an outpatient medical setting. Relative to hospitals, ASCs exhibit a lower cost structure, have lower prices to insurers and patients, and provide a higher quality of care. ASCs have grown in popularity among patients since the late 1980s and among insurers in more recent years. Hospital proponents have expressed concern that ASCs may have negative effects on the availability of hospital services, since ASCs may cherry-pick the most profitable patients who might otherwise have obtained care in hospitals, leaving hospitals with a pool of more costly or less well-insured patients, which could threaten the economic viability of hospitals. Limited research has indicated that hospitals do exhibit a loss of outpatient surgical volume over time in the presence of ASCs. Other studies have noted that ASCs do indeed service more profitable and healthy patients, with indications that these differentials may stem from physician-ownership of ASCs.

While standard theory would dictate that hospitals would exit the market in the face

of superior competitors, hospitals have continued to operate in the outpatient market, and in some cases have exhibited expanding outpatient revenue over time. There are a few factors that likely contribute to hospitals' continued ability to compete with ASCs, and examples include successful lobbying efforts to establish legislative restrictions on ASCs and receiving higher revenue from insurers (reimbursement rates) relative to ASCs. These interventions, however, may not last, as exemplified by recent legislation that proposes to enforce site neutral payments, which would pay hospitals at substantially lower rates. Hospital responses to ASCs that are in line with more typical quantity- or price-based competitive strategies have not been examined. The exact mechanisms for competition under these avenues depend on a hospital's maximizing objectives. For-profit hospitals are assumed to be profit-maximizers. Not-for-profit hospitals, however, have no shortage of theoretical models, with mixed empirical evidence to support them.

This dissertation expands on studies concerning hospital-ASC competition by separating the aggregate outpatient market into surgical procedure classifications, within established market geographies for patients. Specifically, I examine three specialty outpatient markets in which ASCs have exhibited substantial growth nationally and in the state of Florida, from 2000 through 2009, in addition to examining a combined market of all other outpatient surgical procedures. In this outpatient market dissection, I empirically examine how hospital patient volume, the number of physicians, and patient insurer mix vary by ASC presence in a given market. I extend a model of not-for-profit hospitals as revenue maximizers that accounts for physicians as the main driver of service volume and motivates potential not-for-profit service expansion in response to competition.

Using Florida state data, my estimates suggest differential hospital ownership status effects on hospital patient volume, hospital physicians, and highest revenue patients (those privately insured) in select markets. Specifically, estimates indicate that for-profit hospitals have lost a sizable amount of their privately/commercially insured patients in markets where they face ASC competition, while not-for-profit hospitals did not. My estimates further indicate that not-for-profit hospitals are more likely to exhibit output expansion, primarily among privately insured patients. Taken together, my results further the literature on differential objectives of hospital ownership by examining emerging hospital markets and indicating that in Florida, where the split between for-profit and not-for-profit private hospitals is even, ASCs will focus on for-profit hospital populations first, and not-for-profit hospitals can maximize output in a manner that prioritizes revenue.

Chapter 3 of this dissertation focuses on the direct and indirect costs to society of a popular surgical treatment for end-stage knee osteoarthritis - the total knee arthroplasty (TKA). This chapter motivated my historical examination in Chapter 2, as this popular and expensive procedure has potential to transition to an outpatient setting, given advances in anesthesia and its low complication rate. Indeed, while TKA has been isolated to hospital settings to date, recent legislation from Medicare in 2018 notes a potential for a shift of this high revenue procedure from a hospital setting to an ASC setting, which would likely decrease the direct medical costs noted below and increase the societal value of this procedure.

This chapter, published in 2013, notes the importance of societal perspective in valuing surgical procedures, and in doing so, considers hospital medical costs of providing a procedure that is growing in popularity. Using a Markov model, my coauthors and I estimated the value of TKA by comparing direct and indirect costs between surgical and nonsurgical treatment scenarios. Direct costs considered all surgical and non-surgical medical costs for osteoarthritis of the knee, including hospital costs (insurer reimbursements). Indirect costs included lost wages due to an inability to work, lower earnings, or receipt of disability payments. Our model further incorporated quality-of-life measures to estimate costs over patients' lifetimes and quality-adjusted life years. Assumptions and cost estimates came from Medicare claims data (with all-payer adjustments), survey data, clinical expert opinion, and peer-reviewed literature. Compared with nonsurgical treatment, we found that total knee arthroplasty increased lifetime direct costs by a mean of $20,635 (net present value in 2009 U.S. dollars). These costs were offset by societal savings of $39,565 from reduced indirect costs, resulting in a lifetime societal net benefit from total knee arthroplasty of $18,930 per patient. Eighty-five percent of these savings originated from increased employment and earnings, with the remaining 15% from fewer missed workdays and lower disability payments. A large portion of direct medical costs were driven by the hospital-based setting of the surgical procedure. The estimated lifetime societal savings from the more than 600,000 total knee arthroplasties performed in the U.S. in 2009 were estimated to be approximately $12 billion. These societal savings primarily accrued to patients and employers.

Hospital Responses to Superior Competitors And Societal Valuation of Medical Procedures

by

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DEDICATION

To my parents, wife, and son.

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LIST OF ABBREVIATIONS

ASC	Ambulatory Surgical Center
HOPD	Hospital Outpatient Department
CCS	Clinical Classification System
EYE	Ophthalmologic outpatient surgical market
GS	Gastrointestinal outpatient surgical market
NMK	Neurological and orthopedic surgical market
OTHER	other surgical procedures not otherwise included in EYE, GS, or NMK

Chapter 1: Introduction

Medical care providers have adopted emerging medical technology and advancing medical practice in a way that has reshaped how and where patients receive health care. A prime example is the shift of diagnostic, imaging, and surgical services from a traditional hospital inpatient setting to an outpatient setting that does not require an overnight stay. This shift is attributable in part to technological advancements in anesthesia and imaging technology, advancements in minimally invasive surgical techniques, and changes in provider financial incentives (Lumsdon et al., 1992; Duffy and Farley, 1995). Data from the 1980s to more recent years provide perspective on the magnitude of this shift from inpatient to outpatient settings. Specifically, less than 5 percent of the 20 million surgical procedures performed in 1981 were performed in outpatient settings, while approximately 80 percent of the 50 million surgeries performed in 2005 were performed in outpatient settings (AHA, 2006).[1]

Outpatient settings include traditional general/acute care hospital outpatient departments (HOPDs), physician offices, and ambulatory surgical centers (ASCs). HOPDs are typically full-service entities, providing a cadre of surgical services and non-surgical imaging and diagnostic services, while physician offices principally provide diagnostic and

[1] One would not expect a one-to-one transition of procedures from inpatient to outpatient settings, even after accounting for population growth, because the advancements in minimally invasive surgery and anesthesia would expand the surgical market to patients whose risk profile would have not permitted general anesthesia and more invasive surgical techniques.

imaging services. Less than 10 percent of all outpatient surgeries were performed in ASCs or physician offices in 1981, but by 2005, these settings accounted for over 50 percent of outpatient surgeries (AHA, 2006). From the 1980s through the mid-2000s, physician offices exhibited a greater rate of growth in imaging and diagnostic outpatient services relative to HOPDs. MedPAC (2013) notes a reversal in this trend that began in the late 2000s, a shifting of outpatient services (principally diagnostic) back to HOPDs. This trend reversal was consistent with Medicare payment changes over those years that provided higher reimbursement for a given service provided at a HOPD relative to a physician office (MedPAC, 2013).

While HOPDs may compete with physician offices for outpatient diagnostic services, ASCs have burgeoned as the principal competition to HOPDs in select outpatient surgical markets over the past three decades. From capturing approximately 5 percent of the outpatient surgical market in 1981, ASC market share increased to approximately 45 percent of outpatient surgeries in 2005 (AHA, 2006). This increasing share of outpatient surgeries corresponds with ASC firm expansion. In the early 1980s, there were fewer than 300 ASCs in the United States; there were 1,460 ASCs in 1991; 3,028 in 2000; and 5,111 in 2010. (Durant, 1988; MedPAC, 2013; MedPAC, 2017). The majority of ASCs are single-specialty facilities, have few operating rooms, and tend to specialize in the most profitable of outpatient surgeries – opthalmologic, gastroenterology, and orthopedic outpatient surgeries – but may also provide other specialties, such as plastic surgery (MedPAC, 2013; Cram et al., 2012). ASCs are solely or partially owned by physicians and are predominantly for-profit institutions (95+ percent) located in urban areas (MedPAC, 2016b).

The remainder of this chapter reviews existing literature that relates to hospital-ASC competition and how this competition may differ by hospital ownership characteristics. In doing so, this review establishes considerations for my empirical work in Chapter 2, which aims to assess the relationship between ASC presence and hospital outpatient surgical provision by ownership type.

1.1 The Fight Against ASCs

Hospitals have responded to competition from other hospitals in a variety of ways on price and non-price dimensions that have been extensively documented,[2] including strategic investments, mergers, changes in quantity or quality, and reputation. ASCs, however, maintain a particular competitive advantage to hospitals. Namely, ASCs are able to provide outpatient surgical services more efficiently, at higher average quality, and at lower cost relative to HOPDs (Casalino et al., 2003; Munnich and Parente, 2014a). These efficiencies are not unexpected given a production model described as a ”focused factory” (Casalino et al., 2003; Carey and Mitchell, 2017b), even among multi-specialty ASCs (Carey and Mitchell, 2017a). Given ASCs' exhibited benefits to patients, medical providers, and insurers, regulators have called for increased utilization of ASCs since the late 1990s (OIG, 1999).[3]

The appeal of ASCs for patients is clear. ASCs have shorter wait times and easier scheduling relative to hospital outpatient departments (Cullen et al., 2009a; Munnich and Parente, 2014a). Studies have also reported that specialized surgical facilities, such as ASCs, can achieve better quality, efficiency, and patient satisfaction than full-service hos-

[2]Gaynor and Town (2011); Zwanziger and M (2005); Abraham et al. (2007); Devers et al. (2003) provide comprehensive reviews of hospital-to-hospital competition on price and non-price dimensions.

[3]The 1999 report and regulation was to allow ASCs safe harbor under federal anti-kickback legislation.

pitals (Grisel and Arjmand, 2009; Munnich and Parente, 2014b). Further, ASCs provide these surgical services at a lower cost and thus have the potential to offer significant savings to insurers. Under Medicare, for example, ASC payment rates are lower than HOPDs, and in 2011, were approximately 60% of rates paid to hospitals for outpatient surgical services (MedPAC, 2013).

The growth of ASCs is likely to have wide-reaching influences on patient welfare and policy-making decisions. Proponents of ASCs commonly cite the aforementioned increased patient welfare engendered from shorter wait times, increased choice of where to have their procedure done, and overall convenience to the patient. Further, they claim that the competition promoted by the emergence of such entities into the market may foster incentives for further technological innovations that may increase the efficiency of current procedures performed in ASCs (and HOPDs) and decrease costs in the health care industry. Regulators agree. OIG (1999) and OIG (2014) advised policy changes to bolster the utilization of ASCs, including equating HOPD payments for surgical services performed at ASCs to ASC rates.

Other research is not so optimistic. These works suggest that growth and physician ownership of ASCs may result in more, and potentially unnecessary, surgical volume than that already inherent in fee-for-service health care payment systems. Physicians who treat patients on site typically have vested financial interests in the facility as part or whole owners of ASCs (Casalino et al., 2003; MedPAC, 2016b). There is some evidence that physicians ”cherry pick” highly profitable surgical cases (e.g., cataract surgeries) for their ASC and leave low/no-profit and high-risk cases for neighboring hospitals (Plotzke and Courtemanche, 2011; Gabel et al., 2008; Schneider et al., 2008). Winter (2003) similarly found that the average risk (based on comorbidities and age) of patients is significantly lower for those treated at ASCs than those treated in hospital outpatient departments.[4] Expanding on physician ownership incentives, the literature has also found that ASCs potentially induce demand for outpatient surgical procedures via physician-ASC ownership. For example, Hollingsworth et al. (2010) found a greater increase in annual case-loads of presumed ASC physician owners from the pre- to post-ownership period compared with non-owners for five common types of procedures performed in ASCs. Hollingsworth et al. (2009) reported a higher level and growth of annual case-loads of urological surgery for physician owners than non-owners. Similarly, Mitchell (2010) used data from a single private insurer and 42 ASCs and specialty hospitals in Idaho to compare the frequency of three procedures between physician owners and non-owners of ASCs and observed a substantially higher frequency of procedure use among patients treated by physician owners than those treated by non-owners.

Increased ASC utilization and potential patient cherry-picking by physicians affiliated with ASCs have arguably left full-service hospitals and their outpatient departments in a less profitable position that may hinder their ability to sustain uncompensated care services (Casalino et al., 2003). Policy-maker reaction to the rapid growth and utilization of ASCs has been mixed, as perceived benefits may be offset by misaligned incentives. What's a hospital to do?

Previous studies have examined hospitals' competitive responses to specialty provider types. In the late 1990s and early 2000s, for example, hospitals competed for patients

[4] Wynn et al. (2008) and MedPAC (2016a) had similar findings, which varied by patient risk definition and time frame.

against specialty hospitals[5] (inpatient services) and ASCs (outpatient services). These responses included establishing their own specializations (e.g., service lines/teams) and expansion of outpatient services (Berenson et al., 2006) and were not surprising, given hospitals' dependence on high-revenue/profit surgical procedures to subsidize less profitable service offerings, including care for uninsured patients (Casalino et al., 2003; MedPAC, 2006). It is important to note, however, that unlike specialty hospitals, ASCs require less capital and are less complex facilities (FTC and DOJ, 2004). Anecdotal evidence also points to strategic pricing increases or changes in output service offerings in the face of specialty providers – including the shuttering of service types (MedPAC, 2006).

Few studies, however, have examined any direct effect of ASCs on HOPD output. In a national sample, Courtemanche and Plotzke (2010) estimated that ASCs located within 15 miles of an HOPD result in an overall reduction in that HOPD's outpatient surgical volume. Bian and Morrisey (2007) discuss similar findings in larger geographic regions; namely, Metropolitan Statistical Areas. These two studies face a similar critical limitation. Namely, they study HOPDs and ASCs in outpatient surgical markets defined in a singular dimension of geography. In doing so, these authors treat ASCs as homogeneous firms, ignoring ASC specialization. Other studies focused on narrow specific outpatient surgical markets without providing a complete picture of the competition that HOPDs face. Suskind et al. (2014), for example, examined urological surgeries from 2001 to 2010 and found that hospital urological surgeries decreased from 221 to 214 procedures per 10,000 patients within 4 years of baseline (ASC entry) while rates of markets that already had ASCs or did

[5] AHA (2006) notes the near exponential growth of these facilities: 68 facilities nationwide in 2000; 96 in 2002; 160 in 2005; and, 177 in 2006. These entities are however few in number when compared to the general acute care hospitals, which number around the 3,000 mark over this period.

not have ASCs exhibited statistically significant volume increases over the same period.

Hospitals could attempt to deter ASC entry. Incumbent responses to threats of entry have been studied theoretically and empirically, under theories of entry deterrence or accommodation. Empirical studies on entry deterrence and accommodation are relatively sparse and largely focused on a few industries (e.g., pharmaceutical, casino, airline; Morton, 2000; Goolsbee and Syverson, 2008; Snider, 2009) and, generally, examine the role of investments on future competitive play, including incumbent responses to entrant capacity, capital restructuring, advertising, lobbying efforts, and price play across multiple industries.

Hospitals and hospital lobby groups like the American Hospital Association have qualified ASC efficiency as an unfair advantage stemming from ASCs operating under less regulation than hospitals,[6] not being required to offer unprofitable services that community hospitals provide, and ASC selection of more profitable patients (Casalino et al., 2003; Vogt and Romley, 2009). Indeed, panelists in a 2003 FTC hearing on health care competition indicated that hospital engagement in legislative efforts may have hindered ASC entry (FTC and DOJ, 2004). Despite initial support of ASCs in the late 1990s (OIG, 1999), in 2002, the OIG noted the importance of increased ASC oversight and lack of accountability to the government and public (OIG, 2002). Further, the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 (Modernization Act of 2003) froze ASC payment updates until a new pricing structure could be established in 2008, also directing the Government Accountability Office to examine differential costs of procedures as performed in ASCs and

[6] AHA (2006) provides a concise overview of the differential regulatory standards set by Medicare and at federal and state levels.

HOPDs to inform the new pricing structure. Ultimately, the new pricing structure, phased in from 2008 through 2012, allowed for a more expansive array of surgeries to be covered under Medicare, and phased in facility payment reductions for ASCs to approximately 60 percent[7] of HOPD amounts (Munnich and Parente, 2014b; MedPAC, 2010). This price differential clearly benefited HOPDs by affording them continued insurer reimbursements that cover their marginal cost, allowing HOPDs to continue competing in outpatient surgical markets. Further, the uncertainty and ultimately lowering of ASC reimbursement levels under the Modernization Act of 2003 might be seen as lobbying-based efforts to yield a legislative entry deterrent. At the state level, certificate-of-need (CON) laws may similarly act as an entry deterrent. CON laws are state-based laws that require health care providers like hospitals to obtain permission before adding or expanding their facilities or service provision. As Stratmann and Koopman (2016) point out, proponents of ASC regulation under CON laws similarly cite concerns that ASC cream-skimming of profitable patients and selective provision of profitable services leave hospitals with a less profitable patient population that may result in hospital closure, particularly among hospitals with the lowest profit margins, like rural hospitals. The authors further highlight the impact of CON laws by noting that the 26 states that currently have ASC-specific CON laws in place have 14 percent fewer ASCs per capita as of 2016.[8] In more recent years, post-2010, hospitals have been encouraged to purchase ASCs as part of their hospital system (Taylor, 2017). Purchasing or setting up an ASC may deter other ASC entry, as ASC entry decisions are sensitive to ASC density (Al-Amin and Housman, 2012), and provide the purchasing hospital with

[7] Further expanding price differentials, in 2015, Congress cut ASC reimbursement to approximately 50 percent of HOPD reimbursement.

[8] The authors further note that CON laws may have actually decreased the number of hospitals as well and may not be an appropriate tool to maintain access to care.

more equitable competition in specific outpatient markets. Nationwide data indicate that such investments were still rare in 2006, with less than 1 percent of hospitals (51 out of 5,557) having purchased or started an ASC.[9] Recent legislative recommendations, however, aim to blur price differentials between HOPD and ASCs so that patients that may be treated at either facility type would yield the same facility reimbursement amount, potentially bolstering the business case for hospitals to acquire ASCs.

Dafny (2005)'s empirical examination of entry deterrence bears a particular relevance to hospital-ASC competition. Dafny (2005) developed a three-period model of strategic investment that she applied to a specialty *inpatient* surgical procedure. The author employed results from Ellison and Ellison (2011)[10,11] to generate testable predictions for her model and found evidence of entry-deterring investment that manifested in increases in surgical volume (of a particular inpatient specialty surgery) for the first potential market entrant. The author cites and summarizes a variety of strategies (strategic investments) provided by hospital interest groups (e.g., the Advisory Board) that hospitals may employ to bolster surgical volume, including increasing hospital capacity (an increase of inputs/providers) and advertising, as mechanisms that hospitals may have engaged to increase their patient volume. While not identifying the exact strategies employed by hospitals in her study, the author's evidence motivates volume-increasing investment as a form of entry deterrence. These strategies are not specific to pre-entry threats and may also be leveraged by hospitals

[9] Source: analysis of Provider of Service data which details whether an ASC is "hospital-based".

[10] Dafny (2005) cites a 2000 MIT mimeo version of Ellison and Ellison (2011) that I was not able to obtain.

[11] Ellison and Ellison (2011), for example, developed an approach for testing strategic entry deterrence that revolves around market attractiveness. The authors showed that under certain conditions of market attractiveness or size, entry deterrent investments will be non-monotonic compared to non-deterrent accommodating investments. Their empirical application of this theory was on the pharmaceutical industry.

in their attempts to bolster output after entry occurs.

1.2 The Not-For-Profit Hospital

The existing literature on hospitals and ASCs accounts for hospital ownership implicitly if at all.[12] Hospital characteristics like for-profit status, however, may inform hospital objective functions and shape competitive responses.

The literature has theorized different objective functions for not-for-profit (NFP) hospitals while for-profit (FP) hospitals are assumed to be profit-maximizers.[13] Empirical evidence provides mixed support for theories of NFP hospital behavior. The importance of understanding NFP hospital behavior comes from its predominance in the United States relative to FP hospitals, accounting for approximately 75 percent of non-government general hospitals in 2017 (AHA, 2017), a percentage that has held steady over the past few decades (Horwitz and Nichols, 2007). The predominant NFP hospital structure and potential objectives are particularly interesting in the outpatient market, where they face competition from for-profit ASCs.

As Sloan (2000) points out, NFP and FP hospitals are similar in many ways, including cost and revenue profiles. NFP hospitals, however, do differ from FP hospitals in a few noteworthy ways, including the taxes paid and capital investment opportunities. The most relevant difference, particularly in terms of optimization behavior and incentive structure, is that FP hospitals generate profits for stakeholders. As profit-maximizers, FP hospitals

[12] Courtemanche and Plotzke, 2010, for example, specify a model that analyzes of hospital outpatient volume with hospital fixed effects, which captures the time-invariant ownership status of hospitals in addition to other time-invariant characteristics.

[13] Though not as straightforward as firms operating in perfect markets due to asymmetrical pricing information, this profit structure positions FP hospitals as theoretically equivalent to any other profit-maximizing firm.

will select the most profitable patients and provide the most profitable mix of medical and surgical services, given legislative and cost constraints. NFP hospitals, however, are known to provide a fuller service range than FP hospitals to facilitate the needs of the community they service. Competing theories of NFP hospital (behavior) and mixed empirical evidence variously suggest that NFP hospitals are either output maximizers, profit maximizers, or some mixture thereof.

The view of NFP hospitals as output maximizers has two veins in the theoretical literature. First, Newhouse (1970) proposed a model in which hospitals maximize quantity and quality of care subject to a zero-profit constraint. Under this model, NFP hospitals will offer services until profits are driven to zero. Other output maximization theories proffer models in which NFP hospitals maximize total market output (Weisbrod, 1988) to, for example, serve their local community, or as industry output maximizers that further respond to nearby hospitals (Frank and Salkever, 1991).

Other literature proposes that NFP hospitals are simply FP hospitals in disguise, with a different mechanism for distributing profits. Pauly and Redisch (1973), for example, propose multiple models under which profits manifest in stakeholders' salaries or perks. Such models have found real-world corroboration in recent years, given compensation packages enjoyed by executives at NFP hospitals (Review, 2013).

Theoretical literature on hospitals indicate that as with other profit-maximizing firms, FP hospitals, having selected and negotiated the profit-maximizing set of patients, procedures, and insurer payments, will lose market share in a market where they face a far more efficient profit-maximizing competitor and potentially exit the market. Other literature notes that an NFP hospital operating under the typical NFP mission statement of providing community-wide benefits (services) and not a profit-maximizing portfolio of services may act as an FP hospital in the face of a financial shock. Dranove et al. (2017) and Dranove (1988) posited that such responses to negative shocks may include reducing quality, decreasing service provision, raising prices (cost-shifting), or decreasing charity care offerings. Dranove (1988) developed a model for NFP hospitals in which NFP hospitals optimize both output and profits, demonstrating a "share the gain, share the pain" mechanism in which hospitals may increase prices to privately insured patients to offset reimbursement/payment cuts from other patients under other insurers (e.g., Medicare). Dranove (1988) found evidence of this in Illinois in the 1980s and further notes this mechanism's dependence on hospital market power. More recently, Dranove et al. (2017) found limited evidence of large NFP hospitals leveraging their size and reputation after the 2008 financial crisis to negotiate prices with insurers, while other NFP hospitals reduced services available. In a review of the cost-shifting literature, Frakt (2011) similarly notes that, while possibly due to payment policy changes, cost-shifting is not as pervasive as perceived and its potential existence is contaminant with other structural changes and market power balances that hospitals may have with payers.

Horwitz and Nichols (2007) discussed predominant theories of NFP hospital objectives and designed an empirical study aimed at identifying evidence to support one or more of these theories. As such, the authors' work is particularly relevant to my work in Chapter 2 and I expound on their work further here. Horwitz and Nichols (2007) used profitability rankings across medical services such as imaging and outpatient surgery[14] and examined

[14]Ranking profitability was a rather complex process detailed in Horwitz (2005), and was based on interviews and policy reports, among other sources. Horwitz (2005) incorporates into its profitability assessment insurer coverage. For example, the authors considered that medical services with limited (government-only) or no insurance coverage are likely less profitable for medical providers. This profitability assessment is

whether hospitals' service provision varied by hospital ownership and market ownership mix – as measured by FP hospital density in a given market. The authors found that NFP hospital service provision did vary by FP market mix, such that NFP hospitals in markets with high concentrations of FP hospitals are more likely to offer relatively profitable services and less likely to offer unprofitable services, noting the potential for unobserved market heterogeneity may differentially attract FP and NFP hospitals. The authors concluded that their evidence aligned "best" with hospital output maximization theories or theories in which some NFP hospitals are output maximizers. This conclusion stemmed from a rejection of market-output maximization in which hospitals, optimizing across their community needs, would be more likely to offer relatively less-profitable services to "compensate for deficiencies in service provision by neighboring for-profits." Given their estimation strategy of whether a particular service was provided and not the magnitude of such provision, this rationale assumes that responses to such deficiencies require new service provision as opposed to increases in existing service provision.[15] The authors further noted a lack of support for profit-maximization theories despite their findings of increased provision of relatively profitable services in select markets where for-profit penetration was high. The authors arrived at this determination because NFP hospitals exhibited a different service mix than FP hospitals that better aligns with NFP hospital objectives of providing community services, instead of exhibiting a service mix similar to FP hospitals.

In their consideration of the aggregate outpatient market, the authors found evidence

service-based, and, therefore, not necessarily sensitive to *hospital-specific* service profitability that may be influenced by a hospital's specific patient-insurer mix. Horwitz and Nichols (2007) did include proxies for insurance status by employment into some of their models.

[15]Further, as the authors noted, they did not account for legislative requirements behind service provisions (e.g., need assessments of NFP hospitals or CON laws).

that NFP hospitals maximize their own output instead of profit. The authors were unable to determine the profitability of the aggregate outpatient market in particular, and their results indicated a decreased propensity of FP hospitals to provide outpatient services and insignificant findings for NFP hospitals relative to for-profit market saturation.[16] The authors' study did not account for existence or growth of for-profit ASCs in their measure of for-profit market density.

My study in Chapter 2 contributes to both the literatures studying ASCs and NFP hospital behavior by examining markets of increasing importance, outpatient surgical markets, and considering how NFP hospital outpatient surgical provision responds to the entry of superior competitors. First, I expand on previous studies that examine the effect of ASCs on aggregate HOPD volume by examining specific surgical markets. This examination is relevant because ASCs, ASC growth, and insurer reimbursement rates vary by ASC surgical specialization, implying varied competition within a hospital's surgical outpatient offerings. Second, I examine whether these effects differ by FP and NFP ownership status and, in doing so, consider predominant theories of the NFP hospital in the outpatient surgical market.

[16] T-statistics are not provided for the outpatient market NFP estimate; the point estimate is -0.013

Chapter 2: Examination of Specific Surgical Markets Facing Competition by Ownership Status

The advent of medical technology and changing medical practice has transitioned surgical procedures once performed only in full scale inpatient settings to outpatient settings. The efficiency inherent in same-day outpatient surgical procedures that have low complication rates make this a profitable market. Ambulatory Surgical Centers have grown in number nationally and captured large portions of select outpatient markets, making them principal competitors in markets that are critical to hospitals' revenue streams. Indeed, hospitals have claimed the revenue from their outpatient departments and specialty services as offsets for their care of uninsured patients, with anecdotal evidence pointing to strategic pricing increases or changes to output service offerings, including the shuttering of service types, in response to specialty competitors, and other evidence indicating a variety of lobbying and legislative-based responses (Chapter 1). Revenue shares of outpatient and inpatient care point to a continued transition of and reliance on revenue from outpatient markets. MedPAC (2017), for example, notes a continued decrease in hospital revenue share from Medicare inpatient procedures (71 to 60 percent) from 2010 to 2015 and an increase in revenue share in outpatient procedures (21 percent to 28 percent) over the same period.

Understanding how hospitals are impacted by ASCs and respond to the presence of ASCs is particularly relevant in recent years, with payment/reimbursement proposals that aim to reduce payments to hospitals servicing the outpatient market (OIG, 2016; CMS, 2016). I examine in this chapter the relationship between hospital outpatient surgical service provision and hospital ownership in the face of competition from for-profit specialized outpatient service providers, ASCs, that are more efficient in their provision of surgical services and are of lower cost to insurers and patient consumers than hospital providers.

Under normal market conditions, hospital providers would ultimately exit outpatient markets that ASCs enter. Hospitals have, however, remained in outpatient markets and increased their revenue share from outpatient services due in part to market interventions that include higher insurer payments to hospitals (relative to ASCs) for a given surgical service and state-based legislation that restricts ASC entry. As noted in Chapter 1, ASCs may provide multiple specialties but are more likely to specialize in a specific class of outpatient surgeries. Hospitals, conversely, tend to provide a wider breadth of outpatient surgical procedures. Additionally, while hospitals vary in their ownership structure (e.g., for-profit, not-for-profit, or government-owned), ASCs are predominately for-profit entities.

Existing literature studying outpatient surgical procedures has considered these varied surgical procedures as an aggregate market or has focused on a singular outpatient surgical procedure in isolation. Generally, the former vein of literature masks the notable differences in revenue, cost, and specialized inputs across outpatient surgical services, and the latter ignores cross-resource constraints of outpatient services that are provided at the same hospital. Courtemanche and Plotzke (2010) and Bian and Morrisey (2007), for example, found at varying market geographies that neighboring ASC presence was associated with decreases in hospital outpatient market provision. The authors in these studies did not, however, account for ASC specialization in their examination of aggregate HOPD outpatient output, nor did the authors differentiate effects of ASCs by ownership status. Another stream of literature notes that hospital responses to competition may vary by ownership status. While for-profit hospitals are assumed to follow profit-maximizing behavior, not-for-profit hospital objectives may differ, as evidenced by various theories and empirical studies.

My study deviates from existing literature by examining whether changes over time in surgical volume (output) in hospital outpatient market *segments* are associated with the presence of ASC competitors, and how such associations differ by hospital ownership type. I identify meaningful segments in the outpatient surgical market by using an existing surgical classification system that groups similar surgical procedures and focus on the groupings that are the most prevalent in the outpatient market over my study time frame. I further examine whether the hospital-ASC relationship across market segments differs by hospital ownership status. My measures of focus include how hospital outpatient surgery outputs, inputs, and patient mix are associated with presence of ASCs in reduced form models.

There are other facets over which competition between hospitals and ambulatory centers may occur, such as quality and price. Hospital and ASC quality, for example, may impact a consumer's choice of health care facility, particularly for the non-emergency outpatient services I study.[1] Some studies that have considered competition along a quality dimension have approximated quality with volume under hypotheses that link volume to

[1] Competition in the quality dimension does assume at least some visibility of such information to the consumer or, for example, that quality information is relayed through physician recommendation.

quality-increasing experience. Other studies have measured quality as safety or health outcome scores of health care providers or entities. A working paper by Dua and Fournier (2010), for example, examined the growth of ASCs as they relate to hospital quality, as measured by surgical complication rates and safety rates related to nursing activity.[2] While certainly a notable dimension of competition in the health care sector, I examine hospital outpatient volume directly and note that (1) quality among hospitals and ASCs, as measured by factors more relevant to hospital-ASC competition such as patient waiting time and complication rates, have already been studied in recent years and indicate that ASCs provide superior quality (e.g., Munnich and Parente, 2014a; Munnich and Parente, 2014b),[3] and (2) ASC quality measures became publicly available largely after my study period (post-2010).[4]

Prices in the health care sector are largely unobserved by consumers/patients, complicating analysis of competition for consumers among the price dimension. This dimension is further complicated by the fact that insurers set prices that consumers pay, including consumer premiums, deductibles, and copays, while also negotiating with medical and surgical providers for direct payment to providers. Regardless, examining the price dimension would generally be informative about potential hospital competitive strategies. Unfortunately, the data I use for this study do not contain actual prices paid for surgical services that patients receive, preventing my examination of the price dimension. A recent study

[2]The author does not pinpoint the mechanism for this influence; e.g., whether it stemmed from physicians that may have worked both at a hospital and an ASC.

[3]Some studies note that lower complication rates may be a factor of the healthier population that ASCs tend to serve.

[4]Admittedly, even if quality measures that allowed consumers to differentiate between hospitals and ASCs were not publicly available, consumers may still have received such information from their health care providers (e.g., physicians).

does imply the limited value of pricing strategies in hospital-ASC competition due to hospitals' loss of negotiating power among private insurers when ASCs are present in a market (Carey, 2017). This loss of pricing power is likely attributable to ASCs' assumed lower cost, yielding lower prices relative to hospitals (i.e., lower insurer reimbursement (across insurers) and patient copays). This limited value in pricing strategies is furthered by fixed procedure pricing schedules of a large insurer, Medicare, whose reimbursement does not vary by patient health status.[5] I do nevertheless consider two *ordinal* price structures across outpatient surgical market segments and across patient consumers of such services to provide insight into revenue that hospitals may generate from heterogeneous consumers and across outpatient procedure classes. Specifically, I rank patient revenue by insurance type, using the following order $Private > Government \geq Other > Uninsured$,[6] given the generally higher reimbursement rate of private/commercial insurers relative to government-provided insurance (e.g., AHIP, 2016; Carey, 2015). Other literature motivates this ranking implicitly as a ranking of profitability within findings of asymmetric patient-insurer composition between ASCs and hospitals, with ASCs servicing a larger portion of privately insured and healthier patients relative to hospitals. There is also evidence of revenue differentials among outpatient surgical procedures and classes of procedures. Munnich and Parente (2014b), for example, details Medicare facility payments over a portion of my 2000 - 2009 study period, 2007 - 2009, for the five highest volume ASC procedures among Medicare patients.[7] Four of these five ASC procedures are also included in the top 5 procedures

[5]Medicare updates its reimbursement rates for outpatient surgery yearly, as with other hospital services. Private insurer updates, made through hospital-insurer negotiations, however, may result in longer multi-year contracts, as evidenced by industry recommendations to hospitals (Review, 2011).

[6]The "Other" insurance category includes reimbursement from Workers' Compensation or Indian Health Service, for example. The "Uninsured" category also includes charity care from hospital providers.

[7]Note that only Medicare facility payments to ASCs were frozen from 2003 through 2007; thus, this

among patients from all insurers among both HOPDs and ASCs in my data (see Section 2.2.2), which account for over half of all specialty procedures among HOPDs in my study (Table 2.4).[8] Munnich and Parente (2014b) note that the ASC-to-HOPD payment ratios are highest for minor musculoskeletal procedures, second highest for gastroenterology procedures, and third highest for opthalmologic procedures – which coincide with the outpatient surgical market segments that I study in this chapter. While this revenue ranking does not necessarily carry over to profitability, the lower costs that ASCs have relative to hospitals are not in dispute.[9]

In addition to hospital volume in the aggregate and within outpatient market segments, I also study patient health status, as measured by a comorbidity index, and inputs to outpatient surgical provision, as measured by the density of physicians serving a given market. Even if reimbursement does not vary by patient health status, as with Medicare reimbursement for outpatient surgeries, patient health status may be indicative of a potentially more costly effort for patients of poorer health, as such patients may have a greater propensity for post-surgical complications, yielding potential incentives for hospital selection of healthier patients. My examination of physician inputs is meant to identify any changes that might

3-year period covers the majority of my study period.

[8]Plotzke and Courtemanche (2011) also estimated profitability rates of popular ASC procedures, including key procedures covered in similar markets. The authors' measures similarly used Medicare facility fee reimbursement rates. However, the authors' assumed the median HOPD cost for a given procedure would determine one ASC profitability measure, following an estimation suggestion from MedPAC 2014 in their continual attempts to estimate unknown ASCs costs. As noted in MedPAC (2017), CMS does not collect ASC cost data due to industry push back. The authors do construct a different ASC profitability measure that is based on an unsuccessful payment classification system that CMS attempted to implement in the 1990s.

[9]In the absence of actual costs data, the relative difference in costs between ASCs and hospitals can at best be imperfectly approximated (MedPAC, 2017). There is, however, other evidence that ASCs have a lower cost structure than HOPDs. As Pallardy (2015) notes, approximately 30 percent of ASC patients have Medicare/Medicaid as their insurer. Further, Medicare reimbursement to ASCs has experienced a steady decline since 2003 from 87 percent of HOPD reimbursement to 58 percent in 2010. However, as indicated in Chapter 1, the approximate increase in ASC facilities over this time period increased by over 60 percent.

speak to findings on hospital surgical volume from my models and would otherwise be directly included in a structural approach.

Theoretical literature cited in Chapter 1 is consistent on the profit-seeking motives of FP hospitals and mixed in defining NFP maximization objectives. Further, NFP theories are principally based on hospital-to-hospital competition or non-competition (financial/legislative) shocks. Generally, the theoretical literature on NFP hospitals indicates that these hospitals may seek to maximize some combination of reputation/quality and output, revenue, and/or profits, with the latter objective liking NFP hospitals to their FP counterparts. More specifically, different veins of literature can be classified as NFP hospitals maximizing (1) profit as for-profit hospitals do, (2) their own output subject to a zero-profit constraint, (3) output subject to the needs of the community they serve, or (4) revenue subject to some other requirements, such as accreditation. Additionally, some literature suggests hybrid NFP hospital objectives. For example, Dranove et al. (2017) found mixed evidence of pricing behavior heterogeneity among NFP hospitals, in that select hospitals, those with name brand recognition, for example, may switch from quality/quantity maximization to profit maximization in the face of financial shocks. In examining select dimensions of competition across output market segments, I test competing theories and use empirical tools developed by existing work studying not-for-profit (NFP) hospitals. The first three of these classifications I expound on in describing my conceptual framework, leveraging Horwitz and Nichols (2007)'s work, and I motivate the fourth classification as a modification on Finkler (1983)'s model of hospitals as revenue maximizers.

My study explores hospital-driven responses and indicates that hospitals may respond to ASC presence in ways that are (1) market-specific and (2) vary by ownership type. Market-specific effects are not unexpected but have not been fully studied for outpatient markets. My results do not show statistically robust differential associations across HOPD specialty markets in competition with ASCs. However, further examination of state-level data from Florida, which holds a near-even mix of hospitals with for-profit and not-for-profit status, does indicate differential associations between for-profit and not-for-profit hospitals and ASC presence across surgical markets that may be relevant to understanding how hospitals will react to the changing legislative landscape that defines their competition with ASCs. Theoretical and empirical literature are consistent on FP hospital profit-maximizing objectives and mixed on NFP hospital objectives. Though not causal, my results are consistent with the negative relationship between FP hospital output and ASC presence. My results also identify differential responses between FP and NFP hospitals to ASC presence, suggesting that NFP hospitals are able to retain their market share more often than not despite ASC presence, and actually increase patient volume in non-specialty markets, where hospitals appear to face less ASC competition. These findings speak to NFP hospitals as (1) potential revenue maximizers or (2) as entities who service patients that are not sought after by ASCs. The latter finding is suggested by the fact that FP hospitals lose significant private and government- insured patient volume in the presence of ASCs while not-for-profits demonstrate an ability to hold the status quo of their patient population in surgical markets facing ASC competition. This finding aligns with previous studies that find that not-for-profit medical providers tend to serve a different mix of patients than for-profit providers. This result, however, may not hold in other states, where the ratio of not-for-profit hospitals to for-profit hospitals is more akin to the national ratio, in which not-for-profit hospitals dominate. This latter finding is apparent among hospital outpatient market segments that are in clear competition with ASCs. My examination of a market segment with potentially limited competition from ASCs is suggestive of revenue-maximizing behavior among NFP hospitals. Changes in this ”other” market are indicative of continued surgical market trends that are selectively adopted by NFP hospitals; namely, continual shifts of procedures from inpatient care to outpatient settings. Determining whether such expansion from technological adaption is the cause for increases seen in this other market among not-for-profit hospitals, however, requires further research.

Next, I motivate the conceptual framework for my empirical analyses.

2.1 Conceptual Framework

My motivation for segmenting the outpatient surgical market is straightforward. There exist classes of outpatient surgical services that vary by profitability, revenue, cost, and specialized inputs. As noted earlier in this chapter, for example, hospital and ASC providers receive different reimbursement rates for opthalmologic procedures and neuromuscular procedures. Further, these procedure classes require different specialization of inputs - specifically, the specialization of physicians that provide such services and technological equipment/capital required. Another important aspect of my analysis concerns how hospitals optimize these inputs and outputs.

As with most research on NFP hospitals, Horwitz and Nichols (2007) maintained in their study the popular assumption that hospitals, or rather hospital administrators, are the driving force behind service provision.[10] While administrators may indeed provide ap-

[10] Pauly and Redisch (1973)’s theory of NPFs’ as profit-maximizers is a notable deviation from this popular assumption in which physicians capture NFP rents.

proval for service provision, physicians and other medical providers drive the actual health care provision/output as inputs. This consideration is particularly relevant in a competitive environment in which production inputs, namely the physicians, may have competing incentives that direct where they supply their services such as multiple facility affiliations or profit-sharing stakes in other facilities such as specialty hospitals or ASCs. Indeed, the consideration of physicians as a driving force for service provision is particularly relevant in today's health care markets given physician ownership of ASCs and hospitals' and insurers' perennial attempts to align physician interests with their own.[11] I modify the assumptions in Finkler (1983)'s model of NFP hospitals as a revenue maximizer to account for such considerations while also allowing me to consider revenue maximization with community service provision constraints in a health care market where cost and profitability are generally obscured. Finkler (1983) modeled hospital demand as a function of price, p, and the number of physicians affiliated with a hospital, M, as $q = q(p, M)$ and the hospital as a revenue maximizer in a single product market, maximizing

$$\max_{q} p(q)q \tag{2.1}$$

$$s.t \qquad p(q)q - C(q) = 0 \tag{2.2}$$

Finkler (1983) assumes that increases in the number of physicians increases the number of services ($\frac{\delta q}{\delta M} > 0$) for finite patient demand ($q(0, M) < \infty$), which in turn increases patient demand *across* services, hospital-wide. Further, to accommodate the potential for NFP

[11] Examples include current bundled payment models and preceding physician collaborative models that Medicare and private insurers have tested.

hospitals to provide unprofitable services, he notes a required minimum volume threshold J_i for service i that facilitates hospitals' accreditation in service i, which may not be binding.[12] Finkler (1983) also assumes that the percentage of patients referred to hospitals unaffiliated with the physician (R) and the scope (S) of services offered at affiliated hospitals are negatively related, $\frac{\delta R}{\delta S} < 0$. Another key assumption is that the number of physicians increases when scope increases, $\frac{\delta M}{\delta S} > 0$. Finkler (1983) motivates these assumptions for a hospital setting and in hospital competition with other hospitals.

These assumptions, however, might not hold in today's provider market, which is one of increasing physician provider specialization (Barbey et al., 2017) and competition from specialty facility providers like ASCs and specialty hospitals. To account for these modern considerations, I consider a simple modification to the definition of Finkler (1983)'s S, the scope of services at a hospital, such that S is instead qualified as the scope of services provided at a hospital within a given physician's specialization. This qualification retains the plausibility of $\frac{\delta R}{\delta S} < 0$ and $\frac{\delta M}{\delta S} > 0$, particularly in the outpatient markets I study. In my qualification of S, $\frac{\delta R}{\delta S} < 0$ is still a plausible assumption as physicians would be more likely to refer patients to hospitals (or ASCs) that they are affiliated with if the facility in question has a greater scope of specialty services, which implies a greater capacity to treat a wider variety of patients and patient needs. Increases in S could include adoption of new technology and/or innovative medical practices that support service scope expansion, either of which would speak to a physicians' profit- or prestige-maximizing motives captured by Finkler (1983)'s $\frac{\delta M}{\delta S} > 0$ assumption (and indeed, in line with the original rationale for this

[12] Finkler (1983)'s rationale for this constraint not being binding (in practice) is based on findings from Finkler (1979)'s study for a particular inpatient surgery, heart surgery.

assumption).[13]

I further re-parameterize Finkler (1983)'s price, p as a vector $\vec{p}$ that accounts for reimbursements that differ by insurers and across outpatient surgical market types. Medicare reimbursement rates for procedures, for example, are set yearly (CMS, 2017) and are distinct from hospital reimbursement negotiations of multi-year contracts with private/commercial insurers (Review, 2011). Given such price setting, a single-insurer, single-product version of this model effectively reduces NFP hospitals to output maximizers[14] subject to threshold minimums (J) and a zero-profit budget constraint, with threshold minimums corresponding to NFP hospital community requirements (e.g., level of charity care or service provision). This consideration of J as a community-based minimum for select NFP hospital services is a deviation from Finkler (1983)'s context of accreditation minimums, but serves the same purpose as a firm's minimum sales constraint.

Given this re-parameterization of Finkler (1983)'s model, I am able to make predictions on hospital output and other factors I consider in my study. First, however, I consider alternative NFP hospital theories. As **profit-maximizers**, when faced with a more efficient FP competitor in a given market, FP hospitals will lose patients to that competitor. Specifi-

[13]In my conceptual model variant, physicians still drive production. As ASC owners, physicians will have additional incentive not considered in Finkler (1983)'s original model in which NFP hospitals compete against other hospitals. This additional incentive comes from the ability of ASC physician owners to extract rents from the ASC facility fees (one part of insurer reimbursements) in addition to their individual fee. How does such reimbursement contend with the profit-seeking motives of physicians under this model? First, it should be noted that not all physicians would be associated with or have ownership of a neighboring ASC, particularly with the growth of direct employment of physicians by hospitals over the past decade (current rates at around 33 percent of physicians; Kane (2017)). Second, previous research has shown that even physicians with ASC affiliation may still service patients at hospitals. Such physicians, typically referred to as splitters, are, however, more likely to treat more complex cases at hospitals (David and Neuman, 2011). This preference coincides with physicians having preference for a greater scope, S, of services, as for more complex patients, some services isolated to hospitals (e.g., emergency department services) might better serve more complex patients.

[14]Or, as revenue maximizers if output is normalized in terms of dollars.

cally, they will lose their most profitable patients in the market segment in which hospitals face competition and most likely face such competition in the most profitable markets. This assertion holds in the case where demand for services within the market in question is already met by a FP hospital. If, however, demand for services in that market is in excess of supply, the new competitor may extract patients from this excess to the point where the marginal patient profitability meets that of patients the FP hospital currently serves. The competitor may then co-opt the most profitable patients that the FP hospital services if its capacity allows. In my study, one mechanism in which ASCs could extract patients would be through physicians that hold positions in both ASCs and hospitals. The incentive for physicians may come from ASCs having a greater, relevant scope of services (S) or, for physicians with ASC ownership, the added financial incentive from the facility fee they would get in addition to their facility-agnostic payments. Indeed, literature cited in Chapter 1 notes this choice among physicians and further notes that among physicians that provide services at both ASCs and hospitals ("splitters"), patient/service volume at hospitals tends to decrease, with such changes considered expected due to the added (financial) value for physicians to provide services at ASCs.[15] Other mechanisms for ASC patient capture would include those used in hospital-to-hospital competition, such as advertising, as discussed in Chapter 1. Ultimately, with profit-maximizing objectives, NFP hospitals would exhibit a similar outpatient market service provision and insurer patient mix, or even patient mix on other factors like health, to FP hospitals. Given these similarities, NFP hospitals would evidence a relationship akin to that between ASCs and FP hospitals. If,

[15]This added value may come from time saved due to more efficient processing of patients (e.g., shorter wait times) and additional revenue to physicians that have ownership stakes in ASCs.

however, NFP hospitals were only sometimes profit-maximizers, when faced with shocks, then I would expect to see a tendency towards FP hospital service or patient mixes. Dranove et al. (2017) and Duggan (2002), for example, found (limited) evidence for NFP hospital responsiveness to financial shocks and FP hospital density. Under **output maximization** theories such as Newhouse (1970), an NFP hospital would have maximized output to the point of zero profit. As noted in Horwitz and Nichols (2007), Finkler (1983), and other works, neighboring for-profit entities will distort the NFP hospital's pool of patients by co-opting the most profitable patients. This scenario extends to the for-profit ASCs potentially capturing the most profitable patients from NFP (and FP) hospitals. As a result of such capture, the NFP output maximization theories predict that the NFP hospital may aim to increase its provision of profitable services or decrease its provision of less profitable services to maintain its zero-profit constraint.[16] In a stark example, if a neighboring ASC captured the entirety of an NFP hospital's most profitable outpatient market segment, then the NFP might minimize its provision of its least profitable outpatient market segment.[17] Under **market output maximization**, an NFP hospital would service more unprofitable patients to better capture the pool of patients not served by for-profit ASCs. This particular type of scenario would occur if it is evident that incoming ASCs are filling unmet demand but limiting such provision to only profitable patients, and is a financially feasible option for the NFP hospital. Otherwise, even the market output maximizing NFP hospital would default to the outpatient maximizing objective to the extent community constraints allow.

[16] Indeed, this may be seen as a localized profit-maximization within the space that gets the NFP hospital back to the zero-profit constraint, having lost some of its profitable patients.

[17] In practice, a hospital may instead reduce other segments of its services like those in its inpatient setting. I limit this example of counterbalancing to the outpatient market given the likely smaller divestment of an outpatient market segment that consist of non-emergent services versus an inpatient segment like cardiac services that may have larger ramifications to the hospital (e.g., reputation or accreditation loss).

Under Finkler, a **revenue-maximizing** NFP hospital will optimally select the highest revenue patients among the markets it services, prioritizing higher revenue markets. In a market where the NFP hospital loses patients to a for-profit ASC, the NFP hospital will continue to provide services to that market so long as average revenue equals average cost. Unlike other models, like those of output maximization, this physician-driven model allows the hospital to pursue new markets/services, even up to a certain threshold for loss, as such a pursuit would expand the scope of services the NFP hospital provides and consequently increase the number of affiliated physicians and demand for all hospital services ($\frac{\delta M}{\delta S} > 0 \Rightarrow \frac{\delta q}{\delta M} > 0$), ultimately increasing hospital revenue. This mechanism also allows for new market entry that comes about due to technological advancements, in which service provision may initially be provided by the NFP hospital as a loss, to a hospital's break even point. The outpatient surgical market is prime for such adoption given the continual transition of procedures from inpatient to outpatient settings due to advances in surgical and care technologies. Indeed, Medicare led by example in the trend of shifting from inpatient to outpatient, covering procedures first in hospital outpatient departments and then ASCs.[18] Private insurers follow. Given the lower reimbursement rates of Medicare relative to private insurers, this implies that new markets opening due to new technological advances may not yield high revenue or profitability initially. NFP hospitals are more likely to be teaching hospitals, invest tax deferred dollars, and are required to meet potentially diverse community needs, all of which are characteristics that bolster the need for adopting technological advancements. Parente and Van Horn (2006) found that the reasons for use of technology

[18] An example of this can be seen in the "New Technology Add-on" payments that Medicare provides for leveraging new technologies in practice, and in recent, 2017, legislation for total knee replacements – the topic of my third chapter in this dissertation.)

differed by hospital ownership status, providing evidence for this narrative. Specifically, in a nationwide sample of U.S. hospitals in the 1990s, Parente and Van Horn (2006) found that FP hospitals used information technology systems to boost hospital productivity in ways that decreased cost (e.g., increasing patient turnover[19]), while NFP hospitals used such technology to increase the quantity of their services.[20] Further bolstering this narrative is a survey of NFP hospital executives that notes expansion of outpatient capacity as a top investment priority (Ratings, 2015).

Given physician-driven output of ASCs and hospital volume and their relevance in Finkler (1983)'s model, it is worth discussing potential profit-maximizing motives of physicians. Unless otherwise constrained, profit-maximizing physicians would opt to extract rents of privately insured patients first (and potentially only). Corner solutions where physicians only service such patients, however, are unlikely given (1) the service provision minimum requirement threshold, J, that allows for potentially non-profitable, community-needed services, (2) the mix of patient insurers available in the community to which a hospital provides services, and (3) the increasing existence of hospital-physician employment contracts noted earlier that align physician incentives more closely with hospital incentives.

2.2 Data

I used 100 percent of the outpatient claims data from Florida's Agency for Health Care Administration (AHCA) from 2000 through 2009 to obtain information on surgical services provided, their dates (calendar quarter),[21] the type and number of services provided for

[19]The cost component in this example would come from reducing a patient's length of stay.

[20]Note that such use of technology and higher insurer reimbursements relative to ASCs may explain, at least in part, how for-profits continue to survive in the outpatient market.

[21]The exact date of service is not provided due to privacy concerns.

patient visits, patient insurer or lack thereof, and accompanying patient diagnoses.

These data have several favorable attributes. First, hospital outpatient departments (HOPDs)[22] and ASCs in Florida are not impacted by Certificate of Need (CON) Laws that otherwise impact hospital service provision in Florida. Second, unlike nationwide statistics where the overwhelming majority of hospitals are NFPs, Florida has an almost even mix of private NFP and FP hospitals.[23] Third, Florida is second only to California in terms of ASC growth and number[24] over the time period of my study, 2000 through 2009. I note also that the non-emergency nature of surgical outpatient markets allows me to observe hospital output in markets that are not mired in legal requirements such as the 1985 Emergency Medical Treatment and Active Labor Act, which requires hospitals to provide emergency care to patients, regardless of ability to pay.

I linked these AHCA data to the American Hospital Association Annual Survey (AHA) via hospital provider identification codes for years 2000 to 2009 to obtain hospital characteristics such as size (in terms of bed count), number of physicians, and ownership characteristics. I then used ZIP Codes and county identifiers to link AHA and AHCA data with the county-level population data discussed next.

I obtained county-level total and age-stratified population numbers (in 100,000) for relevant study years from the U.S. Census Bureau. Data on the percentage of individuals living under the poverty level and estimated median household income come from the U.S. Census Small Area Income and Poverty Estimates. Finally, county-level estimates of

[22]Hospital outpatient surgical categories that face direct competition from ASCs are not currently restricted by CON laws in Florida; other hospital services like rehabilitation, and psychiatric services are impacted by Florida CON law in 2010.

[23]Local and government hospitals, which I do not study, comprise less than 10 percent of the hospital population in the state.

[24]http://www.ascassociation.org/advancingsurgicalcare/whatisanasc/numberofascsperstate

individuals without health insurance are also obtained from the U.S. Census' Small Area Health Insurance Estimates (SAHIE). The SAHIE are only provided for the years 2007, 2006, 2005, and 2000. I populate years 2001 to 2004 with year 2000 data and years 2008 and 2009 with year 2007 data. I used data from the U.S. Department of Agriculture's Economic Research Service to classify hospitals as urban or rural. I classify a hospital as urban if its Rural-Urban Continuum Code signifies that the metropolitan area has a population of at least 250,000.

2.2.1 Geographic Boundaries

Previous literature on hospital-hospital and ASC-hospital competition focuses on pre-defined geographic regions. Examples of such geographies include population- or legal-based geographies such as metropolitan statistical areas (MSA) or counties, medical service provision-based geographies such as hospital referral regions (HRRs), or hospital service areas (HSAs). HRRs are defined to capture inpatient hospital referral regions of patients for specific procedures (e.g., cardiovascular surgical procedures), while HSAs are a collection of ZIP Codes whose residents receive most of their hospitalization from the hospital facilities in that area. HSA markets are smaller than MSAs and allow for contiguous patient density spaces relative to county lines. Further, unlike HRRs, which also rely on patient densities for select procedures, HSAs provide geographical boundaries that include areas where patients received primary health care, including outpatient surgical procedures considered low-risk and potentially discretionary (relative to inpatient procedures). Given my focus on outpatient surgical procedures that are non-emergency, I also use HSA boundaries to define HOPD and ASC markets in this study. As HOPDs and ASCs may span multiple counties, I create HSA-level characteristics by averaging characteristics of patient populations for HOPDs and ASCs and compute the Herfindahl-Hirschman Index (HHI) as the sum of the squared market share of HOPDs and ASCs in a given year, for each HSA and outpatient surgical market classification (discussed in Section 2.2.2). The HSA geographical boundaries do differ from those used in studies examining the relationship between HOPDs and ASCs from state-level markets (Koenig and Gu, 2013), to MSAs (Bian and Morrisey, 2007), to localized radii (e.g., 15 miles or variable radii; Courtemanche and Plotzke, 2010), with only the first separating out key surgical procedures that ASCs pursue.[25] Other literature, however, validates my use of HSA geographies. Specifically, Al-Amin and Housman (2012) and Suskind et al. (2015) examined the survival rates of HOPDs due to ASC presence and diffusion of ASCs based on HSA market conditions, selecting HSAs for reasons I put forth above.

2.2.2 Surgical Markets

The Ambulatory Surgical Center Association (ASCA, 2016) notes that ASCs tend to specialize in pain management, urology, orthopedic (MSK), gastrointestinal (GS), opthalmologic (EYE), and other specialties; with GS, EYE, and orthopedic/neurological surgeries being among the most prevalent (MedPAC, 2013). To separate the outpatient market into segments that account for predominant ASC specialties, I rely on established clinical and surgical classification systems. The Agency for Healthcare Research and Quality (AHRQ) developed Clinical Condition Service categories (CCS) that categorize surgical and diagnostic procedures into clinically meaningful groups (AHRQ, 2016). AHRQ has

[25] These singular procedures include cataract surgery, gastrointestinal procedures, and arthroscopic (orthopedic) procedures.

established two levels of CCS categorizations. Level 1 CCS categories identify specific (surgical) procedures, while Level 2 CCS categories group surgical operations by body system. Table 2.1, for example, shows Level 1 condition category procedures for the Level 2 CCS body system – opthalmologic (EYE) procedures. I apply CCS to the principal procedure code on a service claim.

Table 2.1
Condition Classification System - EYE

Classification Number	Classification Description
13	Corneal transplant
14	Glaucoma procedures
15	Lens and cataract procedures
16	Repair of retinal tear; detachment
17	Destruction of lesion of retina and choroid
18	Diagnostic procedures on eye
19	Other therapeutic procedures on eyelids; conjunctiva; cornea
20	Other intra ocular therapeutic procedures
21	Other extra-ocular muscle and orbit therapeutic procedures

Notes: This category extract is taken from the Agency for Healthcare Research and Quality's Clinical Classifications Software, available at https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp.

I use both levels of CCS categories to identify and examine the most common ASC outpatient markets. This translates to an examination of the nervous system (CCS Level 2 #1), neuron-musculoskeletal system (CCS Level 2 #14; NMK), ocular system (CCS Level 2 #3; EYE), and digestive system (CCS Level 2 #9; GS) outpatient surgical market segments. I further consider a catch-all category of all other procedures (”OTHER”).[26] Table 2.2 shows the number of patient visits where the principal procedure is categorized into one of the three specialty market segments or the catch-all[27] over my study period. Among all

[26]Examples of procedures in this category include debridement of wounds and tonsillectomies.

[27]An examination of secondary procedures shows procedures that are within the same CCS category and of related surgical or imaging/diagnostic procedures. Moreover, the overwhelming majority of claims in the

HOPDs, EYE, GS, and NMK procedures exhibited relatively monotonic decreases over the 10-year period ranging from a 34 (EYE) to 10 (GS) percent change. The trend for the catch-all market OTHER, however, exhibited a 12 percent increase, contributing heavily to an overall stable trend in total surgical volume (+1 percent change). The trends for FP HOPDs across specialty market segments that face competition are more dramatic than those for NFP HOPDs, with FP HOPDs facing percent changes from -56 (EYE) to -23 (NMK). NFP HOPDs exhibited decreases to a lesser extent over time ranging from -19 (EYE) to -1 (GS) percent, with GS and NMK volume exhibiting declines followed by recoveries for NFP hospitals. The OTHER market also exhibited differential growth between FP and NFP hospitals, with these types of hospitals exhibiting percent changes of +3 and +12, respectively.

The differences between FP and NFP hospitals across the three specialty market segments and the OTHER segment may stem from a variety of factors. Such factors may include differential changes in market population composition; differential hospital characteristics; differences in the density and capacity of ASCs; or differential propitious patient selection of ASCs. As profit-maximizers, FP HOPDs would have already selected the most profitable patients, selected the most profitable procedures, and negotiated the most profitable pricing with insurers prior to ASC entry. Thus, if NFP hospital objectives did require them to service their communities to some extent (as opposed to focusing on their bottom line), it follows that ASCs would seek to capture patients from FP hospitals

AHCA data listed only a single procedure code, the principal procedure code, with a small percentage of claims listing more than one procedure. The number of procedures in the 90th percentile, for example, was 2. National statistics corroborate this with approximately 60 percent of visits having only 1 procedure (Cullen et al., 2009a) and secondary procedures aligning with diagnostics likely used for the principal (surgical) procedure.

more so than from NFP hospitals. Given the profit-maximizing nature of FP hospitals and ASCs and the greater growth of single-specialty ASCs relative to multi-service ASCs,[28] this difference may imply that ASCs prioritized capture of FP hospital patients and that NFP hospitals have a less profitable patient mix to begin with, giving NFP hospitals more ability to retain their volume. Figures 2.1, 2.2, and 2.3 depict quarterly volume (logged) of all procedures from private, government, and uninsured patients, and indicate that FP hospitals experienced a larger decrease in privately-insured patients than NFP hospitals over the study period, while NFP hospitals exhibited increases in surgical volume from government-insured patients, and stable volume of uninsured patients.

Additionally, the differential expansion of the volume of OTHER procedures among NFP hospitals relative to FP hospitals over this time period may be indicative of the adoption of new outpatient procedures, as motivated in my conceptual model. Figure 2.4, depicting logged volume of the OTHER market of Table 2.2, shows stable average volume among FP hospitals and decline then growth among NFP hospitals. The descriptives for NFP hospitals do seem to corroborate an ability of NFPs to lose less, maintain, or even surpass 2000 volume levels. Indeed, total patient volume across outpatient surgical markets demonstrated an 11 percent decrease for FP hospitals over the study period and an 8 percent increase for NFP hospitals.

Among ASCs, the number of visits across specialties increased by at least 41 percent (EYE), while OTHER procedures increased by 31 percent from 2000 through 2009 (Table 2.3). These increases in outpatient surgical volume imply that some of the patients that ASCs captured may have come from either unmet or induced demand in market segments,

[28] Over my study period, see Table 2.7.

such that increases in ASC volume need not correspond to decreases in hospital volume.

Among markets known to be in competition (EYE, GS, NMK), the top 5 procedures in surgical volume among HOPDs and ASCs were similar and captured 60 and 70 percent of volume for HOPDs and ASCs, respectively (Table 2.4). As expected, NFP hospitals[29] held a larger share of the top 5 procedures.[30] Table 2.5 shows the top 5 procedures in patient volume in the OTHER category for FP and NFP hospitals and ASCs. Level 2 classifications were similar between NFP and FP hospitals, though different in volume rank. The top 5 OTHER procedures (Level 1) differed between FP/NFP hospitals and ASCs, with the exception of the integumentary (INTEG) CCS, for which Level 1 procedures were ranked fifth among NFP hospitals, first among FP hospitals, and as three of the top 5 CCSs among ASCs.

Table 2.2
Number of Surgical Operations In EYE, GS, NMK, and OTHER Markets in Florida HOPDs (2000-2009; in 1,000s)

	FP HOPDs					NFP HOPDs					All HOPDs				
Year	EYE	GS	NMK	OTHER	Total	EYE	GS	NMK	OTHER	Total	EYE	GS	NMK	OTHER	Total
2000	20	131	60	238	449	29	213	115	393	750	49	343	175	631	1199
2001	19	142	62	244	468	28	224	119	417	789	46	367	181	662	1256
2002	16	146	65	270	498	30	241	120	459	850	46	388	185	729	1348
2003	13	138	57	249	457	26	219	110	375	730	39	356	168	624	1187
2004	12	130	56	251	449	26	210	116	381	732	37	340	172	632	1181
2005	11	124	53	255	442	27	194	98	388	706	37	317	151	642	1148
2006	11	118	51	257	436	26	197	97	431	752	37	315	148	688	1188
2007	11	111	47	260	428	25	210	100	510	845	35	322	147	770	1273
2008	9	104	46	245	403	24	214	104	507	849	32	318	150	752	1252
2009	9	99	46	244	398	24	211	110	465	809	32	310	156	709	1208
10yr %chg	-56%	-24%	-23%	3%	-11%	-19%	-1%	-5%	18%	8%	-34%	-10%	-11%	12%	1%

Source: Florida state data, years 2000 - 2009.
Notes: Totals are the sums of EYE GS, NMK, and OTHER market segments for FP, NFP, and all NFP and FP hospitals combined. The 10 year percentage change is calculated as the percent difference between year 2009 and 2000.

[29] NFP hospitals tend to be larger in their potential patient capacity; e.g., more beds, surgical operating rooms.

[30] Examples: Level 1 Procedure 76 was 17.5 (NFP) of 27.7 (All HOPDs) percent; Level 1 Procedure 5 was 5.1 (NFP) of 7.9 (All HOPDs) percent.

Table 2.3
Number of Surgical Operations In EYE, GS, NMK, and OTHER Markets in Florida ASCs (2000-2009; in 1,000s)

Year	EYE	GS	NMK	OTHER
2000	250	261	171	157
2001	260	304	209	146
2002	277	361	229	154
2003	280	418	242	161
2004	293	465	267	170
2005	304	515	284	186
2006	309	577	310	196
2007	324	615	329	200
2008	336	641	330	201
2009	353	646	332	206
10yr %chg	41%	147%	94%	31%

Source: Florida state data, years 2000 - 2009.
Notes: Totals are the sums of EYE GS, NMK, and OTHER market segments for all ASCs combined. The 10-year percentage change is calculated as the percent difference between year 2009 and 2000.

Table 2.4
Top 5 Level 1 CCS Surgical Procedures Among EYE, GS, NMK Specialty Markets in Florida (2000-2009)

HOPDs			ASCs		
Level 2 (Market)	Level 1	% of Specialty Markets	Level 2 Market)	Level 1	% of Specialty Markets
GS	76	27.7%	GS	76	26.5%
GS	70	15.5%	EYE	15	20.6%
NMK	5	7.9%	NMK	5	10.4%
EYE	15	4.4%	GS	70	10.0%
GS	85	3.7%	NMK	151	2.1%

Source: Florida state data, years 2000 - 2009.
Notes: Categories taken from the AHRQ's CCS, procedure name cross-walk available at https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp.

Table 2.5
Top 5 Level 1 CCS Surgical Procedures in OTHER Market in Florida (2000-2009)

NFP HOPDs			FP HOPDs			ASCs		
Level 2	Level 1	% of OTHER Market	Level 2	Level 1	% of OTHER Market	Level 2	Level 1	% of OTHER Market
Misc	231	8.97%	INTEG	169	15.73%	Urinary	100	9.26%
OBS	139	6.18%	OBS	139	6.95%	INTEG	175	8.17%
CVD	47	5.64%	CVD	47	6.36%	ETN	30	7.37%
CVD	54	5.49%	CVD	54	5.61%	INTEG	172	6.24%
INTEG	169	4.16%	Misc	222	4.53%	INTEG	170	5.83%

Source: Florida state data, years 2000 - 2009.
Notes CVD- cardiovascular system, OBS- obstetrics, INTEG - Integumentary system
(e.g., skin debridement), Misc - miscellaneous diagnostic and therapeutic procedures. Categories taken from the AHRQ's CCS, procedure name cross-walk available at https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp.

2.2.3 Firm Description and Market Variation

There were 188 FP and NFP HOPDs in my sample period, 57 percent of which were NFP hospitals, across 103 Florida HSAs. HOPDs were predominately hospital monopolists[31] in 70 of the 103 HSAs (68 percent) in my study. The split between NFP and FP hospitals in these 70 HSAs with a singular hospital entity was virtually even, at 36 NFP and 34 FP hospitals. The number of HOPDs in HSAs ranged from 1 to 13, with the average number of HOPDs at 1.83, the median at 1, the 75th percentile at 2, and the 99th percentile at 9 HOPDs. Over 90 percent of the 103 HOPDs had fewer than 3 hospitals. My primary data set excludes hospitals that did not have complete data over the 10-year study period.[32]

ASCs were present in 79 percent of the 103 HSAs over the 10-year study period, including ASCs present at the start of my study period (n=220 present at start of sample). Eighty-six percent of HSAs with any ASC presence exhibited ASC entry during the study period, indicating ASC entry in 68 percent of the 103 HSAs, or 211 ASC entries across 70

[31] In terms of general acute care hospital presence. This metric does not consider ASCs or hospitals such as long-term care hospitals or rehabilitation hospitals that are not competitors to general acute care hospitals.

[32] Later results include these hospitals in a non-balance panel study with similar findings, indicating a lack or minimal bias from this exclusion. The reason for lack of data on these hospitals is unknown (e.g., hospitals could have dropped from the sample due to merger or closure), as my data do not provide sufficient information to discern exit reasons.

HSAs. Table 2.6 shows the percentage of HSAs with any entry by ASC specialty. EYE ASC entries were the least expansive across HSAs, impacting 36 percent of HSAs with any entry, and GS ASC entries were the most expansive. Though ASCs often specialize in operations for a singular body system, some ASCs may offer two or three specialties or a specialty not included in the GS, NMK, or EYE CCS groupings. To account for multi-specialty/service ASCs that may compete in a given surgical market, I classify ASCs that provide a simple majority of operations in a CCS Level 2 category to be an ASC specializing in that particular CCS Level 2 category. ASCs not meeting the simple majority threshold were classified as multi-specialty/service ASCs (MS).[33] Across geographical markets, GS and NMK ASCs exhibited the most growth, at increases of 108 and 124 percent, with ASC growth across market segments exhibiting an 83 percent increase over the 10-year period in Florida (Table 2.7). Almost 14 percent of ASCs present at any time during my 10-year study period exited the Florida market.

Table 2.6
HSAs With At Least 1 ASC Entry By Specialty (2000-2009, n=70)

Specialty	% of HSAs with at least 1 entry
EYE	35.7%
GS	58.6%
NMK	45.7%
Multi-Specialty	42.9%

Source: Florida state data, years 2000 - 2009, counting ASC entry that occurred after quarter 1 of 2000.
Notes: Categories taken from the AHRQ's CCS, available at https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp.

[33] I also set this threshold to 75 percent with no discernible difference in classification.

Table 2.7
ASCs Growth in Florida (2000-2009)

	Year	EYE	GS	NMK	Multi-Specialty	Total
Initial Level	2000	56	59	38	82	235
New Entrants	2001	3	7	2	6	18
	2002	3	8	6	4	21
	2003	4	12	11	7	34
	2004	4	9	3	8	24
	2005	4	9	5	4	22
	2006	3	6	7	6	22
	2007	7	5	5	3	20
	2008	4	4	6	7	21
	2009	0	4	6	4	14
2009 Level	Total	88	123	89	131	431
	10yr %chg	57%	108%	134%	60%	83%

Source: Florida state data, years 2000 - 2009.

Notes: Categories taken from the AHRQ's CCS, available at https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp. The 10 year percent changed is calculated as the percent difference between year 2009 and 2000.

For the 155 HOPDs that were in the sample through the 10 year period, patient visit volumes in the aggregate outpatient surgical market and across specialty markets were higher for NP hospitals (Table 2.8). On average, markets with NFP hospitals had a slightly greater average number of ASCs (by specialty). The socio-demographic market characteristics of uninsured patient rate, unemployment rate, percentage of people in poverty, log median income, and urban location were similar across markets with NFP and FP hospitals. Population in 100,000s was larger in markets with FP hospitals, and FP hospitals were more likely to be of medium or small size – as determined by a capacity measure of their beds. As expected, and mirroring their larger surgical volume output, NFP hospitals had a larger contingent of (unique) physicians across markets than FP hospitals (Table 2.9). Interestingly, FP hospitals exhibited a slightly lower average proportion of privately insured patients (40 percent) relative to NFP hospitals (47 percent) over the study period.[34]

[34]Trends over the study period (not shown) indicate a 40 percent decrease in privately insured patients across surgical markets from 2000 through 2009 among FP hospitals (with NFP hospitals appearing rather stable).

Table 2.8
Summary Statistics by Profit Status, Mean (SD) Across Study Quarters (2000-2009)

	FP	NFP	Total
Hospital Volume			
All Volume	1426.1	2324.1	1930.2
	(878.5)	(1958.1)	(1639.8)
EYE Volume	37.64	77.06	59.77
	(70.42)	(111.1)	(97.36)
NMK Volume	173.5	322.6	257.2
	(121.5)	(296.7)	(247.7)
GS Volume	395.1	622.8	522.9
	(286.1)	(509.6)	(440.9)
OTHER Volume	819.8	1301.6	1090.2
	(609.4)	(1335.1)	(1104.7)
# of Competing ASCs By Type			
EYE ASC	1.138	1.320	1.240
	(1.741)	(1.475)	(1.600)
NMK ASC	0.978	1.423	1.228
	(1.411)	(1.916)	(1.727)
GS ASC	1.417	1.739	1.597
	(1.685)	(2.011)	(1.882)
MS ASC	1.358	1.745	1.575
	(1.502)	(1.693)	(1.623)
Market and Hospital Characteristics			
Pct. Uninsured	20.21	19.48	19.80
(Market)	(5.785)	(5.583)	(5.684)
Pct. Unemployed	5.341	5.213	5.269
(Market)	(2.156)	(2.109)	(2.130)
Pct. Poverty, All Ages	12.92	12.74	12.82
(Market)	(3.275)	(3.113)	(3.186)
Ln(Median Income)	9.929	9.945	9.938
(Market)	(2.108)	(2.107)	(2.107)
Urban	0.897	0.908	0.903
(Market)	(0.304)	(0.289)	(0.296)
Total Population/100k	8.692	7.882	8.237
(Market)	(8.146)	(6.564)	(7.311)
Total Population/100k-Sq	141.9	105.2	121.3
(Market)	(201.0)	(158.6)	(179.4)
Small	0.274	0.209	0.237
(Hospital)	(0.446)	(0.407)	(0.426)
Medium	0.637	0.430	0.521
(Hospital)	(0.481)	(0.495)	(0.500)
Observations	6200		

Source: Florida state data, years 2000 - 2009. Other data sources include AHA Annual Survey and U.S. Census data.

Table 2.9
Summary Statistics by Profit Status Continued, Mean(SD) Across Study Quarters (2000-2009)

	FP	NFP	Total
Hospital Physician Counts			
# Physicians EYE	2.605	5.288	4.111
	(3.206)	(5.985)	(5.137)
# Physicians NMK	23.10	34.35	29.41
	(12.84)	(24.58)	(21.04)
# Physicians GS	25.40	36.99	31.91
	(13.92)	(26.88)	(22.88)
# Physicians OTHER	82.19	122.5	104.8
	(50.02)	(104.3)	(87.16)
Hospital Patient Volume By Insurance Type			Total
Government	745.3	1021.3	900.2
	(452.6)	(882.8)	(738.9)
Private	575.5	1099.3	869.5
	(440.4)	(1059.7)	(884.8)
Other	72.87	107.1	92.09
	(84.84)	(180.0)	(147.1)
None	32.44	96.46	68.37
	(38.09)	(157.1)	(124.5)
Observations	6200		

Source: Florida state data, years 2000 - 2009.
Notes: Other insurer includes unidentified insurance types, Veterans Affairs, Tricare, and other local/federal government insurers.

2.3 Empirical Strategy

I utilize a mixture of Horwitz and Nichols (2007)'s and Courtemanche and Plotzke (2010)'s empirical strategies to inform my base model, Equation 2.3. My initial models examine all outpatient surgeries combined, as these authors did. Following Bian and Morrisey (2007) and Courtemanche and Plotzke (2010), I use the log of hospital outpatient surgical visits as my dependent variable, to provide a percentage style interpretation. I estimate these models on a panel on private NFP and FP hospitals in Florida HSAs for the duration of the study period.

$$ln(v_{hq}^{all}) = \beta_0 + \beta_1 ASC_{mq}^{any} + \alpha_h + \gamma_q + \epsilon_{hq} \tag{2.3}$$

My dependent variable is the log of outpatient surgeries (v_{hq}^{all}) for hospital h in market m at time q (year-quarter). The independent variable of interest in this model is ASC_{mq}^{any}, which accounts for the number of ASCs present in market m at time q. α_h accounts for hospital fixed effects, and γ_q captures time fixed effects. This model and the models discussed below treat ASC presence as exogenous. ASC market entry may be driven by observed or unobserved factors. In a study of ASC diffusion, for example, Suskind et al. (2015) found that ASC entry is most likely to occur in areas that are urban, have higher per capita income, and have less existing competition for outpatient surgeries, as measured by HHI, while latent need of outpatient surgery was not associated with ASC entry. Models discussed next incorporate controls for these observable characteristics and the end of this section discusses analyses I conduct to account for various threats to identification of this fixed-effects model.

Equation 2.4 adds to Equation 2.3 by incorporating a vector of time-varying hospital characteristics, X_{hq}, and market characteristics, Z_{mq}. I limit hospital characteristics to measures of capacity/size based on bed count, qualifying a hospital as small in a given year if its bed count is at or below the 25th percentile of the distribution of the bed count across all study hospitals, medium if its bed count is in the interquartile range, and large otherwise.[35] I abstain from including other hospital-level identifiers such as patient mix, as I am primarily concerned with the volume rather than the mix of patients treated, and want to avoid confounding patient mix with ASC presence, given that ASCs may propitiously select patients. Other potentially important hospital-level characteristics are time invariant over the study period, such as a hospital's teaching status. I include market characteristics to account for underlying economic indicators and potential shifts in health care demand, including the percentage of people uninsured, the unemployment rate, log of median income, total population in 100,000s, and its squared counterpart. Further, I include specialty-specific measures of market concentration. Specifically, I calculate the HHIs for the NMK, EYE, GS, and OTHER outpatient markets as the sum of squares of each hospital's (and ASCs) share of total patient volume within a specialty in each period and HSA. These HHI measures help account for effects of market concentration, (e.g., from mergers), instead of allowing these potential effects to commingle with those of ownership, and are introduced in model variants as lags at various horizons (e.g., 1 quarter or 1 year). Similar to Horwitz and Nichols (2007),[36] I do not interact HHI measures by NFP status when incorporating NFP status in later models.[37]

$$l(v_{hq}^{all}) = \beta_0 + \beta_1 ASC_{mq}^{any} + \beta_2 X_{hq} + \beta_3 Z_{mq} + \alpha_h + \gamma_q + \epsilon_{hq} \tag{2.4}$$

[35] Most hospitals exhibit minor changes in bed count across study years, with few hospitals crossing percentile boundaries during the study period.

[36] Horwitz and Nichols (2007) cite Gaynor (2003) and Philipson (2006)'s evidence that hospitals show no difference in exploiting market power and that both NFP and FP benefit from exploiting market power.

[37] As noted in Horwitz and Nichols (2007) and other studies, FP and NFP hospitals benefit equally from exploiting market power. Additionally, as noted in later models, my work is principally concerned with ownership status in relation to a particular competitor's presence, ASCs, not market-wide concentration that is stable in my study panel.

Equation 2.5 extends Equation 2.4 by breaking out the impact of ASCs by specialty. The independent variables of interest are ASC_{mq}^{NMK}, ASC_{mq}^{GS}, ASC_{mq}^{EYE}, and ASC_{mq}^{MS}.

$$l(v_{hq}^{all}) = \beta_0 + \beta_1 AS_{mq}^{NMK} + \beta_2 ASC_{mq}^{GS} + \beta_3 ASC_{mq}^{EYE} + \beta_4 ASC_{mq}^{MS} + \beta_5 X_{hq} + \beta_6 Z_{mq} + \alpha_h + \gamma_q + \epsilon_{hq} \tag{2.5}$$

The aforementioned models examine whether ASC presence, either in the aggregate or by specialty, is associated with aggregate output changes in HOPDs. Equation 2.6 extends these models to one of my principal hypotheses: namely, that the effects of ASCs are market-dependent. The dependent variable is now surgical market-specific log of outpatient volume of surgical market s, where $s \subset (EYE, GS, NMK, OTHER)$ at hospital h and time period q.

$$l(v_{hq}^{s}) = \beta_0 + \beta_1 ASC_{mq}^{NMK} + \beta_2 ASC_{mq}^{GS} + \beta_3 ASC_{mq}^{EYE} + \beta_4 ASC_{mq}^{MS} + \beta_5 X_{hq} + \beta_6 Z_{mq} + \alpha_h + \gamma_q + \epsilon_{hq}^{s} \tag{2.6}$$

The second aspect of my hypothesis predicts that the relationship between ASC presence and hospital surgical volume within a given market segment is dependent on NFP status. Equations 2.7 and 2.8 examine this second hypothesis by interacting NFP status with ASC presence in Equations 2.3 and 2.4. NFP status, if included on its own, drops out of earlier models, as it is collinear with hospital fixed effects. While NFP/FP status is time invariant for the hospitals in my study over the study period,[38] my hypothesis is that the

[38] In recent years, there have been news articles citing hospital conversions between these two ownership statuses, but such conversion was not apparent in my data.

effect of this ownership status is not invariant to ASC presence. Thus, Equations 2.7 and 2.8 are extensions that incorporate NFP status interactions in Equations 2.3 and 2.4. Given the profit-maximizing nature of FP hospitals, I would expect to see a negative coefficient on β_1. However, given the varied theories of NFP firms, β_2 holds potential for a negative, positive, or neutral effect where the linear combination of β_1 and β_2 determine NFP hospital volume association with ASC presence holding all else equal. This ambiguity is furthered by the potential for hospitals to expand to other lines of services, as noted in my conceptual model, and requires examination of estimates across market segments.

$$l(v_{hq}^{all}) = \beta_0 + \beta_1 ASC_{mq}^{any} + \beta_2 ASC_{mq}^{any} \times NFP_h + \alpha_h + \gamma_q + \epsilon_{hq} \tag{2.7}$$

$$l(v_{hq}^{all}) = \beta_0 + \beta_1 ASC_{mq}^{any} + \beta_2 ASC_{mq}^{any} \times NFP_h + \beta_3 X_{hq} + \beta_4 Z_{mq} + \alpha_h + \gamma_q + \epsilon_{hq} \tag{2.8}$$

I also include the NFP status interaction in a variant of Equation 2.6 expressed in Equation 2.9, where $k \subset (EYE, GS, NMK, MS)$. In models that examine specific surgical markets (e.g., Equations 2.6 and 2.9), I account for potential contemporaneous correlation across outpatient surgical market types s by estimating each $l(v_{hq}^{s})$ in a system of seemingly unrelated equations (Zellner, 1962). This approach allows me to adjust inference for contemporaneous correlation among outpatient surgical markets that may come from cross-input (physician) utilization,[39] or cross-market capital or operating materials such as

[39] A primary example: general surgeons that can perform a variety of surgeries versus specialty surgeons; or, anesthesiologist.

operating rooms or surgical equipment and materials.

$$l(v_{hq}^{s}) = \beta_0 + \sum_{i=1} \beta_i ASC_{mq}^{k} + \sum_{j=1} \beta_j ASC_{mq}^{k} \times NFP_h + \beta_1 X_{hq} + \beta_2 Z_{mq} + \alpha_h + \gamma_q + \epsilon_{hq}^{s} \quad (2.9)$$

In further analyses, I switch my dependent variable from outpatient volume(s) to the number of unique HOPD physicians and volume by patient insurer type (i.e., private/commercial, government, uninsured, or other). I examine these dependent variables in the aggregate HOPD outpatient market and by outpatient specialty market. Examination of the number(s) of unique physicians providing surgical services in HOPDs may provide insight on potential reallocation of inputs that would affect output. For example, a $\beta_i < 0$ on ASCs in market k might indicate (1) a reallocation of (general) surgeons to non-k markets not in competition with ASCs, if accompanied with $\beta_j > 0$ for such markets, or (2) shifts of physicians to ASCs' market k inputs. A $\beta_i > 0$ for ASCs in market k would indicate a positive relationship with HOPD inputs for that market. My data do not allow me to identify physician-hospital employment status; that is, whether a physician is employed with the hospital or merely affiliated.[40] Consequently, I cannot differentiate motives or causal connections using my estimates. For example, assuming that affiliated physicians without full employment contracts are more likely to work at ASCs and that ASCs had a presence in market k, then a $\beta_i < 0$ for market k and $\beta_j > 0$ for a non-k market could be suggestive of a type of voluntary or forced entry accommodation, with a *forced* mechanism

[40]Previous studies, detailed in Chapter 1, for example, have already established that ASC-physician ownership structure is associated with patient shifting to ASCs by physicians affiliated with those ASCs ($\frac{\delta R}{\delta S} < 0$, in my model variant).

stemming from a loss of physician inputs to ASCs and a *voluntary* mechanism stemming from hospital reallocation of inputs and no change in overall (across market) inputs.

I also separate surgical volume by patient insurer type to provide insight into changes that might differ by insurer-hospital relations; for example, strategies that might differ by patient revenue. For example, my examination of the volume of uninsured patients may provide evidence of existing NFP hospital theories, as a negative relationship between the volume of surgical services to these patients and ASC presence may be indicative of output maximizing strategies akin to those discussed in Horwitz and Nichols (2007).[41] Conversely, a positive relationship between NFP hospital volume among these patients and ASC presence may be suggestive of NFP hospitals behaving as community output-maximizers. An increase in or recomposition of HOPD patient volume stemming from changes in patient-insurer mix could be indicative of underlying population changes or hospital selection of patients with insurers that provide higher reimbursements. If the former is the case, I would expect to see no changes in models examining patient-insurer mix associated with ASC presence, given time and population controls. If the latter, I would expect to see revenue-maximizing NFP hospitals exhibit a stronger preference for patients with insurers that provide higher reimbursements such as private/commercial insurers.[42] I would not expect this latter scenario to occur among FP hospitals, as these hospitals would have already selected profitable patients prior to ASC entry, unless their costs or constraints changed. As noted in Section 2.1, an example of such a change might stem from technological investments that FP hospitals are known to make to decrease costs for treating patients. In

[41]E.g., NFP hospitals exhibited behavior similar to profit-maximizing among higher FP hospital density areas, as a decreased likelihood of offering non-profitable services.

[42]Decreases in charity/uninsured patients might be indicative of cost-cutting motives in line with *share the pain, share the gain* theories.

this example, FP hospitals may seek patients that were not previously profitable (in reality or in expectation) in the face of their overall pool of profitable patients decreasing due to ASC capture. For NFP hospitals, this type of scenario might better translate to such capture occurring in new markets, as motived by Finkler (1983)'s model.

When combined with models examining NFP hospital volume, and in relation to ASC presence, increases in HOPD volume with no disproportionate changes in patient-insurer mix or decreases in least profitable patients (to maintain the zero-profit constraint) would indicate output maximization; increases in volume among the least profitable patients to support increasingly unserved patient pools would indicate community output maximization; and, no changes in output, with increases in patients with insurers that provide higher revenue, or the entering of new markets, would indicate revenue optimization. A mixture of findings could indicate mixed objectives within an NFP hospital or across NFP hospitals.

Additional Empirical Considerations

It is natural to cluster standard errors at the hospital level in studies that examine hospital output[43] to engender estimates robust to serial correlation, as hospital service provision is likely dependent over time. However, given the heterogeneity of HSA markets, the rationale for using HSAs as a market definition and evidence pointing to the relevance of HSA geographical characteristics in ASC entry (Suskind et al., 2015), I cluster standard errors at the HSA-level. It may also be instructive to incorporate HSA-level fixed effects, given my clustering rationale. However, the hospital fixed effects likely mitigate the need for HSA fixed effects given the monopolist status of a sizable portion of hospitals in the study, making the inclusion of HSA fixed effects collinear with hospital fixed effects.

[43] Or, other hospital-level changes for that matter.

In other model variants, I further introduce MSA trends to account for the possibility that markets may have exhibited differential growth rates. Ideally, I would include a full set of HSAxTime interactions, but sample size concerns motivated my use of differing linear trends for the 21 MSAs in the sample. This trend inclusion into my panel does not account for non-linear growth across markets; however, it may account for unobserved market characteristics favored by for-profit providers favor (Norton and Staiger, 1994). In yet other model variants, I introduce NFP Status time trends to discern whether linear trends specific to NFP or FP hospitals affect results. Inclusion of these terms restricts identification to hospitals of the same FP/NFP status over time and control for time-varying hospital-ownership trends that may otherwise bias results from my primary fixed-effect models. While these model variants, in addition to controls, may mitigate or eliminate factors that influence ASC presence and differential HOPD capacity to provide services, they do not account for the potential of reverse causality, and this potential issue requires additional analysis that I discuss in the exposition of my results (next).

2.4 Results

Does Hospital Surgical Market Provision Vary by the Presence of ASCs? Base models that account for ownership status through hospital fixed effects indicate that hospital surgical market provision does not vary by the presence of various ASC specialties. Table 2.10 shows estimates for models detailed in Models 2.3 – 2.6. These models attempt to discern the relationship between ASC presence and aggregate HOPD outpatient volume and whether this relationship differs across outpatient market segments and by ASC specialization. The results suggest at best a marginally statistically significant negative relationship between ASC presence and HOPD aggregate volume (Model 2.3), and this significance disappears with the addition of market and hospital controls (Model 2.4). This result is not surprising given the +1 percent change noted in aggregate HOPD volume in Florida over my 2000-2009 study period (Table 2.2). Though not directly comparable, this lack of change in the aggregate is similar to national-level studies such as Cullen et al. (2009b)'s descriptive study, which found HOPD surgical volume to be largely unchanged from 1996 to 2006 or Courtemanche and Plotzke (2010)'s study, which estimated a modest 2 to 4 percent decrease in HOPD (nationwide) output from 1999 through 2004 after controlling for hospital and market characteristics. Estimates of Models 2.5 and 2.6, an examination of aggregate HOPD market volume and EYE, NMK, GS, and OTHER market segments in relation to ASC presence by specialty, indicate no statistically significant relationships.

Does FP and NFP Hospital Surgical Volume Differ With ASC Presence? Table 2.11 shows estimates from variants of Models 2.4, 2.5, and 2.6 that interact NFP status with any ASC presence, and ASC presence by specialty. Results from Model 2.7 indicate a statistically significant differential relationship between ASC presence and hospital ownership on aggregate outpatient volume of +3.8 percent ($NFPxASC$; $p<0.01$) with a marginally significant decrease of 3.3 percent among FP hospitals ($p<0.1$) and no statistically significant change among NFP hospitals (+0.5 percent; $p=0.66$; $ASC + NFPxASC$). As with my descriptive dissection of FP and NFP volume (Table 2.2), these results appear to identify differences between the responses of FP and NFP hospital volume to ASCs that are lost when looking at the aggregate outpatient surgical market. Model 2.8 extends the NFP status interaction across ASC specialties, and its estimates exhibit a significant NFP status differential of +10.3 percent in relation to MS ASC presence, consisting of a 7.1 percent increase in aggregate NFP hospital volume (p=0.023), with no statistically discernible change in aggregate FP hospital volume. Next, I discuss hospital outpatient market segment-specific estimates in Model 2.9 in the context of other facets of hospital competition.

Hospital Specialty Markets. Model 2.9 results are suggestive of a differential relationship by ownership status between EYE ASC presence and hospital EYE volume (43.3 percent; $p<0.1$), with a negative relationship in the EYE market among FP hospitals of 38.4 percent ($p<0.05$) and no statistically significant change among NFP hospitals (0.433 + (-0.384)=0.049; p=0.70), all else equal. The presence of other ASCs did not exhibit any statistically significant relationship with hospital EYE volume. Over the 10-year study period, FP and NFP hospitals evidenced descriptive percent changes of -56 and -19, indicating that market and other controls may have captured a negative trend in the EYE market (Table 2.2). This narrative is potentially furthered by the fact that EYE ASCs exhibited the lowest growth among ASC specialty facilities and second lowest (to multi-specialty ASC) growth in volume. A decrease in volume among FP hospitals is not unexpected given my earlier predictions, and the differentials in this model between NFP and FP volume suggest the existence of different objectives between FP and NFP hospitals. Examination of unique physician counts (inputs) confirm the differential impact of EYE ASC presence by ownership. Table 2.15, estimates on the log of unique physicians and finds a statistically significant difference between NFP and FP ownership in the relationship with EYE ASC presence of +16.4 percent ($p<0.05$), with a decrease in unique physicians servicing FP hospitals' EYE markets of 13 percent ($p<0.05$), and no statistically significant change in the count of unique physicians servicing NFP hospital EYE markets ($ASC^{EYE} + NFPxASC^{EYE}$).

Dissection of hospital surgical volume by insurer type aligns with my predictions on ASC capture of FP and NFP hospital patients: namely, that an ASC will capture the most profitable patients first and that, all else equal, FP hospitals would have already captured the most profitable patients relative to NFP hospitals (pre-ASC). In the EYE market, EYE ASC presence was negatively associated with FP hospitals' volume from privately insured patients (-33 percent, p<0.05; Table 2.13); there was a suggestive negative relationship in patients insured by government (-39 percent, p<0.10; Table 2.12), and no change in uninsured patients (Table 2.14). Among privately insured patients, NFP hospitals exhibited no significant change in volume despite an $NFPxASC^{EYE}$ interaction estimate at +46.5 percent (p<0.01). This finding on volume from privately insured patients corresponds to Section 2.2.3's finding that study period trends indicated a 40-percent decrease in privately insured patients across surgical markets from 2000 through 2009 among FP hospitals, while NFP hospitals' volume of this patient population appeared stable.

There were no discernible ownership differentials by ASC specialty presence in the NMK HOPD market (Table 2.11). NMK ASC presence did, however, exhibit a statistically significant differential relationship with GS volume by ownership status (-22.7 percent; p<0.01), with FP hospitals exhibiting a positive relationship in GS volume (+14 percent; p<0.05) and no change in GS volume among NFP hospitals (0.149+(-0.227)=-0.08; p=0.17). The presence of GS ASCs was not related to GS volume of either hospital type. These findings appear to stem from FP hospital increases in volume from private and uninsured patients (Tables 2.13, 2.14). A potential explanation for this first association may come from consideration of specialty procedure profitability. As noted earlier in this chapter, existing research coupled with the highest ASC growth over my study period occurring in NMK and GS markets indicates a profitability ranking of $NMK > GS > EYE$. Thus, it is possible that increased NMK ASC presence motivated FP hospitals to focus on the next most profitable specialization. This re-optimization narrative is potentially furthered by a statistically significant $NFPxASC^{EYE}$ differential that yields a 14.5 percent increase in GS volume among NFP hospitals (p<0.05; $ASC^{EYE} + NFPxASC^{EYE}$). For NFP hospitals, this re-optimization may be indicative of profit or revenue-maximizing behavior. On its face, however, such re-optimization seems tenuous given (1) the results of Table 2.11, which show no statistically significant negative association between NMK ASCs and NMK HOPD volume, (2) the lack of statistically significant changes in physicians in these markets (Table 2.15), and (3) the ASC growth in this market, indicating that these markets exhibit strong competition. Market research for ASCs notes that the Medicare reimbursements has been and is likely to continue decreasing for ASCs and that private and third-party insurers may follow suit (Tomcanin, 2010), implying that hospitals may see a greater potential to compete against ASCs in the GS market given no decreases in their reimbursements. These decreases, however, were initiated at the tail end of my study period. Further, given the lack of a negative relationship between FP hospital GS volume and GS ASC presence (and no related changes in NFP GS volume), it seems more likely that GS ASCs serviced unmet demand. The second noted association, the FP hospital increases in surgical volume among uninsured patients, is puzzling given a lack of a clear motive for a profit-maximizing hospital.

Hospital OTHER Market. The presence of multi-specialty ASCs yielded differential responses between FP and NFP hospitals, with FP hospitals' exhibiting a negative relationship (-10.7 percent, $p<0.05$) and NFP hospitals' exhibiting a positive relationship (+8.2 percent, (0.189+(-0.107)=0.082; p=0.04). The lack of overlap among the top 5 procedure classes in the catch-all/OTHER category of procedures between HOPDs and ASCs does not necessarily mean that FP hospitals and ASCs do not directly compete in this category. The overall small footprint of even the top 5 procedures in OTHER, however, makes it difficult to determine the extent of competition (Table 2.5).[44] Moreover, while the NFP hospitals' increase in OTHER volume is consistent with output maximization, it is difficult to determine whether this increase resulted from reallocating threatened services to non-threatened services, or a hypothesized revenue-maximizing behavior, such as the opening of new markets. Models estimating whether changes in physician inputs are related to ASC presence do suggest that the +8 percent relation exhibited by NFP hospitals was associated with a 6 percent increase (p=0.03; Table 2.15) of physician inputs and increases in private and government-insured patients of 9 percent (p=0.04) and 8 percent (p=0.04), respectively (Tables 2.13 and 2.12).

Unlike other hospital specialty markets, the private and government patient insurer volumes among NFP hospitals were not simply maintained but appeared to increase in relation to ASC presence (Tables 2.13, 2.14). The increases in these patient insurer populations may align with the market mechanism that induced growth in the outpatient market to begin

[44] Descriptive analysis of insured populations in the OTHER market (Figures 2.5 and 2.6) indicate that FP hospitals experienced a notable decrease in OTHER market volume among privately-insured patients, while experiencing an increase in their government-insured population. This may be indicative of FP hospitals attempting to capture patients under less threat of capture from ASCs or an unexpected focus on new procedures.

with; namely, the adoption of new outpatient procedures transitioning from inpatient to outpatient settings (MedPAC, 2010). Medicare is more likely to cover new procedures/settings first, with private insurers following (Clemens and Gottlieb, 2013). The adoption of new procedures/settings by private insurers would likely influence FP providers' eventual adoption. Until such adoption, however, NFP hospitals would be able to extract rents from private and government-insured patients.

Taken together, these results indicate that FP hospitals and NFP hospitals do indeed have different objective functions. Moreover, NFP hospitals did not appear to exhibit any increases in volume of less profitable patients that one would not expect to be a priority for ASCs – a lack of support for NFP hospitals acting as community output maximizers. If ASCs are present in a given market, then NFP hospitals' principal opportunity for revenue or output maximization would come from new markets. Entering these new markets, however, would require capital investment, which under revenue maximization, may entail entering at a loss. Output maximization, in this context, would more readily manifest as decreases in less profitable services or patients, which my estimates indicate does not happen. Admittedly, such lack of decreases may have failed to manifest because any volume captured by ASCs may have been exhausted by patients captured from FP hospitals. If, however, NFP hospitals did not experience such capture, then an output-maximizing hospital would remain at its status-quo.

Threats to Identification. The results presented above are indicative of a differential relationship between hospital ownership status and ASC presence that varies across outpatient market segments. While the HSA market controls, hospital fixed effects, and time fixed effects I employ in my study should capture some time-invariant and time-varying biases, the relationships I find are not causal. Threats to identification of these models vary and include unobserved time-varying characteristics of the markets that may affect changes in hospital output in a given outpatient surgical market segment as well as ASC entry, which I assume to be exogenous. Additionally, there may exist trends among NFP or FP hospitals not otherwise captured by ASC presence or hospital fixed effects.

As noted in the discussion of my empirical strategy, my models may have benefited from the inclusion of HSA fixed effects and/or $HSAxTime$ effects to further mitigate omitted variable bias from unobserved market characteristics that may vary over time. Additionally, interacting hospital fixed effects and time may further capture potential hospital trends that would otherwise bias my results. With the limited hospital saturation in the majority of Florida HSAs, however, such controls are highly collinear with already included hospital fixed-effects, making such approaches unsuitable. As an alternative, I introduce $MSAxTime$ effects in additional analyses presented in Appendix A to attempt to mitigate omitted variable biases and account for potential differential market growth rates. The inclusion of these effects focuses identification in my models on variation among hospitals within a given MSA. Estimates from Table 2.10 were not robust to MSA×Time effects; however, the market and ownership breakout of models in Table 2.11 were generally qualitatively robust in significance (Table A.2). The differential sensitivity to underlying market trends of models without ownership controls in Table 2.10 and the insensitivity of models with ownership interactions in Table 2.11 aligns with previous studies that indicate FP hospital location choices differ from their NFP counterparts; namely, that FP hospitals choose to locate in better-insured regions (Norton and Staiger, 1994). While the market characteristics I included (e.g., log median income, percentage of population in poverty) do control for economic characteristics, the MSA$\times$Time controls may have captured relationships otherwise concomitant with ownership in my preliminary models that do not account for the varying effect of ownership. The inclusion of these effects into my models does not account for non-linear growth across markets nor does it account for time-varying heterogeneity of hospitals within a given MSA.

In yet other model variants, I introduce NFP Status$\times$TIME effects to discern whether trends specific to NFP or FP ownership status affect results. Inclusion of these terms restricts identification to hospitals of the same FP/NFP status over time and control for time-varying hospital-ownership trends that may otherwise bias results from my primary fixed effect models. Again, results are qualitatively similar to those presented above (Tables A.8 - A.13). As with the inclusion of MSA$\times$Time effects, the inclusion of NFP Status$\times$Time effects would not account for non-linear trends such as S-curve diffusion of new procedures that might, for example, appear first among NFP hospitals in markets favorable to the new procedure(s) adopted. Indeed, to further the technological adoption narrative of the NFP hospitals in the OTHER market, future work would need to model such non-linearities.

While these model variants, in addition to controls, may mitigate or eliminate factors that influence ASCs' presence and differential HOPD capacity to provide services, they do not account for potential reverse causality. Reverse causality in my study of ASC-hospital competition would stem, for example, from the profit-motives of physicians to open up new ASCs as a result of hospital output observations. For example, physicians may have noted excess demand in certain market segments that an ASC might capture or have been incentivized by the financial aspects of ASC ownership and the expectation that they might funnel patients to their ASCs. The previously noted marked GS ASC growth over the study period and lack of a relationship between contemporaneous GS ASC presence and hospital output in the GS market may indeed be the result of such a phenomenon. Courtemanche and Plotzke (2010)'s study of the relationship between aggregate hospital output and the number of (any) ASC in a local geographic market (e.g., within 15 miles) attempts to discern whether their estimates of modest decreases in aggregate hospital outpatient volume in relation to ASC presence are attributable to reverse causality through two approaches. First, the authors incorporate lead ASC presence, one year out, noting that a significant relationship on estimates of the lead term would constitute evidence of reverse causality. Second, the authors use lagged ASC presence as an instrument for contemporaneous ASC presence. The authors found no statistically significant relationship among various leads of ASC presence and instrumenting ASC presence (with lags of 1 to 10 years) did not affect their estimates but did indicate that the effect of ASCs on hospital volume may occur quickly. In additional models, I incorporate ASC presence leads (by specialty) and note that in examination of the GS hospital market, GS ASC leads at 2, 4, and 8 quarters are statistically significant ($p<0.01$), with estimates that range from +11 to +15 percent, indicating potential reverse causality. Further, contemporaneous GS ASC presence, initially statistically insignificant in my primary model (Table 2.11), achieves statistical significance (negative; $p<0.05$). Additionally, and interestingly, leads on MS ASC were also statistically significant in the GS hospital market - potentially indicating a general boost in MS ASCs related to GS market potential. Given these estimates, an instrumental approach, with a suitable instrument, would account for this threat to identification. However, Courtemanche and Plotzke (2010)'s instrumentation approach does not appear plausible for the

GS market given the underlying physician behavior that may impact both ASCs and hospitals. Indeed, underlying physician motives make it difficult to identify an alternative instrument. Medicare reimbursements for ASCs, for example, are observable, vary over time, and differ from rates for hospitals, making them potential instruments (within a given market) for ASC entry. Changes in these rates, however, may also impact hospital output directly either through physicians that split their time between hospitals and ASCs or by incentivizing physicians that leave their hospitals to work at ASCs.[45] Additionally, as with FP hospital location, for-profit ASC entry is likely also dependent on market characteristics and trends that also affect hospital output.

2.5 Concluding Remarks

While standard theory would dictate that hospitals would exit the market in the face of superior competitors, hospitals have continued to operate in the outpatient market, and in some cases have exhibited expanding outpatient revenue over time. There are a few factors that likely contribute to hospitals' continued ability to compete with ASCs, and examples include successful lobbying efforts to establish legislative restrictions on ASCs and receiving higher revenue from insurers (reimbursement rates) relative to ASCs. These interventions, however, may not last, as exemplified by recent legislation that proposes to enforce site neutral payments, which would pay hospitals at substantially lower rates. Hospital responses to ASCs that are in line with more typical quantity- or price-based competitive strategies have not been examined. The exact mechanisms for competition

[45] A similar argument could be made for procedure coverage under ASCs, which typically lags coverage at hospitals.

under these avenues depend on a hospital's maximizing objectives. For-profit hospitals are assumed to be profit-maximizers. Not-for-profit hospitals, however, have no shortage of theoretical models, with mixed empirical evidence to support them.

This dissertation expands on studies concerning hospital-ASC competition by separating the aggregate outpatient market into surgical procedure classifications, within established market geographies for patients. Specifically, I examine three specialty outpatient markets in which ASCs have exhibited substantial growth nationally and in the state of Florida, from 2000 through 2009, in addition to examining a combined market of all other outpatient surgical procedures. In this outpatient market dissection, I empirically examine how hospital patient volume, the number of physicians, and patient insurer mix vary by ASC presence in a given market. My estimates suggest differential hospital ownership status effects on hospital patient volume, hospital physicians, and highest revenue patients (those privately insured) in select markets. Specifically, estimates indicate that for-profit hospitals have lost a sizable amount of their privately/commercially insured patients in markets where they face ASC competition, while not-for-profit hospitals did not. My estimates further indicate that not-for-profit hospitals are more likely to exhibit output expansion, primarily among privately insured patients. Taken together, my results further the literature on differential objectives of hospital ownership by examining emerging hospital markets and indicating that in Florida, where the split between for-profit and not-for-profit private hospitals is even, ASCs will focus on for-profit hospital populations first, and not-for-profit hospitals can maximize output in a manner that prioritizes revenue.

Table 2.10
Log of Patient Volume In Aggregate and By Specialty Market (2000 - 2009)

	Model 2.3	Model 2.4	Model 2.6			
	–	–	ln(EYE Vol)	ln(NMK Vol)	ln(GS Vol)	ln(OTHER Vol)
# of ASC	-0.0223+ (-1.69)	-0.00663 (-0.45)				
EYE ASC			-0.0937 (-0.87)	-0.00324 (-0.04)	0.0640 (0.87)	-0.0548 (-1.01)
NMK ASC			0.00594 (0.07)	-0.0643 (-1.43)	0.00590 (0.10)	-0.0419 (-1.45)
GS ASC			-0.103 (-1.35)	0.0520 (1.34)	-0.0356 (-0.40)	-0.0179 (-0.59)
MS ASC			0.00668 (0.09)	-0.00475 (-0.16)	0.0307 (0.64)	0.00896 (0.26)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes	Yes
HSA Controls	No	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Standard errors for Models 2.3, 2.4, and 2.5 are robust and clustered at HSA. Model 2.6 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table 2.11
Log of Patient Volume In Aggregate and By Specialty Market And Ownership Status (2000 - 2009)

	Model 2.7	Model 2.8	Model 2.9			
	ln(All Vol)	ln(All Vol)	ln(EYE Vol)	ln(NMK Vol)	ln(GS Vol)	ln(OTHER Vol)
# of ASC	-0.0328+ (-1.72)					
NFP × # of ASC	0.0379∗∗ (2.86)					
EYE ASC		-0.0971 (-1.59)	-0.384∗ (-2.36)	-0.104 (-1.31)	-0.0792 (-0.83)	-0.0523 (-0.94)
NMK ASC		0.0262 (0.48)	-0.00496 (-0.04)	-0.0426 (-0.65)	0.149∗ (2.02)	-0.0701 (-1.12)
GS ASC		-0.0429 (-0.92)	-0.174 (-1.48)	0.0448 (0.99)	-0.0548 (-0.55)	-0.0288 (-0.73)
MS ASC		-0.0323 (-0.85)	-0.0368 (-0.30)	-0.0359 (-1.15)	-0.00335 (-0.07)	-0.107∗ (-2.12)
NFP × EYE ASC		0.135+ (1.84)	0.433+ (1.94)	0.153 (1.60)	0.224∗ (2.30)	-0.000348 (-0.00)
NFP × NMK ASC		-0.0636 (-1.12)	-0.00540 (-0.04)	-0.0396 (-0.44)	-0.227∗∗∗ (-3.41)	0.0415 (0.50)
NFP × GS ASC		0.0421 (1.17)	0.100 (0.72)	0.0125 (0.22)	0.0367 (0.56)	0.0161 (0.33)
NFP × MS ASC		0.103∗∗ (2.71)	0.0836 (0.53)	0.0520 (0.96)	0.0521 (1.17)	0.189∗∗ (2.86)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.7 and 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table 2.12
Log Volume of Government Patients (2000 - 2009)

	Model 2.8	Model 2.9			
	ln(All Vol)	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	-0.0141	-0.389+	-0.00725	-0.0224	0.0471
	(-0.13)	(-1.96)	(-0.06)	(-0.15)	(0.44)
NMK ASC	-0.0276	-0.0233	-0.0737	0.0848	-0.110
	(-0.40)	(-0.17)	(-0.96)	(1.01)	(-1.41)
GS ASC	-0.0680	-0.154	0.0234	-0.0339	-0.0710
	(-1.36)	(-1.17)	(0.43)	(-0.30)	(-1.46)
MS ASC	-0.0395	-0.0403	-0.0244	-0.0239	-0.120+
	(-0.83)	(-0.30)	(-0.61)	(-0.42)	(-1.78)
NFP × EYE ASC	0.0101	0.414	0.0246	0.152	-0.138
	(0.08)	(1.57)	(0.17)	(0.98)	(-1.01)
NFP × NMK ASC	-0.0100	0.0275	-0.0351	-0.167+	0.0673
	(-0.13)	(0.17)	(-0.33)	(-1.87)	(0.66)
NFP × GS ASC	0.0732+	0.0520	0.0514	0.0180	0.0676
	(1.74)	(0.34)	(0.88)	(0.22)	(1.21)
NFP × MS ASC	0.124**	0.0576	0.0805	0.0913+	0.203**
	(2.76)	(0.34)	(1.21)	(1.87)	(2.65)
Time FE	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.

(2) Model 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.

(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table 2.13
Log Volume of Private/Commercially Insured Patients (2000 - 2009)

	Model 2.8	Model 2.9			
	ln(All Vol)	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	-0.182**	-0.333**	-0.160+	-0.135	-0.160***
	(-2.98)	(-2.79)	(-1.79)	(-1.43)	(-3.36)
NMK ASC	0.108+	0.0139	0.00671	0.213*	0.0161
	(1.72)	(0.16)	(0.09)	(2.56)	(0.26)
GS ASC	-0.0185	-0.107	0.0553	-0.0493	0.0100
	(-0.34)	(-1.22)	(1.05)	(-0.48)	(0.24)
MS ASC	-0.0705	-0.0317	-0.0753+	-0.0507	-0.153**
	(-1.30)	(-0.35)	(-1.74)	(-0.78)	(-2.61)
NFP × EYE ASC	0.214**	0.465**	0.209*	0.246*	0.119
	(2.69)	(3.27)	(1.98)	(2.20)	(1.52)
NFP × NMK ASC	-0.161*	-0.0820	-0.0760	-0.308***	-0.0615
	(-2.43)	(-0.75)	(-0.87)	(-3.98)	(-0.72)
NFP × GS ASC	0.0273	0.0584	0.00591	0.0373	-0.0204
	(0.66)	(0.53)	(0.09)	(0.50)	(-0.44)
NFP × MS ASC	0.148*	0.0790	0.0805	0.0999+	0.245**
	(2.36)	(0.70)	(1.39)	(1.69)	(3.14)
Time FE	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table 2.14
Log Volume of Uninsured Patients (2000 - 2009)

	Model 2.8	Model 2.9			
	ln(All Vol)	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	0.0863	-0.0262	-0.00740	-0.0246	0.152
	(0.82)	(-0.33)	(-0.05)	(-0.19)	(1.23)
NMK ASC	-0.0893	-0.117*	-0.0220	0.179*	-0.179
	(-1.14)	(-2.14)	(-0.30)	(2.52)	(-1.60)
GS ASC	-0.0782	-0.0805+	-0.0369	-0.0197	-0.0846
	(-0.93)	(-1.66)	(-0.38)	(-0.18)	(-0.94)
MS ASC	-0.116+	-0.132**	-0.0276	-0.0166	-0.209*
	(-1.90)	(-2.87)	(-0.81)	(-0.30)	(-2.03)
NFP × EYE ASC	0.0229	0.0469	0.0364	0.176	-0.0682
	(0.16)	(0.53)	(0.23)	(1.35)	(-0.40)
NFP × NMK ASC	0.100	0.115	0.0485	-0.142	0.164
	(0.84)	(1.48)	(0.52)	(-1.62)	(0.96)
NFP × GS ASC	0.0465	0.0488	0.0677	0.00174	0.0581
	(0.47)	(0.90)	(0.62)	(0.02)	(0.51)
NFP × MS ASC	0.111	0.0262	-0.0410	-0.0268	0.206
	(1.14)	(0.42)	(-0.80)	(-0.46)	(1.43)
Time FE	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table 2.15
Log of Unique Physician Counts (2000 - 2009)

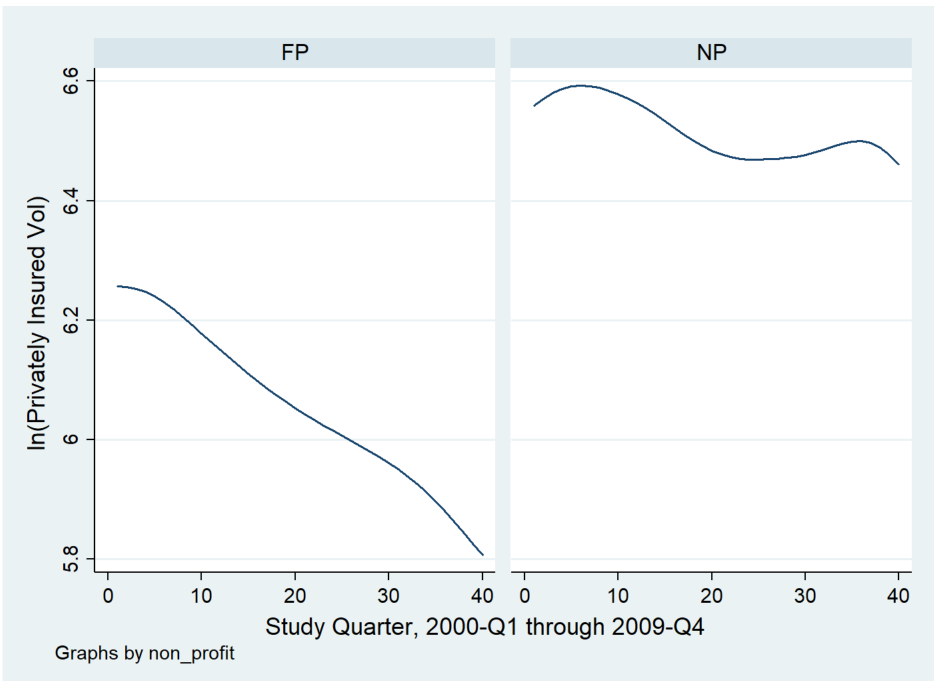
	Model 2.8	Model 2.9			
	ln(All Vol)	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	-0.0808**	-0.129*	-0.0359	-0.0380	-0.0924**
	(-2.97)	(-2.35)	(-1.27)	(-0.94)	(-2.68)
NMK ASC	0.0465	0.00381	0.00901	0.0215	0.0241
	(1.20)	(0.09)	(0.27)	(0.59)	(0.64)
GS ASC	-0.0261	-0.0346	-0.0272	0.0139	-0.0164
	(-0.99)	(-0.84)	(-1.45)	(0.41)	(-0.68)
MS ASC	-0.0645*	-0.0748+	-0.0335	-0.0422	-0.0909**
	(-2.53)	(-1.83)	(-1.37)	(-1.58)	(-3.13)
NFP × EYE ASC	0.0659	0.164*	0.00104	0.0754+	0.0718
	(1.24)	(2.56)	(0.02)	(1.66)	(1.18)
NFP × NMK ASC	-0.0229	-0.00516	0.0203	-0.00852	-0.0204
	(-0.42)	(-0.10)	(0.41)	(-0.19)	(-0.36)
NFP × GS ASC	0.000233	0.0366	0.0285	-0.0259	0.00307
	(0.01)	(0.80)	(0.90)	(-0.85)	(0.09)
NFP × MS ASC	0.114***	0.113*	0.0474	0.0308	0.146***
	(3.72)	(2.14)	(1.60)	(1.14)	(3.87)
Time FE	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200			

(1) + signifies $p<0.1$; * signifies $p<0.05$; ** signifies $p<0.01$; *** signifies $p<0.001$. T-statistics presented in parentheses.
(2) Model 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table 2.16
Charlson Comorbidity Index (2000 - 2009)

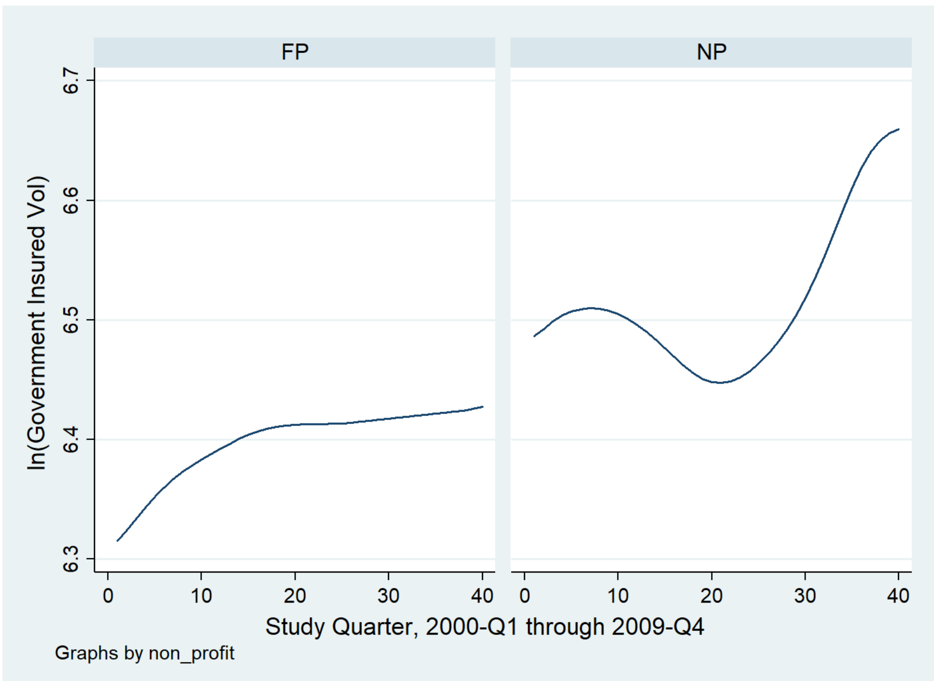
	Model 2.8	Model 2.9			
	(1) All Volume	(2) EYE	NMK	GS	OTHER
EYE ASC	0.0158	0.0247	0.0106	0.00968	0.00359
	(0.71)	(0.84)	(1.00)	(0.60)	(0.12)
NMK ASC	-0.00657	-0.0159	-0.00445	-0.0108	0.0160
	(-0.60)	(-0.61)	(-0.54)	(-1.07)	(1.15)
GS ASC	-0.00131	-0.0285	-0.0127	0.00687	-0.00269
	(-0.09)	(-1.89)	(-1.95)	(0.57)	(-0.18)
MS ASC	-0.00288	0.0217	0.00934	-0.00418	0.0160
	(-0.42)	(1.39)	(1.68)	(-0.66)	(1.29)
NFP × EYE ASC	-0.0433	-0.0314	-0.0496**	-0.0397*	-0.0194
	(-1.75)	(-0.99)	(-3.25)	(-2.14)	(-0.64)
NFP × NMK ASC	0.0170	0.0203	0.0165	0.0259*	-0.0120
	(0.95)	(0.72)	(1.56)	(2.26)	(-0.54)
NFP × GS ASC	-0.00845	0.00172	0.00661	-0.00551	-0.0103
	(-0.53)	(0.11)	(0.83)	(-0.49)	(-0.52)
NFP × MS ASC	-0.0109	-0.0184	-0.0185	-0.00800	-0.0358**
	(-0.84)	(-1.05)	(-1.50)	(-0.70)	(-2.84)
Time FE	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.



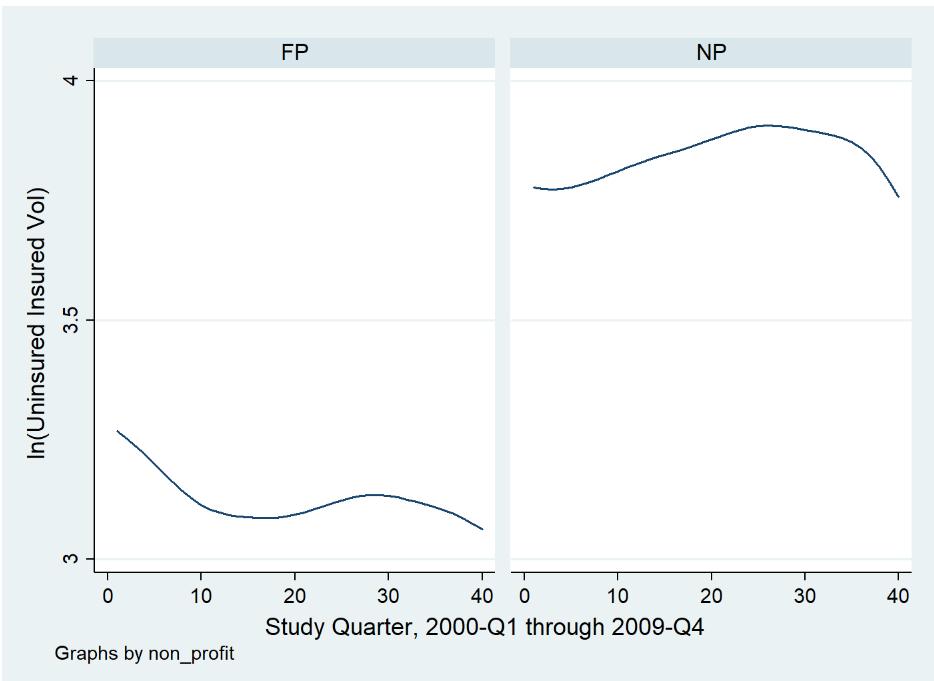
Notes: Data from Florida state from 2000 through 2009 on the log of outpatient surgical volume from privately insured patients serviced at for-profit (FP) or not-for-profit (NP) hospitals.

Figure 2.1
Average Log(Private-Insured Patient Volume) by Ownership Status (2000 - 2009)



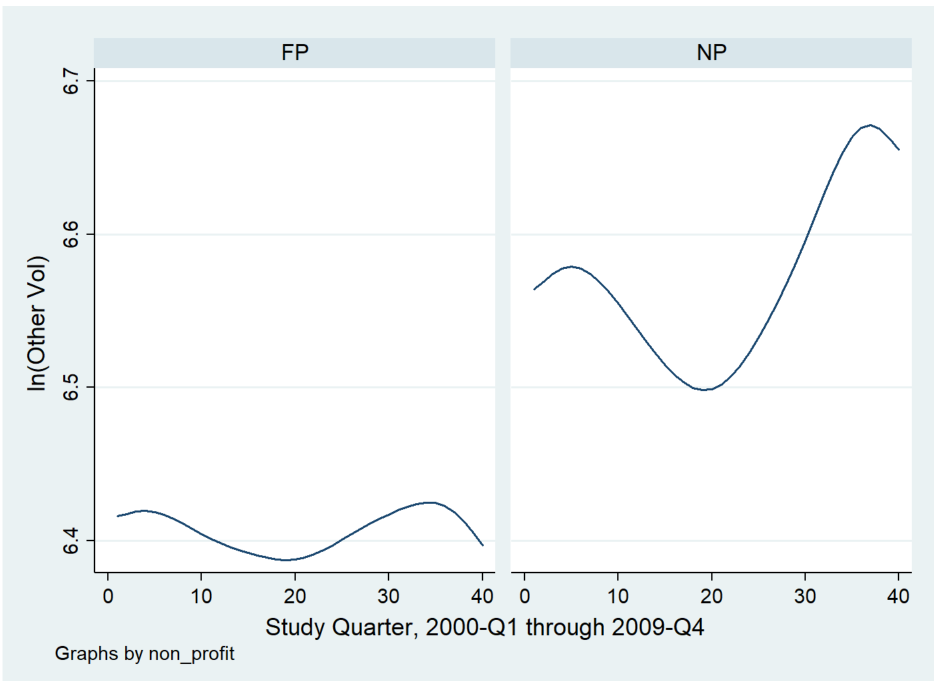
Notes: Data from Florida state from 2000 through 2009 on the log of outpatient surgical volume from government (Medicare/Medicaid) insured patients serviced at for-profit (FP) or not-for-profit (NP) hospitals.

Figure 2.2
Average Log(Government-Insured Patient Volume) by Ownership Status (2000 - 2009)



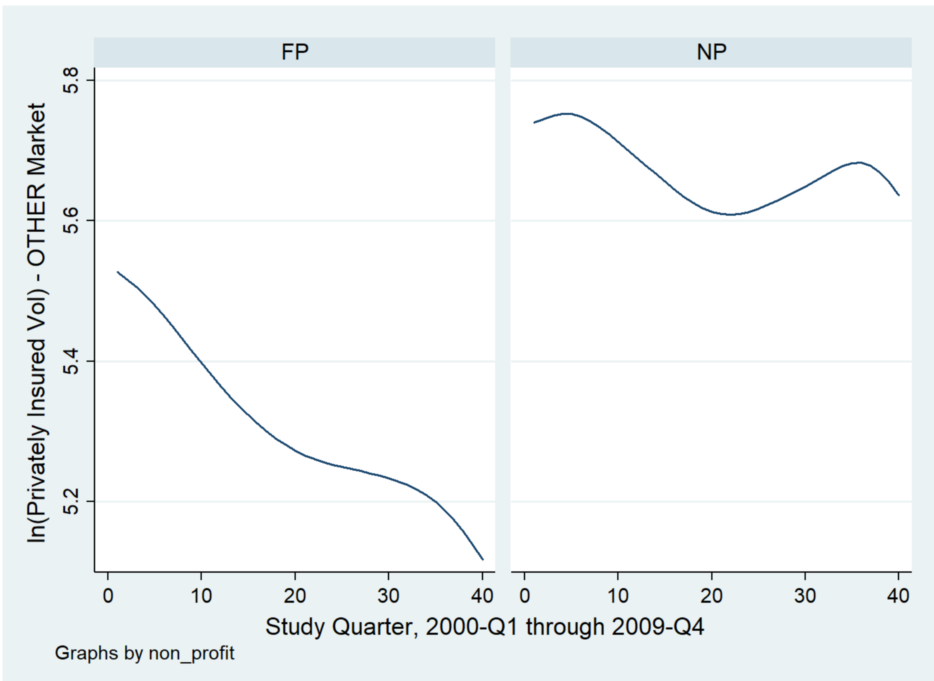
Notes: Data from Florida state from 2000 through 2009 on the log of outpatient surgical volume from uninsured patients serviced at for-profit (FP) or not-for-profit (NP) hospitals.

Figure 2.3
Average Log(Uninsured Patient Volume) by Ownership Status (2000 - 2009)



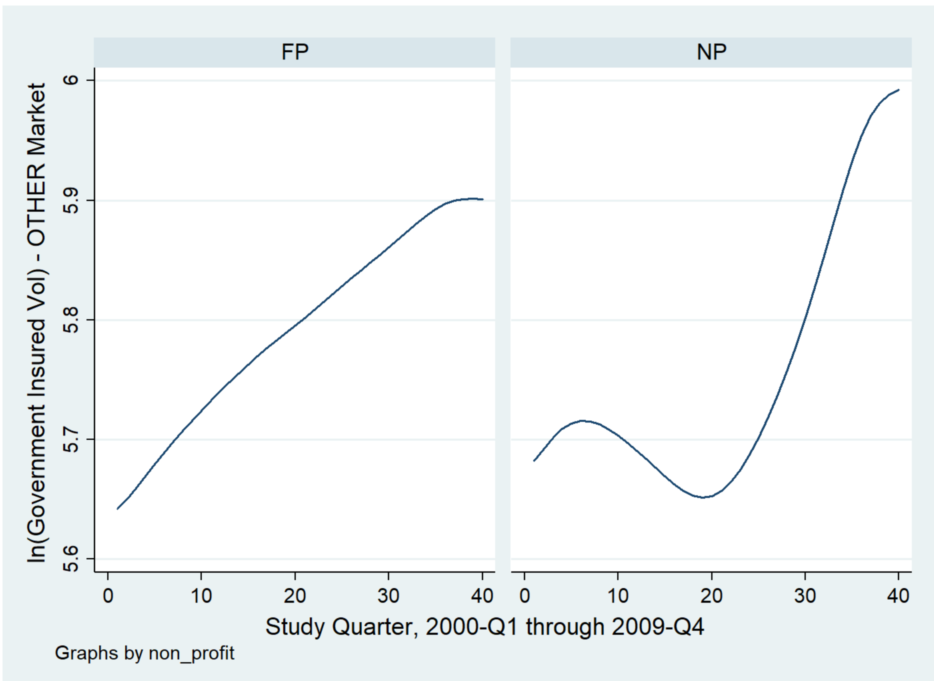
Notes: Data from Florida state from 2000 through 2009 on the log of total outpatient surgical volume in OTHER market provisioned by for-profit (FP) or not-for-profit (NP) hospitals.

Figure 2.4
Average Log(OTHER Patient Volume) by Ownership Status (2000 - 2009)



Notes: Data from Florida state from 2000 through 2009 on the log of total outpatient surgical volume in OTHER market from privately insured patients serviced by for-profit (FP) or not-for-profit (NP) hospitals.

Figure 2.5
Average Log(Private-Insured Patient Volume) in OTHER Market by Ownership Status (2000 - 2009)



Notes: Data from Florida state from 2000 through 2009 on the log of total outpatient surgical volume in OTHER market from government (Medicare/Medicaid) insured patients serviced by for-profit (FP) or not-for-profit (NP) hospitals.

Figure 2.6
Average Log(Government-Insured Patient Volume) in OTHER Market by Ownership Status (2000 - 2009)

Chapter 3: The Direct and Indirect Costs to Society of Treatment for End-Stage Knee Osteoarthritis

Disclosures

- This work was published in 2013 and is a joint publication with Lane Koenig PhD, Timothy M. Dall MS, Paul Gallo BS, Alexa Narzikul BA, Javad Parvizi MD, and John Tongue MD (Ruiz Jr et al., 2013).
- One or more of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), for a third party in support of an aspect of this work. In additional, one or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission [for publication] of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, one or more of the authors has had another relationship, or has engaged in another activity, that could be perceived to influence or have the potential to influence what is written in this work.

The past two decades have seen growth in the number of total knee arthroplasties performed in the U.S. A recent study shows that the number of primary total knee arthroplasties performed in fee-for-service Medicare beneficiaries increased 162% from 1991 to 2010 (Cram et al., 2012). In 2010, over 600,000 total knee arthroplasty procedures were performed across all age groups in the U.S. (Cram et al., 2012). With an aging population, demand for total knee arthroplasty in the U.S. will continue to rise, with the total number of procedures expected to exceed three million by the year 2030 (Kurtz et al., 2009).

The growing utilization of total knee arthroplasty is a reflection of several factors. The procedure is safe and effective, improving the quality of life for individuals with severe osteoarthritis of the knee (Losina et al., 2009; Hawker et al., 2009). The aging of the population and the increase in obesity contribute to a higher prevalence of osteoarthritis and a greater need for total knee arthroplasty, although these factors alone cannot account for the high growth in the procedure (Losina et al., 2012). The most rapid increases in total knee arthroplasty in the U.S. are occurring in the working-age population; from 1997 to 2010, the percentage of all total knee arthroplasty that were performed in adults forty-five to sixty-four years of age increased substantially from 26% to 42% (AHQR, 2012).

Studies have shown total knee arthroplasty to be a cost-effective procedure, with an incremental cost of $18,300 per quality-adjusted life year (QALY) for individuals in the Medicare program, including high-risk individuals (Losina et al., 2009). Although a few studies have examined the economic burden of osteoarthritis, we are not aware of any studies that have examined the impact of total knee arthroplasty from a societal perspective (daCosta DiBonaventura et al., 2011; daCosta DiBonaventura et al., 2012; Yelin et al., 2004). Existing, but limited, literature supports a link between total knee arthroplasty for osteoarthritis and workforce participation, with the latter being a major component of societal costs.[1] However, this literature is based on small observational studies, and the strength of this link between total knee arthroplasty and work status is not well established (Lyall et al., 2009). We hypothesized that the economic effects of total knee arthroplasty may be substantial, particularly given the growth in knee replacement among individuals of working age and the trend among working adults to choose to delay retirement (Toossi, 2012).

The purpose of this study was to estimate the value of total knee arthroplasty from a societal perspective by estimating its costs and benefits to patients, employers, payers, and government in the U.S. We used a Markov model framework with three primary components: (1) quality of life; (2) direct medical costs for the total knee arthroplasty, compli-

[1] Sayre et al., 2010; Jones et al., 2003; Jones et al., 2001;Hootman and Helmick, 2006; Dionne et al., 1999; Fautrel et al., 2005' Gupta et al., 2005; Bieleman et al., 2011; Lyall et al., 2009; Norman-Taylor et al., 1996; Desmeules et al., 2010; Jorn et al., 1999; Lerner et al., 2002; Palmer, 2012; Palmer et al., 2005

cations of surgery, and revision arthroplasty; and (3) indirect costs involving employment status, earnings, time missed from work (or absenteeism), and disability payments.

3.1 Data and Methods

3.1.1 Modeling Approach

We developed a Markov cohort model for patients with end-stage osteoarthritis of the knee to assess the incremental costs and outcomes of total knee arthroplasty compared with nonsurgical treatment. This approach considers the timing and probability of different patient outcomes. The Markov model calculates the present-day value of the expected (direct and indirect) costs and QALYs gained over the lifetime of a cohort of patients for each treatment strategy, with future costs and benefits discounted at a rate of 3% per year (West et al., 2003).

Model results were generated for the population forty years of age or older who received a total knee arthroplasty in the U.S. in 2009. This group accounted for 99% of all total knee arthroplasties performed in that year. For each age and treatment strategy, the direct cost, quality-of-life (termed utility), and disability payment components of the models were calculated until the age of ninety-nine years or mortality. Household income and missed workdays (accounting for age and sex-specific differences in income and workforce participation) were calculated until the age of seventy-five years, at which point workers were assumed to retire. An age-weighted mean of the model findings was obtained with use of the age distribution of patients undergoing total knee arthroplasty in 2009. The model operated on a one-year cycle.

The principal objective of the study was to determine the societal savings from total knee arthroplasty, measured as the difference between the total costs associated with surgical and nonsurgical treatment. Five outcomes were calculated in the model: (1) QALYs, which are the accumulation of years of life weighted by an indicator of quality ranging from 0 for death to 1 for a year in perfect health; (2) lifetime direct medical costs; (3) indirect cost components involving expected income (the product of income for a worker and the probability of working); (4) the value of missed days of work; and (5) expected disability payments (the product of mean disability payments and the probability of receiving Supplemental Security Income [SSI] because of a disability). These components were projected over the lifetime of individuals.

3.1.2 Markov Model

The structure of the Markov model and the assumed utilities (quality-of-life measures) and transition probabilities are derived from Losina et al. (2009). In accordance with that study, ten health states were included (Figure 3.1) Two of these states are surgical (primary and revision total knee arthroplasty). An individual could not be in a particular surgery-related health state for more than one consecutive year at a time, whereas the remaining states were potentially chronic (e.g., a patient could stay in the full-benefit total knee arthroplasty state until death). After being in any state for one year, an individual was permitted to either transition to a chronic state or, if already in a chronic state, stay in his or her current state. Once in the primary or revision total knee arthroplasty surgical state, an individual was required to transition to the limited-benefit state, the full-benefit state, or an early failed total knee arthroplasty state after one year.

Transitions to either chronic state are dependent on WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) thresholds, normalized to a maximum possible score of 100 points, provided in Losina et al. (2009). Specifically, an individual with a postoperative WOMAC score of >60 points transitions to the full-benefit postoperative state, whereas an individual with a WOMAC score of ≤ 60 points transitions to the limited-benefit postoperative health state. Individual patients may stay in these health states for the remainder of their life or have a failure in the knee prosthesis and transition to the failed total knee arthroplasty health state. Once in the failed state, individuals may remain in that state or choose to undergo a revision total knee arthroplasty and transition to the revision total knee arthroplasty state. After this revision state, individuals will transition to either the post-revision full-benefit state or the post-revision limited-benefit state, where they may remain until they transition to either the failed revision total knee arthroplasty state or death.

Death is an absorbing state that could occur at any point, with a natural mortality probability based on sex and age data from U.S. Census Bureau life expectancy tables (Bureau, 2012) (or with a combined natural mortality probability and surgical mortality probability if transitioning from a surgical state).

3.1.3 Direct Cost Estimates

The direct medical costs of surgical treatment were calculated with use of 2009 Medicare inpatient claims for a 5% sample of beneficiaries. The ICD-9 (International Classification of Diseases, Ninth Revision) diagnosis code 715.x6 was used to identify patients admitted to a hospital with a primary diagnosis of osteoarthritis of the knee. The ICD-9 procedure code 81.54 was used to identify treatment with total knee arthroplasty, and

81.55, 00.80, 00.81, 00.82, 00.83, and 00.84 were used to identify revision knee arthroplasty. The direct model costs included Medicare payments for inpatient care, physician services, and care provided in post-acute care facilities, such as skilled nursing facilities, hospice, home health care, inpatient rehabilitation facilities, and long-term care hospitals (Table 3.1). These costs were tracked for three months after surgery, as our panel of clinical experts estimated that the expenses that accrued in this time period were most likely attributable to the arthroplasty surgery. Additionally, we estimated the mean cost of physical therapy visits over this time period to be $2,016 (net present value in 2009 U.S. dollars) and included it as part of the rehabilitation costs associated with primary or revision total knee arthroplasty. Because payer and patient costs were derived with use of Medicare payments, we applied an adjustment to the direct costs estimated under Medicare to account for non-Medicare payments for persons younger than sixty-five years (see Appendix B).

The costs of perioperative complications ($17,514 per year) and endstage osteoarthritis ($5,282 per year) for the Medicare population were obtained from Losina et al. (2009), adjusted for an all-payer population, and converted to 2009 dollars. Costs accrued within one year of primary and revision total knee arthroplasty were calculated as the cost of the relevant procedure plus the equally weighted expected cost of experiencing the limited-benefit or full-benefit state.

3.1.4 Indirect Cost Estimates

The effects of knee osteoarthritis on indirect costs were estimated with use of methods and data from the National Health Interview Survey (NHIS) reported by Dall et al. regarding functional limitations, employment, missed workdays, income, and disability payments

(Dall et al., 2013). These findings allowed us to predict an individuals probability of being employed, number of missed workdays (if working), household earnings (if working), and probability of receiving SSI disability payments conditional on his or her level of functional ability in a given year (see Appendix B).

Predicted values for indirect cost components were obtained by utilizing patient-reported data on pre-surgery and post-surgery functional status collected by a large orthopaedic group practice. Electronic questionnaires were sent to 310 patients who received a total knee arthroplasty from September 2010 to April 2011. A total of seventy-three responses were received and used in the analyses. The survey contained questions regarding an individuals socioeconomic status and functional ability (using the questions on functional status from the NHIS) prior to obtaining surgery and after receiving surgery. Functional questions included the following possible answers: no difficulty, only a little difficult, somewhat difficult, very difficult, and cannot do. Numerical values of 1 through 5 were assigned to the responses, with no difficulty assigned a value of 1 and cannot do assigned a value of 5.

Patients were categorized as receiving full benefit from the total knee arthroplasty if their mean post-surgery response averaged over all functional questions was ≤ 3 (somewhat difficult) and as receiving limited benefit otherwise. Assuming this response categorization allowed us to match the distribution of patients experiencing full benefit from total knee arthroplasty (88%) in the study by Losina et al. (2009) (Table 3.2).

3.2 Results

Relative to nonsurgical treatment, the mean lifetime net societal savings per patient resulting from total knee arthroplasty was $18,930 (Table 3.3). Each knee arthroplasty increased lifetime direct costs by a mean of $20,635, while the societal savings in lower indirect costs from improved functional status averaged $39,565. Eighty-five percent of these savings originated from increased income, through a combination of increased probability of working and higher earnings. The remaining 15% of societal savings resulted from fewer missed workdays and lower disability payments. Although our results showed net societal savings from total knee arthroplasty in the full cohort of patients, direct medical costs from total knee arthroplasty began to exceed societal savings at a patient age of seventy years at the time of the index procedure, indicating a crossover from positive net societal savings from total knee arthroplasty procedures to negative net societal savings.

The youngest patients receiving a total knee arthroplasty predictably accrued substantially higher lifetime savings associated with surgery because they accrued benefits over more years than elderly patients. The difference in societal savings between the oldest age group (80 years) and youngest group (forty to forty-four years) was $174,364 over a lifetime (Table 3.3). The only savings accrued for retired patients involved lower disability benefits, which were relatively small compared with earnings. For patients younger than sixty years, the net increase in societal savings resulting from surgery ranged from $85,263 (fifty-five to fifty-nine years old) to $177,342 (forty to forty-four years old).

The difference in total direct medical costs between surgical and nonsurgical treatment increased with age. For patients in the forty to forty-four-year age group, the lifetime direct medical costs of surgery were $19,232 greater than the direct medical costs of nonsurgical treatment (Table 3.4). For patients eighty years of age or older, the difference in lifetime direct medical costs was $22,339. The higher incremental cost of surgery compared with nonsurgical treatment for older patients is driven by the assumption that post-surgery medical spending for patients who undergo total knee arthroplasty is less than that for patients treated nonoperatively. Younger patients are able to accrue savings from lower medical spending after total knee arthroplasty over a longer time period compared with older patients. Although the savings from lower medical costs after total knee arthroplasty do not fully offset the cost of the procedure, they reduce the difference in direct medical costs between the surgical and nonsurgical treatment options.

Our model demonstrated large QALY increases from total knee arthroplasty as a result of higher quality of life for patients treated surgically compared with nonsurgically. For patients from forty to forty-four years of age, surgery resulted in an increase of 3.4 QALYs. The principal outcome calculated was the incremental cost effectiveness ratio (ICER), which is the ratio of the cost difference between the treatment options and the corresponding QALY difference. Considering only direct costs, this implies an ICER of $5,656 for total knee arthroplasty in the entire cohort. In comparison, the improvement for those eighty years old or older was 1.8 QALYs, with an ICER of $12,410. Thus, our model demonstrates that total knee arthroplasty was cost effective across all age groups, assuming a willingness-to-pay threshold of $50,000 per QALY gained.

We performed a one-way sensitivity analysis on our assumptions regarding direct costs, utility measures, and relevant transition probabilities (Figure 3.2). In this analysis, the cost effectiveness in cohorts ranging from forty to ninety-nine years of age was recalculated as the assumed value of each single parameter was varied. The net societal savings reported in Table 3.5 are mean (age-weighted) values across all age groups. The sensitivity analysis indicated that the QALY changes resulting from surgery were robust to the investigated level of variation in the utility for the full-benefit state. Net societal savings remained positive with variations in the transition probabilities and the costs associated with end-stage osteoarthritis of the knee, primary and revision total knee arthroplasty, and perioperative complications.

We found little variation in net societal savings from variations in disability payments and in expected missed workdays. The results were more sensitive to changes in expected income increases from the full-benefit state. When the simulated expected income was decreased by 25%, the positive net savings dropped from $18,930 to $9,762.

3.3 Discussion

Primary and revision total knee arthroplasty involving a wide array of methods and prostheses are cost-effective (Burns et al., 2006; Novak et al., 2007; Rissanen et al., 1997; Lavernia et al., 1997; and Katz et al., 2004). However, to our knowledge the present study is the first to focus on the societal value of total knee arthroplasty, taking into account a broad array of economic outcomes, for the full cohort of patients receiving this procedure. We confirmed that total knee arthroplasty is a cost-effective intervention for individuals with end-stage osteoarthritis of the knee. Furthermore, we demonstrated positive net societal savings for patients younger than seventy years of age at the time of surgery, and we demonstrated an age-weighted positive net benefit of $18,930 over all ages.

Our analysis expands on the analysis of Losina et al. (2009) in four important ways.

First, we updated and expanded the direct medical costs associated with total knee arthroplasty by conducting an analysis of 2009 Medicare claims. Second, we estimated the cost-effectiveness of total knee arthroplasty for the full cohort of patients receiving the procedure in 2009, including the growing segment of working-age individuals receiving knee replacement surgery. Third, we adjusted reimbursement levels for an all-payer population. Fourth, we incorporated indirect costs related to employment, earnings, and disability payments into the model to generate findings from a societal perspective.

The calculated ICER for individuals sixty-five years of age or older differs from the $18,300 reported previously by Losina et al. (2009). The difference in direct medical costs for total knee arthroplasty between our study (ranging from $20,523 for the sixty-five to sixty-nine-year age cohort to $22,339 for the eighty year-and-older cohort) and that of Losina et al. (2009) ($20,800) was small. The key factor leading to our lower (better) calculated ICER is the greater estimated QALY increase from surgery in the present study (ranging from 2.4 additional QALYs for the sixty five to sixty-nine-year age cohort to 1.8 additional QALYs for the eighty-year-and-older cohort) compared with the study by Losina et al. (2009) (1.4 additional QALYs for the Medicare population). The QALY difference may be due to our assignment of higher utility values in the primary and revision total knee arthroplasty health states. Specifically, we assigned a mean utility value based on pre-surgery and post-surgery utility values.

This study has several limitations that are worth noting and represent areas for future research. First, we applied the same utility assumptions for all patients reaching the full-benefit health state as well as for all patients reaching the limited-benefit health state. These utility levels were obtained from the study by Losina et al. (2009), which is based on Medicare-age patients receiving total knee arthroplasty and may therefore understate the initial benefits received by a younger population that experiences better recuperation. Second, patient outcome data were obtained retrospectively from patients up to two years following total knee arthroplasty, introducing the possibility of recall bias regarding functional limitations prior to surgery. However, the functional scores reported in our survey are comparable with those in the existing literature (see Appendix B; Hawker et al., 2009; Jones et al., 2001; Lingard et al., 2001). Third, we inferred the effects of total knee arthroplasty on indirect costs by linking osteoarthritis of the knee, functional limitations, and economic outcomes (e.g., employment). This was done because of the lack of published evidence. Fourth, our estimates of net societal savings from knee replacement are based on mean indirect cost reductions for individuals who undergo the procedure. However, not all of these individuals will have had equal osteoarthritis severity, as suggested by large geographic variations in the total knee arthroplasty rate (Fisher et al., 2014; for the Evaluative Clinical Services, 2007). Thus, careful consideration of individual patient needs and alternatives to total knee arthroplasty may further increase the estimated value of the procedure.

Finally, the societal savings calculated in the present study may be conservative because we did not account for workplace productivity, depression-related symptoms, cardiovascular health, home modification costs, and nursing home costs. Workers having advanced pain due to osteoarthritis report lower productivity at work compared with those with more limited symptoms (daCosta DiBonaventura et al., 2012; daCosta DiBonaventura et al., 2011). A study of Medicare data documented reduced mortality and fewer cardiovascular events for patients with end-stage osteoarthritis of the knee who undergo total knee arthroplasty compared with those who do not (Lovald et al., 2013).

We estimated total lifetime societal savings of approximately $12 billion (net present value in 2009 dollars) from the more than 600,000 total knee arthroplasties performed in the U.S. in 2009. These benefits will accrue primarily to the patients in the form of additional working years and increased income while in the workforce. These findings demonstrate the importance of using a societal perspective for evaluating the costs and benefits of knee replacement surgery. With the expected continued growth of total knee arthroplasty, there will be increased pressure on payers to reduce the use of this procedure by imposing coverage restrictions or higher copayments. Our study demonstrates the potential for substantial negative societal effects if payers and policy makers unduly restrict access to appropriate total knee arthroplasty.

Table 3.1
Utilities and Costs∗

State	Utility	Direct Cost ($)
End-stage Osteoarthritis of the Knee	0.69	$5,282[a]
Current primary TKA and rehabilitation	0.78	$24,793[b]
Full benefit after primary or revision TKA	0.835	$4,770[a]
Limited benefit after primary or revision TKA	0.76	$5,282[a]
Current revision TKA and rehabilitation	0.781	$30,199[b]
Failed primary TKA	0.5175	$7,923[a]
Failed revision TKA	0.5175	$7,923[a]
Death	0	$0

[*] Estimates were adjusted to reflect different reimbursement rates across payers (e.g., private, Medicare, Medicaid). Estimates include costs from the index hospitalization to three months after discharge from the index hospitalization. All costs are expressed in 2009 dollars. TKA = total knee arthroplasty.
[a] Assumption from Losina et al. (2009) after converting from 2006 to 2009 dollars and adjusting for all-payer reimbursement levels.
[b] Assumption derived from the authors' analysis of the Medicare 2009 5% Standard Analytic Inpatient file.
[c] The utility value of 0.781 used for the primary and revision TKA health states was derived by averaging the utility before treatment and the weighted mean of the full and limited-benefit utilities after treatment.

Table 3.2
Parameters for Each Health State

Parameter	Probability
Full benefit	0.88[a]
Limited benefit	0.12[a]
Failure within first year	0.0105
Failure within first year and undergoing revisions	0.1
Surgical mortality	0.0063*Natural Mortality
Failure after first year	0.0134
Failure after first year and undergoing revision	0.5

[a] Source: Losina et al. (2009). Natural mortality was obtained from U.S. Census data.

Table 3.3
Summary of Benefits from Surgical Treatment According to Age*

Age Group	Direct Cost Offsets	Total Societal Savings	Net Societal Savings	Difference in QALY
40-44 Years	$19,232	$177,342	$158,110	3.4
45-49 Years	$19,428	$149,930	$130,503	3.2
50-54 Years	$19,637	$119,521	$99,884	3.1
55-59 Years	$19,871	$85,263	$65,391	2.9
60-64 Years	$20,167	$50,531	$30,364	2.6
65-69 Years	$20,523	$22,398	$1,875	2.4
70-79 Years	$21,193	$6,520	-$14,672	2.1
80+ Years	$22,339	$2,978	-$19,362	1.8
All	$20,635	$39,565	$18,930	2.4

* Authors' calculations. Age-weighted mean based on the distribution of total knee arthroplasties performed in the U.S. in 2009.

Table 3.4
Direct Medical Costs and QALYs According to Age and Treatment*

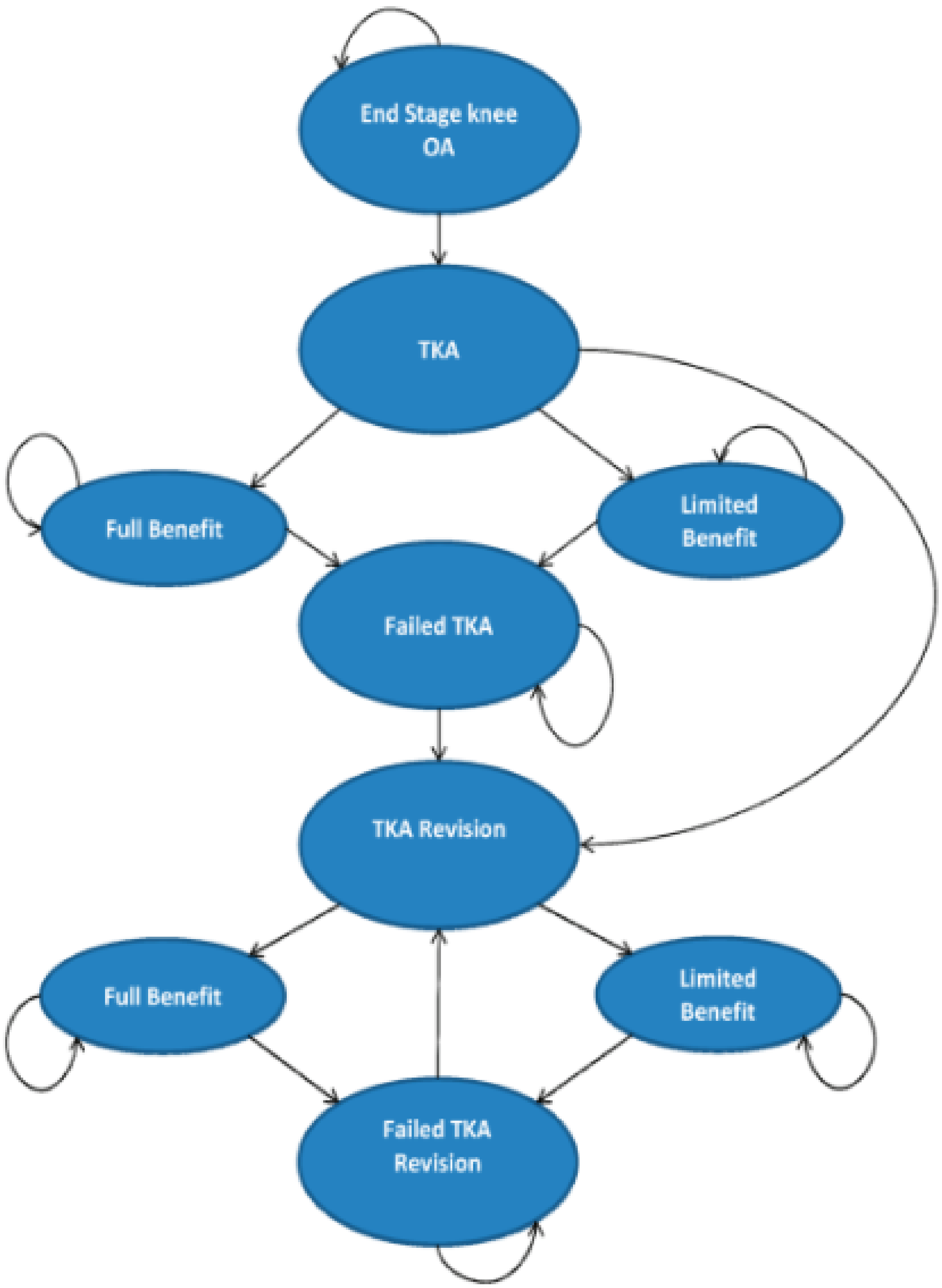
	Total Direct Costs			QALYs		
Age Group	Surgery	Non-Surgery	Difference in total Direct Medical Costs	Surgery	Non-Surgery	Difference in QALYs
40-44 Years	$142,437	$123,205	$19,232	18.8	15.4	3.4
45-49 Years	$134,684	$115,256	$19,428	17.6	14.4	3.2
50-54 Years	$126,346	$106,710	$19,637	16.3	13.2	3.1
55-59 Years	$117,032	$97,161	$19,871	14.9	12	2.9
60-64 Years	$107,069	$86,902	$20,167	13.3	10.7	2.6
65-69 Years	$96,232	$75,709	$20,523	11.6	9.2	2.4
70-79 Years	$80,071	$58,878	$21,193	9.1	7	2.1
80+ Years	$60,866	$38,527	$22,339	6.1	4.3	1.8

* Authors' calculations.

Table 3.5
Sensitivity Analysis of Selected Model Parameters*

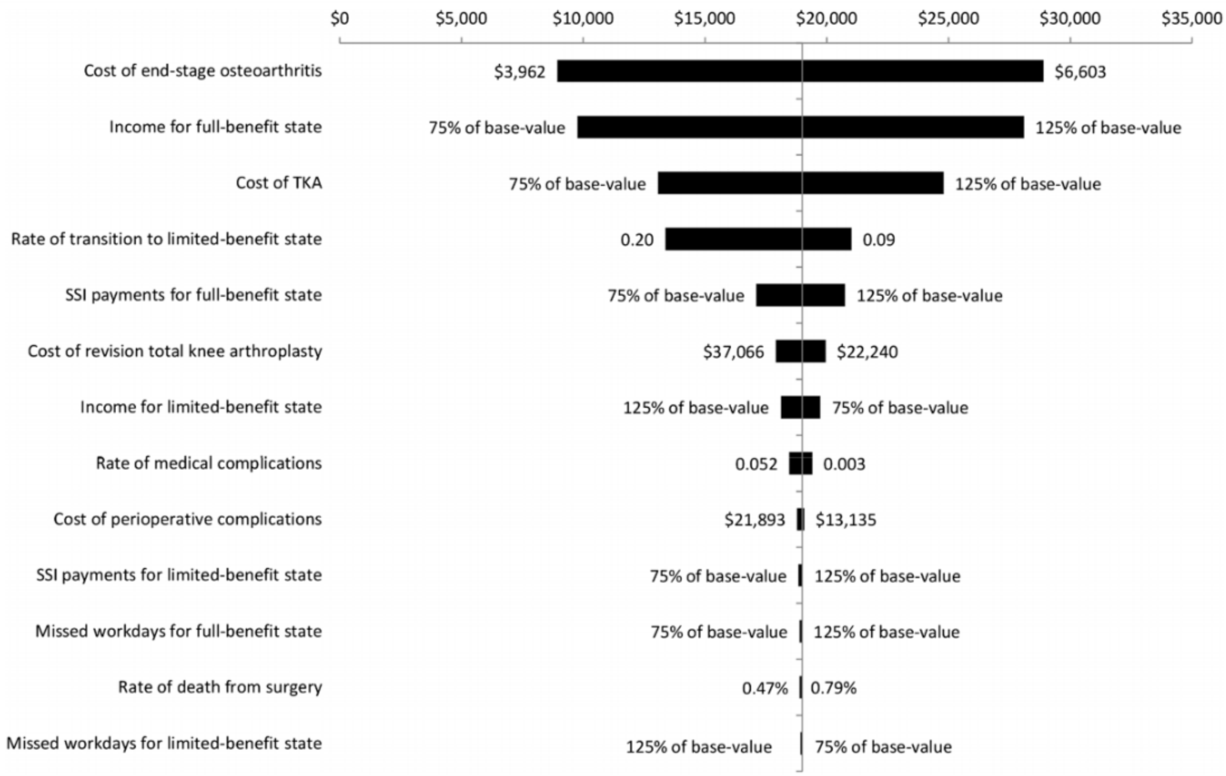
Parameter	Base Model Value	Value Range	Range of Net Societal Savings*	Range of Change in QALY*
Utility in Limited-Benefit State	0.76	0.57-0.95	na	2.30-2.52
Utility in Full-Benefit State	0.835	0.626-0.1	na	1.50-3.21
Rate of Transition to Limited-Benefit	0.12	0.09-0.20	$21,015 - $13,371	2.42-2.40
Rate of Medical Complication	0.028	0.003-0.052	$19,405 - $18,455	N/A
Rate of Death from Surgery	0.0063 x Natural Mortality	0.0047-0.0079	$18,886 - $18,960	2.41-2.31
Cost of End-stage OA	$5,282	$3,962 - $6,603	$8,935 - $28,899	na
Cost of primary TKA	$24,247	$18,185 - $30,309	$13,064 - $24,796	na
Cost of revision TKA	$29,653	$22,240 - $37,066	$19,955 - $17,905	na
Cost of perioperative complications	$17,514	$13,135 - $21,893	$19,081 - $18,779	na
SSI payments for full-benefit state	Varies by age	25% intervals (50% decrease)	$17,109-$20,751 ($15,288)	na
Income for full-benefit state	Varies by age	25% intervals (50% decrease)	$9,762 - $28,098 ($594)	na
Missed workdays for full-benefit state	Varies by age	25% intervals (50% decrease)	$18,883 - $18,997 ($18,836)	na
SSI payments for limited-benefit state	Varies by age	25% intervals (50% decrease)	$18,840 - $18,19,020 ($19,110)	na
Income for limited-benefit state	Varies by age	25% intervals (50% decrease)	$19,734 - $18,126 ($20,539)	na
Missed workdays for limited-benefit state	Varies by age	25% intervals (50% decrease)	$18,937 - $18,923 ($18,945)	na

* Authors' calculation. na = not applicable. Age-weighted mean based on the distribution of total knee arthroplasties performed in the U.S. in 2009.



Notes: Death is an absorbing state and not included in this representation. OA = osteoarthritis; TKA= total knee arthroplasty.

Figure 3.1
Representation of Markov Model For End-Stage Knee OA



Notes: Sensitivity analysis of total societal savings (net savings in direct and indirect costs) from total knee arthroplasty. The base value of societal savings was $18,930. OA=osteoarthritis, and TKA = total knee arthroplasty.

Figure 3.2
Sensitivity Analysis of Total Cost Savings For End-Stage Knee OA

Chapter A: Appendix A

Table A.1
Log of Patient Volume In Aggregate and By Specialty Market With MSAxTIME (2000 - 2009)

	Model 2.3	Model 2.4	Model 2.5	Model 2.6			
	ln(All)	ln(All)	ln(All)	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
# of ASC	-0.0206	-0.0137					
	(-1.42)	(-1.15)					
EYE ASC			-0.0591	-0.263*	-0.0873	0.0199	-0.102**
			(-1.52)	(-2.39)	(-1.16)	(0.30)	(-2.68)
NMK ASC			-0.0207	-0.0290	-0.0980+	0.0484	-0.0550
			(-0.74)	(-0.34)	(-1.88)	(1.04)	(-1.46)
GS ASC			-0.000563	-0.0207	0.0920*	-0.0752	0.0193
			(-0.02)	(-0.29)	(2.51)	(-1.47)	(0.76)
MS ASC			-0.0211	0.00543	-0.0466	0.0282	-0.000831
			(-1.19)	(0.07)	(-1.60)	(1.24)	(-0.02)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HSA Controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Standard errors for Models 2.3, 2.4, and 2.5 are robust and clustered at HSA. Model 2.6 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.2
Log of Patient Volume In Aggregate and By Specialty Market And Ownership Status with MSAxTIME (2000 - 2009)

	Model 2.4	Model 2.5	Model 2.6			
	ln(All)	ln(All)	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
# of ASC	-0.0295+ (-1.83)					
NP × # of ASC	0.0237 (1.47)					
EYE ASC		-0.0965 (-1.46)	-0.497** (-2.99)	-0.109 (-1.21)	-0.0617 (-0.64)	-0.0388 (-0.63)
NMK ASC		0.0204 (0.39)	-0.0581 (-0.51)	-0.0830 (-1.34)	0.184** (3.19)	-0.0942 (-1.54)
GS ASC		-0.0337 (-0.88)	-0.102 (-0.98)	0.0534 (1.16)	-0.0779 (-1.02)	-0.00758 (-0.19)
MS ASC		-0.0215 (-0.65)	-0.0340 (-0.26)	-0.0400 (-1.04)	0.0170 (0.49)	-0.0948* (-1.99)
NFP × EYE ASC		0.0360 (0.56)	0.385+ (1.88)	0.0346 (0.43)	0.135 (1.51)	-0.0814 (-0.95)
NFP × NMK ASC		-0.0448 (-0.79)	0.0240 (0.17)	-0.0285 (-0.34)	-0.210*** (-3.52)	0.0619 (0.72)
NFP × GS ASC		0.0545 (1.36)	0.111 (0.90)	0.0597 (1.20)	0.00971 (0.16)	0.0357 (0.61)
NFP × MS ASC		0.0628+ (1.72)	0.0875 (0.54)	-0.00743 (-0.14)	0.0167 (0.42)	0.157* (2.22)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Standard errors for Models 2.4 and 2.5 are robust and clustered at HSA. Model 2.6 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.3
Charlson Comorbidity Index with MSAxTIME (2000 - 2009)

	Model 2.8	Model 2.9			
	(1) All Volume	(2) EYE	NMK	GS	OTHER
EYE ASC	0.00875	0.0260	0.0154	0.0146	-0.0159
	(0.35)	(0.94)	(1.28)	(0.98)	(-0.53)
NM ASC	0.00178	-0.0122	-0.00521	-0.0182	0.0281
	(0.14)	(-0.47)	(-0.57)	(-1.88)	(1.81)
GS ASC	0.00179	-0.0367*	-0.0133*	0.0193*	-0.00175
	(0.13)	(-2.49)	(-2.14)	(2.04)	(-0.09)
MS ASC	0.00232	0.0128	0.0106	-0.00247	0.0202
	(0.23)	(0.88)	(1.39)	(-0.33)	(1.65)
NP × EYE ASC	-0.0277	-0.0345	-0.0422**	-0.0322*	-0.000906
	(-1.15)	(-1.12)	(-3.04)	(-1.99)	(-0.03)
NP × NM ASC	0.00882	0.0157	0.0136	0.0241*	-0.0234
	(0.51)	(0.59)	(1.32)	(2.18)	(-1.16)
NP × GS ASC	0.00205	0.00903	0.00803	-0.00436	0.00434
	(0.14)	(0.53)	(1.11)	(-0.45)	(0.22)
NP × MS ASC	-0.00744	-0.0148	-0.0138	-0.00385	-0.0357**
	(-0.63)	(-0.96)	(-1.23)	(-0.35)	(-2.87)
Time FE	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.4
Log Volume of Government Insured Patients with MSAxTIME (2000 - 2009)

	Model 2.8	Model 2.9			
	ln(Vol)	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	-0.0207	-0.550**	-0.0130	0.00593	0.0555
	(-0.16)	(-2.79)	(-0.09)	(0.04)	(0.46)
NMK ASC	-0.0222	-0.0626	-0.115	0.124+	-0.126
	(-0.31)	(-0.51)	(-1.50)	(1.69)	(-1.52)
GS ASC	-0.0575	-0.0536	0.0366	-0.0550	-0.0457
	(-1.48)	(-0.48)	(0.70)	(-0.61)	(-1.02)
MS ASC	-0.0287	-0.0336	-0.0313	-0.00746	-0.106
	(-0.67)	(-0.24)	(-0.69)	(-0.18)	(-1.59)
NFP × EYE ASC	-0.0894	0.377	-0.107	0.0510	-0.217
	(-0.71)	(1.50)	(-0.74)	(0.33)	(-1.49)
NFP × NMK ASC	-0.00196	0.0625	-0.0218	-0.154*	0.0774
	(-0.03)	(0.39)	(-0.23)	(-2.03)	(0.75)
NFP × GS ASC	0.0983*	0.0739	0.100+	0.000622	0.0959
	(2.48)	(0.55)	(1.80)	(0.01)	(1.49)
NFP × MS ASC	0.0847*	0.0573	0.0249	0.0528	0.170*
	(1.99)	(0.33)	(0.35)	(1.13)	(2.08)
Time FE	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.

(2) Model 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.

(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.5
Log Volume of Privately Insured Patients with MSAxTIME (2000 - 2009)

	Model 2.8	Model 2.9			
	ln(Vol All)	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	-0.142*	-0.347**	-0.139	-0.0952	-0.107*
	(-2.18)	(-2.59)	(-1.37)	(-1.01)	(-2.16)
NMK ASC	0.0902	-0.0714	-0.0338	0.233***	-0.0185
	(1.50)	(-0.84)	(-0.52)	(3.43)	(-0.31)
GS ASC	-0.0168	-0.0398	0.0593	-0.0769	0.0183
	(-0.37)	(-0.47)	(1.13)	(-0.95)	(0.42)
MS ASC	-0.0483	-0.0277	-0.0739+	-0.0340	-0.132*
	(-0.99)	(-0.28)	(-1.81)	(-0.69)	(-2.33)
NFP × EYE ASC	0.109	0.431**	0.0808	0.173+	0.0241
	(1.64)	(3.07)	(0.99)	(1.67)	(0.34)
NFP × NMK ASC	-0.134*	-0.0212	-0.0620	-0.284***	-0.0243
	(-2.12)	(-0.19)	(-0.79)	(-4.11)	(-0.30)
NFP × GS ASC	0.0329	0.0380	0.0543	-0.000521	-0.00472
	(0.75)	(0.36)	(1.09)	(-0.01)	(-0.08)
NFP × MS ASC	0.102	0.0865	0.0126	0.0650	0.204*
	(1.62)	(0.67)	(0.29)	(1.21)	(2.49)
Time FE	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.6
Log Volume of Uninsured Patients with MSAxTIME (2000 - 2009)

	Model 2.8	Model 2.9			
	ln(All Vol)	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	0.0371	-0.0838	0.0458	-0.0626	0.139
	(0.32)	(-1.02)	(0.34)	(-0.52)	(1.00)
NMK ASC	-0.112	-0.101	-0.0813	0.202**	-0.230*
	(-1.24)	(-1.62)	(-1.03)	(3.00)	(-1.99)
GS ASC	-0.0435	-0.0756	-0.0145	0.0179	-0.0537
	(-0.50)	(-1.54)	(-0.17)	(0.21)	(-0.55)
MS ASC	-0.0999	-0.131**	0.00815	0.0531	-0.219*
	(-1.43)	(-2.91)	(0.24)	(1.01)	(-2.24)
NFP × EYE ASC	-0.0892	0.0217	-0.0935	0.0859	-0.182
	(-0.54)	(0.21)	(-0.54)	(0.61)	(-0.95)
NFP × NMK ASC	0.142	0.131+	0.0900	-0.118	0.212
	(1.14)	(1.66)	(0.97)	(-1.43)	(1.20)
NFP × GS ASC	0.0509	0.0513	0.0892	-0.0143	0.0549
	(0.42)	(0.84)	(0.76)	(-0.15)	(0.40)
NFP × MS ASC	0.0832	0.0226	-0.0948+	-0.0660	0.197
	(0.78)	(0.35)	(-1.89)	(-1.20)	(1.31)
Time FE	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.7
Log Volume of Unique Physician Count with MSAxTIME (2000 - 2009)

	Model 2.8	Model 2.9			
	ln(All)	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	-0.0526	-0.143*	-0.0195	-0.000649	-0.0629
	(-1.56)	(-2.37)	(-0.52)	(-0.02)	(-1.62)
NMK ASC	0.0453	-0.0271	-0.0156	0.00820	0.0243
	(1.09)	(-0.69)	(-0.53)	(0.26)	(0.60)
GS ASC	-0.0234	-0.0223	-0.0148	0.0146	-0.0142
	(-0.95)	(-0.59)	(-0.71)	(0.51)	(-0.60)
MS ASC	-0.0485+	-0.0630	-0.0342	-0.0323	-0.0798**
	(-1.85)	(-1.44)	(-1.59)	(-1.64)	(-2.81)
NFP × EYE ASC	-0.0171	0.140*	-0.0601	0.0123	-0.0146
	(-0.32)	(2.25)	(-1.43)	(0.25)	(-0.25)
NFP × NMK ASC	-0.00703	0.00224	0.0344	0.00158	-0.00102
	(-0.14)	(0.04)	(0.76)	(0.04)	(-0.02)
NFP × GS ASC	0.0264	0.0420	0.0480+	-0.0143	0.0284
	(0.90)	(1.00)	(1.74)	(-0.45)	(0.78)
NFP × MS ASC	0.0726*	0.109*	0.0169	-0.00150	0.102*
	(2.15)	(2.04)	(0.52)	(-0.05)	(2.43)
Time FE	Yes	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes	Yes
Observations	6200	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.8 standard errors are robust and clustered at HSA. Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.8
Log of Patient Volume In Aggregate and By Specialty Market And Ownership Status with NFP Status x TIME (2000 - 2009)

	Model 2.9			
	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	-0.358*	-0.0880	-0.0663	-0.0492
	(-2.24)	(-1.09)	(-0.69)	(-0.81)
NMK ASC	0.0216	-0.0251	0.168*	-0.0661
	(0.16)	(-0.41)	(2.17)	(-1.08)
GS ASC	-0.159	0.0521	-0.0608	-0.0395
	(-1.31)	(1.09)	(-0.61)	(-0.96)
MS ASC	-0.0190	-0.0235	0.00468	-0.105*
	(-0.16)	(-0.71)	(0.10)	(-2.14)
NFP × EYE ASC	0.381+	0.121	0.203*	-0.00300
	(1.77)	(1.24)	(2.06)	(-0.03)
NFP × NMK ASC	-0.0515	-0.0711	-0.262***	0.0289
	(-0.33)	(-0.83)	(-3.67)	(0.35)
NFP × GS ASC	0.0746	-0.000782	0.0435	0.0335
	(0.48)	(-0.01)	(0.68)	(0.62)
NFP × MS ASC	0.0518	0.0332	0.0441	0.189**
	(0.33)	(0.59)	(0.95)	(2.81)
Time FE	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes
Observations	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.9
Charlson Comorbidity Index with NFP Status X TIME (2000 - 2009)

	Model 2.9			
	(1) EYE	NMK	GS	OTHER
EYE ASC	0.0283 (0.97)	0.00783 (0.75)	0.00776 (0.51)	-0.00751 (-0.26)
NMK ASC	-0.00953 (-0.36)	-0.00604 (-0.73)	-0.0134 (-1.32)	0.0101 (0.66)
GS ASC	-0.0280 (-1.79)	-0.0152∗ (-2.27)	0.00469 (0.40)	-0.0141 (-0.89)
MS ASC	0.0251 (1.59)	0.00801 (1.44)	-0.00577 (-0.93)	0.0109 (0.89)
NFP × EYE ASC	-0.0398 (-1.23)	-0.0444∗∗ (-2.91)	-0.0350∗ (-2.01)	0.00171 (0.06)
NFP × NMK ASC	0.0101 (0.35)	0.0180 (1.62)	0.0307∗ (2.57)	-0.00682 (-0.32)
NFP × GS ASC	0.000166 (0.01)	0.0111 (1.23)	-0.00212 (-0.19)	0.0103 (0.42)
NFP × MS ASC	-0.0232 (-1.31)	-0.0155 (-1.30)	-0.00491 (-0.44)	-0.0239∗ (-1.96)
Time FE	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes
Observations	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.10
Log Volume of Government Insured Patients with NFP Status x TIME (2000 - 2009)

	Model 2.9			
	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	-0.363+	-0.00226	-0.0195	0.0415
	(-1.91)	(-0.02)	(-0.13)	(0.40)
NMK ASC	0.00411	-0.0657	0.0923	-0.110
	(0.03)	(-0.87)	(1.02)	(-1.43)
GS ASC	-0.149	0.0171	-0.0514	-0.0961+
	(-1.09)	(0.28)	(-0.45)	(-1.78)
MS ASC	-0.0230	-0.0200	-0.0225	-0.121+
	(-0.18)	(-0.47)	(-0.39)	(-1.86)
NFP $\times$ EYE ASC	0.362	0.0177	0.153	-0.123
	(1.48)	(0.13)	(1.02)	(-0.90)
NFP $\times$ NMK ASC	-0.0203	-0.0533	-0.186+	0.0547
	(-0.11)	(-0.52)	(-1.85)	(0.54)
NFP $\times$ GS ASC	0.0398	0.0606	0.0437	0.110+
	(0.24)	(0.88)	(0.53)	(1.69)
NFP $\times$ MS ASC	0.0309	0.0797	0.0980+	0.216**
	(0.19)	(1.17)	(1.83)	(2.76)
Time FE	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes
Observations	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.

(2) Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.

(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.11
Log Volume of Privately Insured Patients with NFP Status x TIME (2000 - 2009)

	Model 2.9			
	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	-0.318**	-0.125	-0.105	-0.136**
	(-2.67)	(-1.48)	(-1.15)	(-2.77)
NMK ASC	0.0237	0.0395	0.245**	0.0350
	(0.28)	(0.54)	(2.89)	(0.56)
GS ASC	-0.108	0.0754	-0.0480	0.0142
	(-1.21)	(1.39)	(-0.48)	(0.34)
MS ASC	-0.0235	-0.0525	-0.0338	-0.141*
	(-0.26)	(-1.27)	(-0.55)	(-2.54)
NFP × EYE ASC	0.440**	0.139	0.192+	0.0756
	(3.12)	(1.39)	(1.82)	(0.89)
NFP × NMK ASC	-0.104	-0.131	-0.367***	-0.0951
	(-0.93)	(-1.48)	(-4.63)	(-1.07)
NFP × GS ASC	0.0598	-0.0302	0.0306	-0.0304
	(0.51)	(-0.42)	(0.42)	(-0.60)
NFP × MS ASC	0.0669	0.0426	0.0769	0.227**
	(0.59)	(0.76)	(1.39)	(3.00)
Time FE	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes
Observations	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.

(2) Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.

(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.12
Log Volume of Uninsured Patients with NFP Status x TIME (2000 - 2009)

	Model 2.9			
	ln(EYE)	ln(NMK)	ln(GS)	ln(OTHER)
EYE ASC	-0.00784	0.00895	-0.0192	0.173
	(-0.11)	(0.06)	(-0.15)	(1.32)
NMK ASC	-0.116*	-0.0160	0.173*	-0.199+
	(-2.13)	(-0.22)	(2.54)	(-1.80)
GS ASC	-0.0557	-0.0280	-0.0245	-0.0918
	(-1.21)	(-0.29)	(-0.22)	(-1.05)
MS ASC	-0.132**	-0.0230	-0.0207	-0.220*
	(-2.88)	(-0.69)	(-0.38)	(-2.09)
NFP × EYE ASC	0.0169	0.0104	0.177	-0.0820
	(0.20)	(0.07)	(1.26)	(-0.44)
NFP × NMK ASC	0.122	0.0463	-0.131	0.207
	(1.50)	(0.52)	(-1.52)	(1.22)
NFP × GS ASC	0.00407	0.0488	0.00523	0.0597
	(0.08)	(0.47)	(0.05)	(0.54)
NFP × MS ASC	0.0127	-0.0514	-0.0215	0.221
	(0.20)	(-0.96)	(-0.36)	(1.50)
Time FE	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes
Observations	6200			

(1) + signifies $p<0.1$; * signifies $p<0.05$; ** signifies $p<0.01$; *** signifies $p<0.001$. T-statistics presented in parentheses.
(2) Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Table A.13
Log Volume of Unique Physician Count with NFP Status x TIME (2000 - 2009)

	Model 2.9			
	EYE	NMK	GS	OTHER
EYE ASC	-0.131∗	-0.0250	-0.0322	-0.0896∗
	(-2.40)	(-0.85)	(-0.78)	(-2.24)
NMK ASC	-0.00220	0.0123	0.0219	0.0208
	(-0.05)	(0.37)	(0.59)	(0.57)
GS ASC	-0.0363	-0.0253	0.00996	-0.0260
	(-0.85)	(-1.28)	(0.29)	(-1.05)
MS ASC	-0.0782+	-0.0309	-0.0426	-0.0922∗∗
	(-1.93)	(-1.18)	(-1.59)	(-3.25)
NFP × EYE ASC	0.172∗∗	-0.0142	0.0706	0.0726
	(2.66)	(-0.29)	(1.41)	(1.04)
NFP × NMK ASC	0.00554	0.0153	-0.00963	-0.0176
	(0.10)	(0.32)	(-0.21)	(-0.31)
NFP × GS ASC	0.0393	0.0233	-0.0218	0.0177
	(0.79)	(0.66)	(-0.66)	(0.49)
NFP × MS ASC	0.118∗	0.0428	0.0327	0.151∗∗∗
	(2.21)	(1.33)	(1.14)	(3.86)
Time FE	Yes	Yes	Yes	Yes
HOPD FE	Yes	Yes	Yes	Yes
HSA Controls	Yes	Yes	Yes	Yes
Observations	6200			

(1) + signifies p<0.1 ; * signifies p<0.05; ** signifies p<0.01; *** signifies p<0.001. T-statistics presented in parentheses.
(2) Model 2.9 estimated as seemingly unrelated regression equations such that errors are allowed to correlate across equations; standard errors are also robust and clustered at HSA.
(3) HSA controls include market-specific HHI, number of hospitals, proportion of uninsured population, proportion of population in poverty, total population in 100k, total population in 100k squared; hospital-specific controls include small and medium bed size indicators. Partial F-tests indicate predictive power of ASC variables, including their interactions, market controls, time and hospital fixed effects, and hospital controls.

Chapter B: Appendix B

This technical appendix describes our approach to estimating the indirect costs associated with end-stage osteoarthritis of the knee and the effects of total knee arthroplasty (TKA) on these costs. In addition, we present our approach to convert Medicare to all-payer reimbursement levels.

B.1 Framework for Estimating Indirect Costs

We used data from the National Health Interview Survey (NHIS) to generate regression coefficients that described the statistical relationship between physical functional status and economic outcomes. We applied regression coefficients to surgical outcomes data obtained from a survey of patients treated at a multi-practice orthopaedic surgeon group to estimate the effect of surgery on income, missed work days, and the probability of receiving disability payments (Supplemental Security Income (SSI)). These findings were incorporated into a Markov decision model to estimate total societal savings resulting from total knee replacement. The NHIS, which is used to monitor the health of the U.S. population, is one of the major data collection programs of the National Center for Health Statistics (NCHS) which is part of the Centers for Disease Control and Prevention (CDC). The NHIS covers the civilian noninstitutionalized population residing in the United States with an expected

NHIS sample size (completed interviews) of approximately 35,000 households each year.

B.2 Estimating the relationship between functional limitations and indirect costs

The NHIS collects information from a stratified random sample of the U.S. population on physical function, economic factors such as employment status and income, and other patient characteristics. Our analysis combined the 2003 through 2010 NHIS files to increase the sample size, resulting in a sample of 202,525 adults age 18 and older living in non-institutional settings. The NHIS asks respondents: By yourself, and without using any special equipment, how difficult is it for you to...

- Walk a quarter of a mile - about 3 city blocks?
- Walk up 10 steps without resting?
- Sit for about 2 hours?
- Reach up over your head?
- Stand or be on your feet for about 2 hours?
- Stoop, bend, or kneel?
- Lift or carry something as heavy as 10 pounds such as a full bag of groceries?
- Push or pull large objects like a living room chair?

Responses to each question include: (1) Not at all difficult, (2) Only a little difficult, (3) Somewhat difficult, (4) Very difficult, (5) Can't do at all. Our analysis focuses only on activity limitations where the respondent indicates that back pain, bone/joint injury, or arthritis contributed to his/her limitations. Using regression analysis we compare the probability of being employed, household income, missed worked days, and probability of receiving disability payments for adults with activity limitations to economic outcomes for adults without activity limitations. Responses to physical functioning questions were decoupled such that for each question and each response (e.g., only a little difficult, somewhat difficult, very difficult, can't do at all, and not at all difficult), a binary variable (1=yes, 0=no) was created. Persons claiming that the physical functioning task was not at all difficult were used as the comparison group. We including the following control variables in each model: age (age groups: 18-39, 40-44, 45-49, 50-54, 55-59, 60 to 64, 65-69, and 70 years and over), sex, highest educational attainment (high school diploma, baccalaureate degree, post-baccalaureate degree), and occupation (for analysis of household income and missed worked days). Logistic regression was used for employment and disability payment status models. In the employment model, the dependent variable took on a value of 1 if a survey respondent reported that he or she has a job in the last week. For the disability payment model, the dependent variable took on a value of 1 if a survey respondent reported that he or she was currently receiving SSI. Ordinary least squares regression was used to quantify the impact of activity limitations on household income and missed work days. These models only included respondents who reported that they were employed in the last week. Regression results are shown in Table A1 for the functional outcome variables.

B.3 Physician Group TKA Patient Outcome Data

Predicted values for indirect cost components were obtained by utilizing patient-reported data collected by a physician group practice with multiple locations. Electronic questionnaires were sent to approximately 310 patients who received a TKA between September 2010 and April 2011. A total of 74 responses were received and used in the analyses. The survey contained questions concerning an individuals socioeconomic status and functional ability (using the same questions on functional status as in the NHIS) prior to obtaining surgery and after receiving surgery. Functional questions included the following possible answers: No difficulty, Only a little difficult, Somewhat difficult, Very Difficult, and Cannot do. Numerical values of 1 through 5 were assigned to the responses; with No difficulty assigned a value of 1 and Cannot do assigned a value of 5. Patients were categorized as receiving full-benefit from the TKA if their average, post-surgical response for all functional questions was equal to or less than 3 (somewhat difficult) and limited benefit otherwise. Assuming this response categorization allowed us to match the Losina et al. (2009) distribution of patients experiencing Full-Benefit, which was 88 percent.

B.4 Methods for Combining Indirect Cost Components and Patient Outcome Data

The relationships between functional status and indirect costs were determined by least squares and logistic regression models (above). The results from the models allowed us to determine changes to an individuals probability of being employed, number of missed work days, household income, and disability payments conditional on their level of functional ability in a given year. Data from the 74 patients who received a TKA between 2009 and 2011 allowed us to determine changes in functional measures for TKA recipients. For each observation from the patient outcome data, functional responses were held constant while age was allowed to vary from 40 to 99. This allowed us to obtain predicted values from our indirect cost model for assumed ages 40 to 99 for the probability of being employed, probability of being disabled, income (in dollars), and missed work days for pre- and post-surgical periods. Persons older than 75 years were assumed to be employed with a probability of 0. Thus, there were 59 observations, varied only by age, for each observation of in the patient survey, resulting in a total of 59 x 74 observations. The predicted probabilities for employment, disability, predicted income and missed work days were then averaged at each age. Once the average employment probability by age was obtained, we computed expected income changes from having a TKA as:

Expected Income = (Estimated Income Post Surgery * Probability of Being Employed Post Surgery) (Estimated Income Pre Surgery * Probability of Being Employed Pre Surgery).

Our change in the value of missed worked days from receiving a TKA was computed as:

Expected Value of Missed Work Days = (Estimated Income Post Surgery * Probability of Being Employed Post Surgery*(Missed Work Days Post Surgery/240)) (Estimated Income Pre Surgery * Probability of Being Employed Pre Surgery*(Missed Work Days Pre Surgery/240)).

Additionally, we assumed that workers lost an average of 40 days as a result of the TKA surgery. To account for income lost during this period, average predicted incomes by age were multiplied by an individuals probability of being employed. Changes in expected disability payments were computed by multiplying the change in probability of being disabled due to TKA receipt by SSI payments, by gender and age. Our change in disability payments from receiving a TKA was computed as

Expected Disability Payments = (Estimated disability payment * Probability of Be-

ing on Disability Post Surgery) (Estimated disability payment * Probability of Being on Disability Pre Surgery).

Disability payments were determined as a function of age and gender, as shown in the table below, and were taken from the 2011 Current Population Survey.

B.5 Converting Medicare costs to all-payer costs

Cost estimates based on Medicare payment rates may underestimate payments made by private insurers and overestimate payments made by Medicaid, self-insured, and uninsured patients. To reconcile these differences, we adjusted our estimates of direct medical costs using payment rates of other insurers (as a percentage of the Medicare rate) and then weighted by the national distribution of payers for TKA. We set the payment rates of Medicaid and self-pay patients as 80 percent and 50 percent of the Medicare rate, respectively. For private insurers, we used the payment rates reported in the literature. Ginsburg (2010) estimated that private insurers, on average, paid 139 percent of the Medicare payment rates for inpatient care nationally in 2008. The same study also reported private insurer payments as a percentage of Medicare rates for outpatient services in selected areas, ranging from 193 percent in Cleveland to 368 percent in San Francisco. We used the median of the reported range, which is 280 percent, to adjust costs of outpatient services. The Medicare Payment Advisory Committee (MedPAC) estimated that the private rate for physician services was, on average, 123 percent of the Medicare rate across all services and areas in 2003 (MedPAC, 2005). For all other patients, including those paid by workers compensation, we assumed their rate was the same as the average rates of Medicare and private insurers.

Table B.1
Regression Results from National Health Interview Survey

	All Adults (Age 18+)		Employed Adults (Age 18-74)	
	Employed	Receives SSI	Household Income ($)	Missed Work Days
Intercept	(2.11)*	(1.05)*	22,389.00*	1.54*
Male	0.56*	(0.09)*	1,724.89*	(0.78)*
Age 40-44 vs. <40	0.98*	0.02	6,849.05*	0.44*
Age 45-49 vs. <40	1.00*	0.06	6,586.54*	0.34*
Age 50-54 vs. <40	0.88*	0.06	6,081.18*	0.45*
Age 55-59 vs. <40	0.51*	0.09*	6,982.35*	0.54*
Age 60-64 vs. <40	(0.23)*	0.09*	5,513.12*	0.02
Age 65-69 vs. <40	(1.25)*	0.09*	3,517.98*	-0.15
Age 70+ vs. <40	(2.45)*	(0.26)*	(2,200.42)*	(1.67)*
Difficulty walking vs. no difficulty				
Only a little difficult	0.10*	0.08	(1,622.05)*	2.51*
Somewhat difficult	0.01	0.04	(3,206.39)*	2.77*
Very difficult	(0.11)*	-0.05	(3,577.24)*	3.83*
Can't do at all	(0.28)*	-0.02	(4,562.09)*	6.63*
Difficulty climbing vs. no difficulty				
Only a little difficult	0.07	-0.06	(2,746.64)*	1.27*
Somewhat difficult	0	0	(3,000.66)*	1.03*
Very difficult	0.04	0.17*	(2,811.49)*	2.53*
Can't do at all	(0.19)*	0.17*	-2,899.45	5.48*
Difficulty sitting vs. no difficulty				
Only a little difficult	0.19*	(0.15)*	1,137.17	0.21
Somewhat difficult	0.01	-0.04	455.22	2.21*
Very difficult	-0.03	0.11*	522.52	0.76
Can't do at all	(0.40)*	0.24*	-1,811.47	9.92*
Difficulty reaching vs. no difficulty				
Only a little difficult	0.19*	0.04	349.2	0.56
Somewhat difficult	-0.01	-0.01	461.73	4.60*
Very difficult	(0.20)*	0.09	-802.84	2.97*
Can't do at all	(0.28)*	-0.08		2.97*
Difficulty standing vs. no difficulty				
Only a little difficult	0.28*	-0.07	782.15	0.2
Somewhat difficult	0.06*	-0.01	356.92	2.11*
Very difficult	(0.21)*	0.14*	980.34	1.60*
Can't do at all	(0.66)*	0.09	-782.01	5.06*
Difficulty stooping vs. no difficulty				
Only a little difficult	0.03	0.06	609.53	0.11
Somewhat difficult	0.01	0	-244.53	0.53
Very difficult	0.03	-0.06	-690.16	0.89*
Can't do at all	0.01	-0.07	456.71	4.70*
Difficulty carrying vs. no difficulty				
Only a little difficult	0.04	-0.06	(1,796.57)*	-0.62
Somewhat difficult	0.07	-0.01	(2,486.52)*	1.21*
Very difficult	(0.29)*	0.19*	(4,736.26)*	4.38*
Can't do at all	(0.14)*	0.17*	(4,645.73)*	2.52*
Difficulty pushing vs. no difficulty				
Only a little difficult	0.08*	-0.09	-292.5	1.17*
Somewhat difficult	0.11*	-0.01	-861.07	2.81*
Very difficult	-0.01	0.13*	-441.08	3.36*
Can't do at all	(0.38)*	0.07	1,679.21	14.53*
Has mobility difficulty due to				
Back pain	0.09*	-0.03	-297.35	1.32*
Joint injury	0.09*	0.01	985	4.70*
Musculoskeletal condition	(0.15)*	0.15*	-603.61	2.47*
Arthritis	0.15*	0.09	257.24	(1.38)*

Source: Author' analysis of the NHIS 2003-2010 data.
Notes: (1) Coefficients from Logistic regression.
(2) Coefficients from Ordinary Least Squares regression.
Comparison group is female, under age 40, no activity limitations, year 2010, unemployed
or occupation not available (for regressions that include occupation), and no high school degree.
*Statistically significant at the 0.05 level. Additional control variables included in the model but not shown:
dummy variables for survey year and occupation.

Table B.2
TKA Patient Responses from Rothman Institute (n=74)

	Pre-Surgical Responses		Post-Surgical Responses	
Questions	% in Full-Benefit	% in Limited-Benefit	% in Full-Benefit	% in Limited-Benefit
Walk a quarter of a mile	48%	52%	90%	10%
Walk up 10 steps	64%	36%	92%	8%
Sit for about 2 hours	85%	14%	100%	0%
Reach up over your head	96%	4%	99%	1%
Stand or be on your feet for about 2 hours	49%	51%	81%	19%
Stoop, bend, or kneel	33%	67%	75%	25%
Lift or carry 10 lbs	74%	26%	93%	7%
Push or pull large objects (e.g., chair)	63%	37%	89%	11%

Notes: Differences between average pre- and post- surgical scores are statistically significant at $p<0.001$.

Table B.3
Disability Payments

Age	Male	Female
18-39	$8,816	$9,090
40-44	$14,296	$7,619
45-49	$16,741	$12,824
50-54	$17,500	$12,824
55-59	$17,566	$9,578
60-64	$21,208	$11,052
65-69	$13,896	$9,587
70+	$15,667	$8,756

Notes: Amounts in 2009 dollars.

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