Title
Price Variation for Colonoscopy in a Commercially Insured Population

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Publication Date
2014

Peer reviewed|Thesis/dissertation

Price Variation for Colonoscopy in a Commercially Insured Population

By

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A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Health Services and Policy Analysis

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Richard M. Scheffler, Chair
Professor William H. Dow
Professor Benjamin Handel

Fall 2014

Abstract

Price Variation for Colonoscopy in a

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Price variation is acceptable in most markets because: 1) higher prices reflect better quality or convenience; 2) the price, and usually the quality, of those goods is generally known to the consumer before that good is purchased, and at the very least after it is purchased; and 3) the "search costs" of discovering the price or quality is reflected in the final price. But these attributes are generally inapplicable to health care, where prices, though widely variable, are non-transparent and do not reflect the quality of medical services. This study investigates the determinants of price and drivers of price variation using adjudicated fee-for-service claims from a large commercial insurer with nearly three quarters market share. The scope of the study was narrowed to diagnostic and therapeutic colonoscopy, a well-defined procedure with substantial price variation. Consistent with both the empirical and theoretical work in the bargaining and price concentration literature, I found a substantial positive relationship between market share and a facility's colonoscopy price relative to the price in the market. I estimated that for every percentage point increase in a system or individual facility's bed share, relative price increases by three to four percentage points; this result was stable across a number of specifications and included controls for facility, system, and county characteristics. Further, I found that an increase in the Hirschman-Herfindahl Index (HHI) by 1,000 points was associated with a decrease in the coefficient of variation, a measure of spread, by only 1.6 percentage points. While this effect size was quite small in magnitude, (for comparison, the standard deviation of the coefficient of variation was 0.14), it was robust to the addition of several county-level controls. Colonoscopy is a well-defined procedure whose negotiated price within a given CPT code is highly variable and strongly dependent upon market share. Knowing which "policy lever" to pull to address price variation in the commercial market will require data on more markets and procedures to understand whether price variation is justified; if market

share is associated with better quality, then price variation is warranted, but if market share represents only bargaining power, then variation may be unwarranted. The positive relationship between market share and price is of particular policy significance in the current political climate with merger incentives created by the 2010 Patient Protection and Affordable Care Act.

To Dad, my constant cheerleader

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Acknowledgements

Several people and animals made my life better while writing this dissertation. Most of all, I'd like to thank my husband, Kevin Monahan, for cooking me dinners, doing the laundry and the dishes, waking up early to take out the dogs, and not whimpering one bit while doing any of it. I love him very much. Gracie and Huxley the dogs did whimper a bit but made my life much better anyway. Thanks so much to my parents, who essentially had to go through this process with me, and to my brother Jonah, who is always on my side and makes me laugh in absurd situations. Grace and Kate, I wish I could consolidate my besties on one coast; I could not have gotten through school without you two. Thanks to my fellow HSPAers Peter Martelli and April Falconi Mengel for helping me to get through the program with humor, to Justin White for his excellent and continued mentorship, and to our past and current Program Managers Dion Shimatsu-Ong and Ghada Haddad, respectively, for what I can only describe as extreme moral support. And thanks to my committee, Richard Scheffler, Will Dow, and Ben Handel. I would also like to thank the HSPA program for financial support during my time at Berkeley and participants in the HSPA dissertation seminar for their helpful comments, as well as participants in seminars at the Mailman School of Public Health at Columbia University (2014), the School of Public Health at the City University of New York (2014), and conference participants at Academy Health (2013). All errors are mine.

This study was approved by the University of California Berkeley Institutional Review Board.

Chapter 1

Overview and Background

The problem that motivated this dissertation is unwarranted variation in health care spending in the United States. This chapter overviews that problem and gives background information on work that has been done examining its scope and etiology. I link the issue of price variation to that of market concentration, the latter of which has been pointed to as a major culprit for high prices as well as the large spread in prices seen in medical care in the U.S.

1.1 Overview

Variability in prices is an acceptable phenomenon in most markets. There is a substantial spread in prices in the markets for cars, hotels, and housing. But with some exceptions especially in the extreme, such variability is not alarming for several reasons: 1) higher prices reflect better quality or convenience; 2) the price, and usually the quality, of those goods is generally known to the consumer before that good is purchased, and at the very least after it is purchased; and 3) the "search costs" of discovering the price or quality is reflected in the final price. But these attributes generally do not apply to the health care context. Secret negotiations between provider and insurer, non-transparent pricing for services, and lack of incentive for price comparisons as a result of low cost-sharing have contributed to a system where neither physicians nor patients may be able to foresee the price of medical services, and spending is not commensurate with quality. There is strong and consistent evidence that health care spending is not correlated with better health care outcomes ([Fisher et al., 2003a]; [Fisher et al., 2003b]; [Sirovich et al., 2006]; [Fowler et al., 2008]; [Wennberg et al., 2009]; [Newhouse et al., 2013]. Instead, price variations for the commercially insured may reflect factors that are warranted, such as wages for nurses or administrative staff, on the one hand, or factors that are unwarranted or in a gray area, such as bargaining power or technology, on the other hand [Wennberg, 2011].[1] Of particular concern is whether providers or systems of providers that negotiate higher

[1] The language of acceptable and unacceptable variations has generally been used in the context of national medical care spending, e.g. Newhouse et al. [2013]. For example, regional variations in

prices with insurers are truly "deserving" of those prices, based on their patient, staff, and service mix, and based on quality and efficiency, or whether they are just better bargainers, an issue of particular concern with providers' renewed interest in mergers in wake of the recession and the 2010 Patient Protection and Affordable Care Act (ACA).

Because of the non-transparent nature of negotiations between providers and insurers, often protected by antidisclosure agreements, the considerations behind the price of medical care services are generally a mystery to patients, physicians, and researchers. Ideally, prices should be commensurate with quality, but as previously discussed, there is consistent evidence against such a relationship. For the purposes of aligning quality and prices, quality could be measured in terms of clinical outcomes, adherence to evidence-based practice, or, where, appropriate, patient satisfaction.

A further question is to what extent, if any, price should vary with the level of technology available in a facility. If a facility's technology offers only marginal clinical benefit, but greatly increases the facility's prestige or reputation, then should that facility be reimbursed more highly compared to others in the market? Prestige may increase demand and may also attract more skilled physicians. And teaching hospitals use technology as a tool to teach residents and medical students; the level of technology required at these hospitals is therefore higher and the depreciation greater than at a small community hospital; should these hospitals be reimbursed more highly, not just for their additional personnel costs but for their additional capital outlays as well?

Finally, if we are willing to accept that medical care prices should vary somewhat to account for quality and cost of living, at the very least, then how *much* should they vary? If we can observe everything about a facility and its patients, its geographic and product competitors, and the insurers and employers with which it bargains, then is there room for any residual variation? In other words, is it permissible for a facility to simply be a good bargainer, extracting higher markups from payers? What roles should regulators, legislators, the courts, or the market play in maintaining the balance of power among providers, insurers, and employers?

This dissertation explores drivers of price and price variation for medical care services in a market in which both providers and payers are concentrated. It is possible that the market influence of the two sets of oligopolies balance each other such that the effect of provider concentration is less pronounced than in markets where there is a more diffuse network of payers. Nevertheless, my finding is that provider concentration does have a substantial and statistically significant effect on prices. I chose to narrow the focus of this study to diagnostic and therapeutic colonoscopies because they are well-defined outpatient procedures. The clinical outcome of colonoscopy is

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health status or age distribution might justify spending variation, while the provision of services with low clinical benefit or the duplication of services might not. In this context there are also "gray areas," such as differences in patient demographics and and preferences for the intensity of service provision.

somewhat operator-dependent in that finding polyps requires skill; I did not, however, observe clinical outcomes, so in that sense there are better procedures to study. But colonoscopies also have a high level of price variation, which makes them ideal for studying determinants of price.

1.2 Background

1.2.1 Spending Variation in Medical Care

Since Wennberg and Gittelsohn [1973] published their landmark paper in *Science* documenting disparities in hospital, physician, and nursing home spending across small hospital service areas, there has been great interest in explaining health care spending variation in the United States. These studies have found that higher spending is not the result of justifiable factors such as sicker patients or higher wages, but rather residual factors that are potentially attributable to physician practice styles and patient preferences for more aggressive care in certain areas.[2]

The Medicare population has been the target of many spending studies, but similar research on the commercially insured is more sparse, as data are less readily available for this population. The rationale for adding the commercial sector to the spending variation literature is multifold: patterns of variation may differ [Chernew et al., 2010]; [Newhouse et al., 2013]; drivers of variation may differ [Franzini et al., 2014]; and spending variation in the commercial market reflects an additional layer of potential waste, since prices may vary as well as utilization.

As commercial claims databases have become available for sale or have been collected for individual researcher use, substantial spending variation has been documented for the privately insured as well. For the most part, the commercial spending variation literature has relied on data from MarketScan, claims from large self-insured employers. Using the MarketScan data, Chernew et al. [2010] found that the interquartile range for spending across hospital referral regions (HRRs) from 1996 to 2006 was 1.50, and 1.22 for 2006. Marder et al. [2011] used 2009 MarketScan data and, stratifying analysis by age, found that the ratio of medical spending in the 90th percentile metropolitan statistical area (MSA) to the 10th percentile MSA was 1.46 for adults and 1.74 for seniors (65 and older). Combining two large commercial claims databases, the Milliman Consolidated Health Sources Database and MarketScan, Pyenson et al. [2010] found that inpatient admissions per 1,000 lives for non-elderly patients in 2007 in the highest utilization HRR was 1.5 times the admissions per 1,000 in the lowest utilization HRR; inpatient facility per member per month (PMPM) costs

[2] See, for example, The Dartmouth Atlas of Health Care research articles, available at http://www.dartmouthatlas.org/publications/articles.aspx (accessed March 18 2012).

were 2.8 times as high in the highest HRR as in the lowest. Using 2008 MarketScan data, the Medicare Payment Advisory Commission [2011] found that allowed payment (the maximum theoretical amount an insurer could pay for a procedure, or the negotiated paid-in-full price) for inpatient services in the highest priced MSA was three times the lowest. The Attorney General's Office (AGO) of Massachusetts [2010] collected prices and payments for hospital and physician services from the largest insurers in the state. Prices were reported for Blue Cross Blue Shield (BCBS) of Massachusetts, while payments, which reflect severity adjustments in addition to price, were reported for Harvard Pilgrim Health Care (HPHC). For BCBS, the second highest priced hospital was 1.9 times that of the lowest priced hospital (the AGO suspected that the highest priced hospital was an outlier). For HPHC, payments were 3.3 times higher for the highest paid hospital than for the lowest.

Using claims data from both MarketScan and OptumInsight, Newhouse et al. [2013] calculated the ratio of PMPM spending from 2007 to 2009 in the 90^{th} percentile HRR to the 10^{th} percentile HRR to be 1.36 for the MarketScan data and 1.42 for the OptumInsight data. The ratio of spending in the 90^{th} percentile core-based statistical area (CBSA) versus the 10^{th} percentile CBSA was 1.36 for MarketScan and 1.50 for OptumInsight. HRRs are not universally larger or smaller than CBSAs, but there was more variability found in the OptumInsight data, likely because it represents a wider variety of markets rather than just large employers or because of the smaller sample size of OptumInsight claims versus MarketScan claims. For comparison to Medicare spending variability, in the same report and time frame, the ratio of PMPM Medicare spending in the 90^{th} percentile HRR to the 10^{th} HRR was 1.42 (1.38 for CBSAs); spending variability for Medicare thus fell somewhere between the MarketScan and OptumInsight estimates. The report found that geographic variability in medical spending from all payers, Medicare or commercial, came from warranted sources such as demographics, health status, and area-level wages, but that a large proportion of variation remained after warranted variations were accounted for.

But drivers of variation in Medicare may be very different than drivers in the commercial market, leading to different policy implications. In Medicare, which administers prices, spending variation reflects disparities in utilization only; but in the commercial market, spending variation may also reflect disparities in prices. Where utilization is the problem, policies must be implemented to address variability in patient and physician decision-making. Pricing decisions, on the other hand, are not made at the level of the physician-patient interaction, but at the level of the market. Where prices are drivers of spending, restricted provider networks and checks on institutional influence may be necessary to reduce spending variability, depending on the particular factors that drive price. In order to decide which "policy lever" to pull, the mechanisms behind pricing decisions must be better understood.

The literature has begun to investigate these mechanisms. Philipson et al. [2010]

used data from Ingenix (now called OptumInsight) to evaluate the contribution of patient covariates, as well as year and MSA fixed effects, to spending variation for inpatient and outpatient hospital services. The authors reported that the covariates explained 50 to 70 percent of the variability in utilization and spending across MSAs and substantially less within MSAs. Notably, the study did not include facility characteristics, which may have explained some variation along with prices. A recent paper comparing commercial and Medicare claims data in Texas found that in both Medicare and the commercial sector, utilization drove spending variability for outpatient services (where prices are relatively low), but that prices drove variability for inpatient services in the commercial sector (where prices are relatively high), while a mix of factors drove variability for inpatient services in Medicare: administrative prices, area level wages, and to a lesser extent, quantity [Franzini et al., 2014]. Compared to other states, Texas has only a moderately concentrated insurance market [Kaiser Family Foundation, 2012] and hospital market [Ho et al., 2013], and it is unclear whether these factors affected the results of the study. A national study commissioned by the 2010 ACA, however, also found similar results; while Medicare spending variation was found to be driven primarily by variation in utilization, commercial spending (2007 to 2009 nationwide claims from OptumInsight and MarketScan) was found to be driven primarily by variation in prices for medical care services [Newhouse et al., 2013].

Researchers investigating the effects of realized mergers use commercial claims for these types of studies as well. Using data from five commercial insurers and a differences-in-differences analysis with area hospitals as the control, Haas-Wilson and Garmon [2011] investigated the effects on price of two mergers occurring in 2000 in the Chicago area. The authors found that while one of the mergers increased prices, the other actually decreased prices, though analysis was limited to inpatient services, so the possibility of cost-shifting to outpatient services was not considered.[3] Similarly, Thompson [2011] found mixed evidence of anticompetitive effects of a 1998 North Carolina merger using data from four commercial insurers and comparing prices in the pre- and post-merger period to those in area hospitals. Two affected insurers' prices increased, one stayed the same, and another's decreased for inpatient services. Tenn [2011] also evaluated the effects of a consummated merger of two Northern California hospitals using data from three commercial health insurers and found evidence of anticompetitive effects.

[3] The merger between Evanston Northwestern Health Care Corporation (ENH) and Highland Park Hospital was found to be anticompetitive both by this study and by the courts in 2004. But ENH was not ordered to divest itself from Highland Park Hospital; instead, the two entities were ordered to negotiate contracts separately with managed care organizations, provoking the response of several industrial organizational economists in an amicus brief. (See http://www.ftc.gov/sites/default/files/documents/cases/2007/10/071017econprofsamicusbrief.pdf).

Commercial claims data have been used in some additional studies to investigate the link between provider competition and prices. In health services research, Capps and Dranove [2004] used data collected from five distinct geographic areas in the U.S. from 1997 to 2001 and found evidence that market concentration is associated with higher inpatient prices. In the economics literature, Gowrisankaran et al. [2013] used data from four large managed care organizations from Northern Virginia and found that in a simulated merger, consolidation would increase prices.

1.2.2 Defining Market Concentration

In determining whether a market is concentrated, or whether a merger would increase prices, defining the boundaries of that market is crucial. Defining markets too narrowly spuriously isolates facilities from their true competitors, while defining markets too broadly throws together facilities that do not truly compete.

In general, providers have two types of competitors, geographic and product competitors. With regards to both types of competition, hospital markets may be described as monopolistically competitive [Dranove and Satterthwaite, 2000] in that while there many be many facilities in a given geographic area offering the same nominal services, these services are not perfect substitutes for each other because of the individualized nature of medical care. Patients have different preferences for technical quality, bedside manner, and physician demographics. Parking may be important for some patients, while low waiting times may be important for others. Patients may prefer some services to be performed by a specialist rather than a primary care provider, and may be influenced by hospital branding and reputation.

An important consequence of monopolistic competition is that, as with traditional monopoly, providers may raise prices and lower quantity (or quality or convenience) without losing market share. The market is most at risk for these consequences in the case of a horizontal merger, when it is the responsibility of agencies such as the Department of Justice and the Federal Trade Commission to proactively or retroactively intervene and estimate the welfare impacts of the [potential] merger. However, the difficulty that these agencies have in determining welfare impacts is that what constitutes a market for medical care services is not straightforward; under monopolistic competition, both the product and geographic boundaries are highly segmented and subject to individual patient preferences.

Much debate has surrounded how to define geographic markets for hospital services. Patients may be willing to travel far for high stakes procedures that can be scheduled in advance, while for more mundane services or where there are plenty of acceptable substitutes, patients may wish to receive care at the closest community hospital (and for emergency care, patients may have no choice but to be taken to the nearest hospital). A standard method of defining the geographic market has been the Elzinga-Hogarty test [Elzinga and Hogarty, 1973], in which patient inflows and outflows are used to determine whether a hypothetical monopolist could raise prices in the event of a merger. To conduct the test, a boundary surrounding the merged entity is expanded until there are sufficiently few inflows and outflows (usually a threshold of 10 or 20 percent). With a captive audience, the merged entity can exercise market power and raise prices. But in what a group of researchers termed the "silent majority fallacy," Elzinga-Hogarty was shown to be a poor set of criteria for predicting post-merger hospital prices for hypothetical mergers in San Diego because, while a minority of patients were willing to travel for care, a "silent majority" were not [Capps et al., 2001]. In particular, the minority of travelers tended to seek out specialty care for which there was no good substitute in the area, while the majority of non-travelers tended to seek out more everyday care or specialty care for which there was substantial competition, such as childbirth services. Yet patient flow data used in merger analysis are aggregated and do not differentiate these two groups; hospitals may still raise prices for the travel-averse after a merger even if they cannot do so for the minority willing to travel. But the blunt application of aggregate flow analysis in the case of the would-be San Diego mergers was misleading in that it delineated geographic boundaries that were too large because of the presence of these travelers, resulting in a greater number of predicted competitors post-merger.

A second critique of flow analysis called the "payer problem," is that patient flow data reflect demand after prices and network inclusion have already been negotiated between payers and providers [Haas-Wilson, 2009]. Demand for medical care services can be broken down into two stages: in the first stage, providers and payers (insurers or employers) negotiate for services and payers settle on a network of providers and a bundle of services; in the second stage, enrollees who become ill choose amongst providers in the network (or pay more for out-of-network services). But while price is likely to play a considerable role in the first stage, demand in the second stage is likely to be driven much more by reputation, quality, and convenience, since patients generally pay such a small proportion of their total medical care bill. Despite the importance of the first stage in determining prices, however, flow analysis is silent on its role in geographic market formation. An improved method of delineating geographic market boundaries for the purposes of determining potential price increases would account for this initial bargaining stage between payers and providers.

A largely ignored area in the industrial organization literature is the presence of other competitors in addition to hospitals for outpatient services. As technology quickens the pace of patient recovery, hospitals have relied more heavily on outpatient services for their revenue (Figure 1). Consequently, low-overhead facilities such as ambulatory surgery centers (ASCs) and even physicians' offices have become competitors to hospital outpatient departments (HOPDs). ASCs are small facilities, usually with only a few operating rooms, that perform only outpatient procedures, the most common being gastroenterology, general surgery, and ophthalmology. While some hospitals are engaged in joint ventures with ASCs or even own these facilities, others are freestanding. Competition by freestanding ASCs may pose a threat to HOPD profits because in total, ASCs outnumber community hospitals [American Hospital Association, 2012], and their numbers are growing at a steady rate; from 4,571 centers in 2003, the number of Medicare-approved ASCs grew to 6,297 by 2008 [Centers for Medicare and Medicaid Services, 2009]. And despite their small capacities, ASCs are the site of almost half of ambulatory surgery visits [Cullen et al., 2009]. Studies of ASC competition with HOPDs have shown that they lower outpatient volume (but not inpatient volume) [Bian and Morrisey, 2007]; [Courtemanche and Plotzke, 2010], as well as profits, costs, and revenues [Carey et al., 2011].

Proponents of ASCs contend that they deliver care more efficiently and conveniently to patients, while opponents argue that the high rate of physician ownership in ASCs creates perverse incentives since physicians receive a portion of the facility fee in addition to their usual professional fee for performing procedures in their own facilities [Bian and Morrisey, 2007]. It is also not clear whether ASCs compete on price or other amenities, the latter of which might create a medical arms race with HOPDs and therefore raise prices. ASCs have a number of efficiency advantages over hospitals which would allow them to price compete. Smaller sizes require fewer administrative staff and smaller physical space. Further, ASCs generally do not have emergency departments, minimizing expensive rescheduled procedures due to emergency surgeries and also eliminating a service that could be unprofitable. Finally, ASCs generally focus on only one type of procedure (usually orthopedics, ophthalmology, or gastroenterology); dedicated space, staff, and time may contribute to efficiencies through economies of scale. On the other hand, ASCs may be able to compete on non-price amenities such as convenience (a less hectic environment, no rescheduled surgeries, better parking, and so on), and technology (a task made easier with newer facilities). If these amenities are expensive to provide, then competing on them will raise prices [Dranove and Satterthwaite, 2000]. Competition on non-price amenities is exacerbated by ownership incentives.

Despite the increased competition from ASCs, the market for hospital services across the United States is heavily consolidated [Cutler and Morton, 2013]. And while the wave of [mostly uncontested] mergers in the 1990s eventually tapered off, the 2010 ACA has introduced new incentives for health care facilities to merge. The law permits Medicare to reimburse accountable care organizations (ACOs), groups of providers responsible for coordinating care and subject to quality measurement. ACOs may reap financial rewards for lowering patient costs. Economies of scale are thus advantageous for providers who must work together to reduce duplicate services, meet quality standards, and coordinate patient care. And as with many policies, private payers have been quick to follow Medicare both in recognizing and in reimbursing

ACOs, as well as in allowing them to participate in shared savings programs. As the provisions of the ACA continue to unfold, then, the U.S. may be on the brink of a new wave of mergers [Dafny, 2014].

This dissertation employed commercial claims to evaluate the relationships between price and market structure to determine the drivers of price and price variation for privately insured patients. Price variation in the commercial market has begun to be documented, but the determinants of this variation are unclear. In particular, whether variations are warranted or unwarranted is unknown; and whether bargaining or market power is a major determinant is of particular concern. Further, because of limitations on data availability, commercial data have just begun to be used to investigate the relationship between bargaining power and price. Using commercial colonoscopy claims data from a large private insurer, I investigated the relationship between facility price for outpatient colonoscopy and both warranted and unwarranted factors include patient demographics and facility and market characteristics.

Colonoscopy was selected because it is a routine (generally every 10 years in healthy individuals over 50), well-defined outpatient procedure whose price is known to vary widely [Rosenthal, 2013]. Colorectal cancer, for which colonoscopy tests, is the second most fatal cancer among cancers affecting both genders, affecting 131,607 people in the United States in 2010 and killing 52,045; early detection, however, can greatly reduce colorectal cancer mortality [Centers for Disease Control and Prevention, 2013]. While many individuals do not get regularly screened for colorectal cancer [Centers for Disease Control and Prevention, 2010], colonoscopy is the most popular screening test despite less invasive but more commonly used alternatives such as the fecal occult blood test (which has a higher false positive rate and is recommended to be administered more frequently) [Maxwell and Crespi, 2009]. As evidenced by recent experimentation with reference pricing (a payment scheme in which the insurer or employer pays the first part of the facility fee, the amount the colonoscopy "should" cost, and patients shoulder the responsibility for a more expensive facility),[4] it can be inferred that much of the variation in prices is unwarranted, yet it is unclear what drives such variation.

1.3 Overview and Background Summary

Price variation is a major problem in the health care industry in particular compared to other industries because prices in health care do not reflect quality, convenience, or transaction costs, and because prices are generally not known to the patient (and perhaps not even to the physician) before or even after the patient receives care. Spending variation has been well-explored for Medicare, but not for private payers,

[4]For example, Safeway and the California Public Employees' Retirement System (CalPERS) have implemented reference pricing for colonoscopy.

largely due to data availability. As commercial claims data have become more readily available to researchers, however, interest in private spending, which reflects both utilization and prices, has grown. Because patterns and drivers of spending may be different for commercial payers than for Medicare, research in this area is not obviated by the plethora of research on Medicare spending.

This dissertation used a commercial claims dataset to investigate the drivers of both price and price variation, particularly the role of market structure. Defining a market and its competitors is empirically difficult. A largely ignored area in the industrial organization literature has been the presence of ASCs in the market for outpatient services; the data used here included ASC claims as well as hospital outpatient claims. I chose to focus on colonoscopy because it is a well-defined procedure, generally taking place over the course of just one day. It also has substantial price variation, both in this dataset and nationwide.

Chapter 2

Literature Review

This chapter reviews several areas of the economic literature to inform the conceptual model in the chapter that follows. The price concentration and bargaining literatures both address the relationship between prices and market power, albeit from different angles. In general, the bargaining literature explicitly assumes that insurers act as agents for their enrollees in determining network status and prices for hospital services, while the price concentration literature implicitly assumes that insurers compete for enrollees by forming the most valuable network of providers [Gowrisankaran et al., 2013]. The price dispersion literature informs theory on the relationship between price variation and market concentration. While most of this literature addresses the role of the demand side, in particular search costs, in creating price dispersion, there is a small but theoretically important sector that addresses the role of the supply side as well.

2.1 Hospital Price Concentration

To measure the effect of market competitiveness on price, the standard structure-conduct-performance (SCP) study regresses price, or some proxy thereof, on a measure of market consolidation such as the Hirschman-Herfindahl Index (HHI), the sum of squared market shares.[5] SCP studies have generally found that consolidation raises prices ([Melnick et al., 1992]; [Dranove et al., 1993]; [Keeler et al., 1999]), but these studies are subject to numerous criticisms [Gaynor, 2000]. A major problem is that HHIs based on actual patient flows (such as admissions or beds, or even a fixed or variable radius around a facility) may be endogenous to prices in two ways. First, there is a reverse causation issue: since hospitals enter markets only where there are profits to be made, and exit if profits are negative, prices affect market concentration in addition to the other way around; therefore a finding of a positive effect of HHI on price may be upwardly biased. Second, differences among hospitals in demand and

[5] Note that doing so requires both the boundaries of the market and the share of the market to be defined by the researcher, in ways that could potentially be problematic and which will be addressed in this section.

costs influence both prices and the number of firms that can be supported in a market. But if SCP equations do not capture these demand and cost factors, then measures of market concentration and HHI will be correlated with the regression error terms [Evans et al., 1993].

Investigating the effect of entry on variable profits in oligopolistic markets, Bresnahan and Reiss [1991] addressed the potential endogeneity of changes in market share by leveraging the insight that firm profits are supported by a given population size. If entry reduces variable profits, then firms in a given area will need a greater population per hospital to generate sufficient variable profits to cover entry costs. Therefore, growth of population with entry of more firms would be evidence that variable profits decrease with the competitiveness of the market. Bresnahan and Reiss did find that entry quickly reduced variable profits, with most of the reduction coming from the entry of the second or third firm, and disappearing almost entirely after the market contained between three and five firms. Without making strong assumptions about firm costs and demand, however, the authors could not separate the effect of competition on variable profits from that of fixed costs; a growing population size could be evidence of higher fixed costs to be covered rather than lower profits. Abraham et al. [2007] expanded this entry model by incorporating quantity information, and were therefore able to separate the entry effect on fixed costs from that on variable profits. Entry of a second hospital increased admissions by a factor of 1.29 and decreased profits by 1.6 percent; entry of a third hospital non-significantly increased admissions and decreased profits by 0.8 percent; and entry of a fourth hospital non-significantly increased admissions and non-significantly increased profits. In a review of the literature on competition and quality, Gaynor [2006] interpreted these results to mean that competition increased welfare since a decline in profits and an increase in demand could only be welfare increasing. But this interpretation rests on the assumption that patients are the true demanders of health care; if providers are simply compensating the fact that they have lost some market share by inappropriately referring patients for admission, then net welfare effects are ambiguous.

As new methods have been developed to address the endogeneity problems in the older SCP studies, the effect of competition on quality rather than prices or profits has been an area of greater focus. In evaluating the effect of hospital market concentration on spending and clinical outcomes for a sample of elderly Medicare beneficiaries hospitalized with incident heart attack in the late 1980s and early 1990s, Kessler and McClellan [2000] used a multi-part model to construct an exogenous HHI. The authors hypothesized that market share is a function of both distance from a patient's home to the hospital, which is exogenous, and unobserved measures of quality, which is endogenous, and modeled patient choice of hospital as a discrete choice problem with patient utility based only on distance and other patient and hospital variables exogenous to a hospital's share of admissions. The authors then developed an HHI based on patients' probabilistic hospital of admission. Next, a differences-in-differences model was run to estimate the effect of predicted market competitiveness on spending and outcomes. They found that before 1991, market consolidation reduced spending by 2.18 percent for the most concentrated quartile compared to the least concentrated quartile, but somewhat worsened mortality for heart attack patients, with those in the third most concentrated quartile having a 0.88 percentage point higher chance of dying within a year than those in the least concentrated quartile. But after 1991, consolidation increased spending and worsened mortality. Patients in markets in the most concentrated quartile had 8.04 percent higher expenditures and were 1.46 percentage points more likely to die within a year than those in the least concentrated quartile. The sign differences before and after 1991 are suggestive of HMO spillover effects; HMO penetration reduced spending for Medicare enrollees and did not have an effect on health outcomes. As Gaynor [2006] noted, whether welfare was improved by competition depends on whether the mortality improvements were worth the costs. Spending per patient is only part of the total economic costs, and clinical outcomes must be factored in as well.

Whether hospitals compete on quality at all is an empirical question. Using a random coefficients discrete choice model, Tay [2003] found that hospital quality, along with distance, was a substantial predictor of hospital choice for heart attack patients, even with controls for factors that might be associated with quality, such as volume, teaching status, and nurses per bed, and controls for the availability of high-technology services whose quality might be correlated with the quality of heart attack care, such as cardiac catheterization and revascularization.

Nevertheless, it is possible that hospitals compete on quality more strongly for patients who have more discretion over their choice of hospital than on those patients who have less discretion. Using hospital discharge data from 1989 to 1993 from California, Gowrisankaran and Town [2003] compared the effects of competition on clinical quality for pneumonia patients and heart attack patients, hypothesizing that the former have more discretion over hospital choice than the latter, and that hospitals therefore compete on quality for pneumonia patients more so than for heart attack patients. (As the authors pointed out, hospitals may still compete on quality for heart attack patients if managed care organizations contract with hospitals based on quality, and also if care quality for heart attack patients is correlated with care quality for non-emergent cardiac care associated with follow-up care after a heart attack, such as cardiac catheterization). They constructed a measure of market concentration based on measures of patient and hospital characteristics exogenous to hospital choice using a multinomial logit specification and found that for Medicare patients, a 10 percent increase in the predicted HHI (specially constructed for Medicare patients) was associated with a 3.3 percent decline in mortality for heart attack and a 3.5 percent decline in mortality for pneumonia. For HMO patients, a 10 percent increase in the predicted HHI (specially constructed for HMO patients) was associated with a 2.3 percent increase in mortality for heart attack patients and a non-significant increase in mortality for pneumonia patients. Payer type had more of an effect on the association between competition and quality than did diagnosis. These results contradict those of Kessler and McClellan [2000], who found that for Medicare patients, competition improved quality around the same time period. One explanation may be the different datasets. Many of the mergers in the late 1980s and early 1990s took place in California and were the result of financial hardship; these merging hospitals may have had to sacrifice quality for the patients with the lowest margins.

Summarizing the effect of competition on quality, Gaynor [2006] reviewed several of the studies discussed here, including Kessler and McClellan [2000], Gowrisankaran and Town [2003], and an earlier version of Abraham et al. [2007]. Because so many papers study heart attacks, which are well-reimbursed by Medicare, Gaynor [2006] concluded that for administered prices above marginal cost, competition improves quality, discounting the findings by Gowrisankaran and Town [2003] as an anomaly (which may be justified given its use of data from just one state, California, compared to other studies' use of national data). For market prices, on the other hand, the effect of competition on quality is ambiguous. Further, as previously discussed, extensions to the SCP work that have constructed exogenous measures of HHI have generally focused on clinical quality as an outcome measure (likely because of the availability of these measures compared to prices), so the full welfare effects of market concentration according to this literature are unclear.

2.2 Hospital-Insurer Bargaining

In the hospital-insurer bargaining literature, market share (and more generally, hospital leverage)[6] has also been found to be positively associated with prices. The basic setup of most bargaining models is that hospitals and insurers negotiate over the division of some surplus, the outcome of which is the price of medical care services. The hospital values the insurer insofar as inclusion into its network drives enrollees there; out-of-network hospitals usually incur higher out-of-pocket expenses for enrollees. The insurer values the hospital insofar as the addition of the hospital to its network attracts enrollees. To the extent that enrollees do not know whether and what type of hospital care they will need *before* they sign up for an insurance plan, hospitals are an option demand market. In other words, by signing up for an insurance plan, enrollees purchase networks of hospitals so that they have the option of using one of those hospitals on an in-network basis at a future date.

[6] Leverage may include perceived quality, reputation, bargaining ability, geography, and other factors that improve a facility's standing other than market share.

The parameter to be estimated is the bargaining parameter, the degree of leverage each party has over one another and its relationship with price. The bargaining parameter may be broken down further into exogenous characteristics that do not enter into the utility function of the hospital to determine the effects of, for example, market share on price. This literature is relatively new and was thoroughly reviewed in a paper by Gaynor et al. [2014].

Establishing the premise of this literature, Ho [2006] used a three-step model (analogous to that in the price concentration literature) to account for endogenous plan choice, and found that enrollees value hospital networks when choosing insurance plans. Ho [2009] then investigated reasons for higher hospital markups. Using the previous estimates for consumer preferences for insurance, she modeled network formation with a hospital profit function, since no actual transaction prices were available. Higher markups were predicted by system status, attractiveness to patients (defined as those offering high technology services, teaching hospitals, or those with high quality reputations), and capacity constraints. Pakes [2010] also found a positive relationship between hospital margins and capacity constraints.

In a fully specified bargaining model permitted by the availability of private claims data, Gowrisankaran et al. [2013] simulated a proposed merger in the Northern Virginia area between a large and small hospital and found that it would increase quantity-weighted average prices. Comparing the results of the bargaining model to those of a Bertrand model in which insurers compete on price for enrollees, the authors found the price increase to be larger in the Bertrand model, 7.2 percent compared to 3.1 percent. The reason for this discrepancy is that in the Bertrand model, enrollees had more agency than insurers since insurers were in competition for enrollees; but low coinsurance rates meant that enrollees had very low price elasticities for hospital services. The Bertrand model thus overstated price increases as a result of the merger.

Ho and Lee [2013] investigated the effect of *insurer* competition on prices also using a fully specified bargaining model, with claims data from California. The authors found that competition reduced prices except for the most attractive hospitals, for whom competition actually raised prices. It was beyond the scope of the study to test the mechanism for this finding, but the authors speculated that brand loyalty to centers of excellence might have played a role.

2.3 Hospital Price Dispersion

The price dispersion literature generally focuses on consumer search costs as the primary driver of heterogeneous prices in markets with homogeneous goods ([Stigler, 1961]; [Salop and Stiglitz, 1977]; [Varian, 1980]; [Stahl, 1989]), but a subset of this literature also addresses the supply side, namely price dispersion related to the number of sellers in the market or sellers' differing marginal costs ([Reinganum, 1979]; [Rosenthal, 1980]; [Carlson and McAfee, 1983]). The main conclusions of this literature are that one or more price distributions may exist, contrary to the neoclassical theory of the single-price equilibrium ([Salop and Stiglitz, 1977]; [Stiglitz and Salop, 1982]).

For models that assume that search costs drive price dispersion, the general consensus is that price variation is a non-monotonic function of search costs. For example, the classic model by Varian [1980] predicts that price dispersion exists only for moderate search costs, but that for very high search costs, it is too costly for consumers to be informed and there is a single equilibrium price, the monopoly price; but for very low search costs, all consumers are informed and there is another single equilibrium price, the competitive price or marginal cost. Stahl [1989] established similar results, but modified the setup to allow uninformed consumers to shop subject to search costs. Analogous to Varian [1980], Stahl [1989] found that price dispersion was commensurate with the proportion of shoppers in the market; when all consumers shopped, sellers priced at marginal cost, but when no consumers shopped, sellers charged the monopoly price.

Models that account for the supply side have commonly found that an increase in the number of sellers in the market is associated with greater price dispersion, yet these models differ in their consideration of the primary driver of the distribution of prices. For example, both Carlson and McAfee [1983] and Rosenthal [1980] found that an increase in the number of sellers was associated with greater price variation. Yet in Carlson and McAfee [1983], differences in consumer search costs and sellers' marginal costs of production drove price dispersion, while in Rosenthal [1980], such differences were explicitly excluded from the model. Instead, the authors found price dispersion to exist under circumstances where sellers could exercise monopoly power for some consumers but not others. Further, in Carlson and McAfee [1983], price dispersion was bound from above commensurate with the distribution of sellers' marginal costs.

Perloff and Salop [1985] examined price-cost markups in markets with imperfect information and concluded that price dispersion may exist where many consumers have identical tastes. Taking this model to its logical conclusion, Barron et al. [2004] suggested that with asymmetric demand, an increase in the number of sellers is associated with a decrease in price variance since entry drives markups towards zero; but nonlinear effects of number of sellers on variance are not considered.

Reinganum [1979] included both search costs and differing marginal costs of production as a crucial part of her model but made no explicit predictions regarding the association between the number of sellers and price dispersion in the market. An extension of the Reinganum model by Baye et al. [2006] showed a positive association between search costs and equilibrium price variance.

2.4 Literature Review Summary

Several areas of research inform the conceptual model in the following chapter. The hospital price concentration and bargaining literatures are related in that they both address the relationship between price and market concentration, and both theoretically and empirically positively associate the two. Data availability has limited the price concentration literature from fully exploring the relationship between concentration and price, so in the past decade the literature has focused more on the relationship between concentration and quality; yet these studies can still inform studies of price in illuminating hospital incentives in concentrated versus competitive markets. For commercial payers, the effect of concentration on quality is ambiguous [Gaynor, 2006]; earlier studies suggest a positive relationship between concentration and price for commercial payers [Melnick et al., 1992]; [Dranove et al., 1993]; [Keeler et al., 1999].

The bargaining literature approaches the question of price and market concentration from the assumption that payers act as agents for an already existing set of enrollees. In other words, rather than competing for enrollees by having the optimal network of providers, the payer already has a set of enrollees and bargains with providers for inclusion into the network at an optimal set of prices. This literature, too, finds a positive relationship between hospital concentration and price; it is new enough that only a few studies with commercial prices have been used to test its theories.

Finally, the price dispersion literature will be used to inform the theory on the relationship between market concentration and price variation. While most of this literature has focused on search costs as a driver of price variation in the market, some has also recognized the importance of the supply side as well. In particular, market concentration has generally been found to be negatively associated with price variation [Rosenthal, 1980]; [Carlson and McAfee, 1983], though there is not much evidence in the health care sector to support this argument, and the presence of asymmetric demand may reverse this conclusion [Barron et al., 2004].

Chapter 3

Conceptual Model

3.1 Model Summary

Accounting for the roles of both provider and insurer in negotiating a price for medical care services, I grounded my empirical specification in the theory of hospital–insurer bargaining, adapting a model from Brooks et al. [1997]. This model was chosen because it allows me to make predictions regarding the relationships between both price and price variation and market power, as well as components of market power exogenous to price. According to the theory, hospitals (or ASCs, or systems including either or both) and payers (insurers and employers), with potentially asymmetric bargaining power, negotiate a price for medical services. Both parties are profit maximizers[7] and if a price is not agreed upon, then the hospital is excluded from the insurer's network.

3.2 Negotiated Price

The negotiated price is then:

$$V = \underset{p_{hi}}{\operatorname{argmax}}\{[\Pi_h - \overline{\Pi}_h]^{\tau} * [\Pi_i - \overline{\Pi}_i]^{(1-\tau)}\}, \tag{3.1}$$

where h indexes hospital; i indexes insurer; and p_{hi} is the price negotiated between the two parties. Π_h is the hospital's profit if it joins insurer i's network and $\overline{\Pi}_h$ is the hospital's profit if it does not, the disagreement outcome. Analogously, Π_i is the insurer's profit if it includes hospital h in its network, and $\overline{\Pi}_i$ is the insurer's disagreement profit. The parameter τ is hospital h's bargaining power; insurer i has bargaining power $1 - \tau$.[8]

[7]This assumption may be more appropriate for for-profit hospitals than for non-profit hospitals, whose behavior has been shown to be inconsistent with profit maximization [Chang and Jacobson, 2011]; at the same time, there is no evidence of differing pricing behavior between for-profits and non-profits [Capps et al., 2010]; [Duggan, 2000].

[8]This model assumes that providers do not use other payers as leverage for higher prices, and

Insurer profit is further parameterized as:

$$\Pi_i - \overline{\Pi}_i = (R - K - p^{\star}_{hi}n) - (R - K - \overline{p}_{hi}n), \tag{3.2}$$

where R is insurer revenue from other sources, K is the cost of production independent of the number of enrollees, n is the number of enrollees, $p^{\star}_{hi}$ is the negotiated price from equation 3.1, and $\overline{p}_{hi}$ is the maximum price an insurer would pay before it dropped a hospital from its network (the threshold before the disagreement outcome).

Analogously, hospital profit is also parameterized as:

$$\Pi_h - \overline{\Pi}_h = n(p^{\star}_{hi} - c) - n(\underline{p}_{hi} - c), \tag{3.3}$$

where n is again the number of enrollees and $p^{\star}_{hi}$ is the negotiated price should the insurer and hospital agree to include the hospital in-network. The cost per episode of care is c and $\underline{p}_{hi}$ is the minimum price that the hospital would accept before it does not join the insurer's network.

Substituting in equations 3.2 and 3.3, equation 3.1 can be rewritten in terms of price:

$$V = [n(p^{\star}_{hi} - \underline{p}_{hi})]^{\tau} * [n(\overline{p}_{hi} - p^{\star}_{hi})]^{1-\tau}. \tag{3.4}$$

Finally, the model is solved and rearranged for the purpose of comparative statics:

$$p^{\star}_{hi} = \tau(\overline{p}_{hi} - \underline{p}_{hi}) + \underline{p}_{hi}. \tag{3.5}$$

3.3 Model Implications

An intuitive result is that negotiated price increases with a hospital's bargaining power. Consider the two extreme cases. If τ is equal to one, then the hospital has all the bargaining power and the insurer has none; the negotiated price is equal to the highest price that the insurer would accept before excluding the hospital from its network. At the other extreme, τ is equal to zero and the hospital has no bargaining power. The negotiated price is equal to the lowest price that the hospital would accept before dropping out of the insurer's network.

In the Brooks model, bargaining power may be parameterized in order to further elucidate the model's comparative statics. For example, a hospital's bargaining power can be broken down into two components: α, a component that does not vary

analogously that payers do not use other providers as leverage for lower prices. This assumption will make the model easier to solve but may be less applicable to markets with multiple influential insurers and providers.

with exogenous characteristics; and β, a component that does vary with exogenous characteristics Z, (such as market structure), such that:

$$\tau = \alpha + \beta Z. \tag{3.6}$$

Substituting the above equation into equation 3.5:

$$p^{\star}_{hi} = (\alpha + \beta Z) * [(\overline{p}_{hi} - \underline{p}_{hi}) + \underline{p}_{hi}]. \tag{3.7}$$

This extension of the model allows me to make further predictions about the relationship between exogenous characteristics Z and the negotiated price $p^{\star}_{hi}$. In the extreme, β is equal to zero and price does not vary with bargaining power.

Finally, the model can be generalized to the case of multiple hospitals[9] to make predictions about price dispersion as well. Since bargaining power is assumed to be fixed - for instance, somewhat unrealistically, the exclusion of one hospital from the insurer's network does not increase the bargaining power of another hospital - each insurer-hospital negotiation can be written out separately as in equation 3.7. Then in the extreme, if the insurer has all of the bargaining power such that τ is equal to zero, then price dispersion is equal to the dispersion of minimally acceptable prices $\underline{p}_{hi}$. In a competitive market, these prices would approximate marginal costs. At the other extreme, if the hospitals have all of the bargaining power such that each hospital's τ is equal to one, then the price dispersion in the market is equal to the distribution of minimally acceptable prices plus a markup (the difference between the highest price a hospital would charge an insurer and the minimally acceptable price). Attractiveness to patients and low patient cost sharing are factors that might predict high markups ([Ho, 2009]; [Gowrisankaran et al., 2013]).

3.4 Aims and Summary of Conceptual Model

The conceptual model raises the following questions, which this dissertation aims to address:

1. What is the relationship between provider market share and colonoscopy prices?

   Hypothesis 1: There is a strong, positive relationship between provider market share and colonoscopy prices.

   With the exception of some mixed evidence in the case of realized mergers ([Haas-Wilson and Garmon, 2011]; [Thompson, 2011]; [Tenn, 2011]), the

[9]For simplicity, the model continues to assume a single insurer; for most U.S. states, this assumption is not unreasonable [Kaiser Family Foundation, 2012].

econometric evidence linking market power to higher prices is consistent. Although flaws in measures of market consolidation in the earlier SCP literature generally limit the conclusions that can be drawn from those studies, the direction of the association between price and concentration is positive ([Melnick et al., 1992]; [Dranove et al., 1993]; [Keeler et al., 1999]. Furthermore, the bargaining literature also finds consistent evidence of a positive relationship between price and concentration [Gowrisankaran et al., 2013]; [Ho and Lee, 2013].

2. What is the relationship between market concentration and price variation for colonoscopy?

   Hypothesis 2: There is a negative relationship between market concentration and price variation in the market for colonoscopy.

   This hypothesis rests mostly on theoretical grounds, as empirical work on price variation in both the bargaining and price dispersion literatures is sparse. However, bargaining theory suggests that price variation should increase with marginal costs [Gaynor et al., 2014], the spread of which increases with the number of sellers. This theory is supported by the price dispersion literature, which suggests that price variation should increase with the number of sellers, whether because of differences in facilities' marginal costs [Carlson and McAfee, 1983] or because of the ability of facilities to exercise monopoly power over some payers but not others [Rosenthal, 1980].[10]

[10] In the next section, I will note that the market in my data is dominated by a large insurer, so the prospect of price variation being driven by providers' exercising differential market power is very real; but since my data come from that one insurer, the price variation that I observe is not driven by variation in prices among payers.

Chapter 4

Empirical Model

In this chapter, I discuss the empirical model. I will describe the data and methods used to test the specific aims outlined in the previous chapter.

4.1 Data

The data consist of adjudicated fee-for-service claims from a large commercial insurer with nearly three quarters market share by total enrollment in the state in which it operates, as well as some market share in a neighboring state. The dataset is proprietary and unique in that it contains actual transaction prices rather than just hospital charges, which are not well correlated with insurance reimbursement rates. I studied patients undergoing diagnostic or therapeutic colonoscopy, excluding surgical colonoscopy and colonoscopy through a stoma (a surgical opening in the large intestine), and included current procedural terminology (CPT) codes: 45378 to 45387; 45391 to 45392; G0105; and G0121.[11] All procedures were outpatient (day procedures) and occurred in a HOPD or ASC between October 2005 and December 2012. To protect patient confidentiality, the only demographic information available was age and sex. There were, however, other claim-level variables, including date of service, patient comorbidities, allowed amount (the insurer's theoretical payment-in-full), transaction price, and patient copayment, coinsurance and deductible. Each claim included a facility identifier. Analysis was limited to adults 18 and over, with age top-coded at 110.

The claims were supplemented with facility information from several sources. The 2008 American Hospital Association (AHA) Annual Survey, a national survey of U.S.

[11] Diagnostic colonoscopy (CPT 45378); colonoscopy with foreign body removal (CPT 45379); colonoscopy and biopsy (CPT 45380); colonoscopy with submucosal injection (CPT 45381); colonoscopy with control of bleeding (CPT 45382); lesion removal colonoscopy by ablation (CPT 45383) by hot biopsy forceps or bipolar cautery (CPT 45384) or by snare (CPT 45385); colonoscopy with balloon dilation (CPT 45386); with transendoscopic stent placement (CPT 45387); with endoscopic ultrasound examination (CPT 45391); with transendoscopic ultrasound guided needle aspiration or biopsy (CPT 45392); and colonoscopy for individuals at high risk (CPT G0105) and not at high risk (CPT G0121).

hospitals with a 70 percent annual response rate [American Hospital Association, 2014], contains information such as system status;[12] name and headquarter location; geographic information such as HRR number and CBSA name and code; critical access status; ownership type; and teaching status. There are also utilization measures such as total beds and admissions. Information on ASCs was obtained from the 2010 full-year Medicare Provider of Services (POS) Extract, created from the Online Survey and Certification Reporting System (OSCAR) database. The POS data contain information on ASC ownership type, number of operating rooms, and MSA.

The 2010 American Community Survey (ACS) was used to provide socioeconomic data on the included hospital markets. I theorized that market-level variables were an important determinant of prices for two reasons: first, wages are a substantial proportion of prices, and workers likely live near the facility in which they work (travel time to work was included to control for areas where workers might be more spread out); and second, even though I did not observe where patients lived and thus could not directly estimate their demand, facility geography is at least a rough proxy for patient geography. Patients may travel for more serious non-emergent medical services, but for the vast majority of services they will likely receive care locally [Finlayson et al., 1999]; [Capps et al., 2001]. I therefore included from the ACS the following county-level variables: estimated population (2012); percentage female (2012); percentage white (of any ethnicity), black or African American, American Indian or Alaskan Native, Asian, Native Hawaiian or other Pacific Islander, or multiracial (2012); percentage of high school graduates 25 years or older (2008 to 2012); average travel time to work in minutes for workers 16 and older (2008 to 2012); and median household income (2008 to 2012).

Because wages from the ACS reflect occupational mix in addition to labor price and are therefore not comparable across markets with different mixes of occupations, I substituted the Medicare occupational-adjusted wage index as a market-level control. The wage index is used to standardize Medicare payments to hospitals based on area-level wages. These areas are defined as CBSAs, but I matched CBSAs to counties using a crosswalk provided by Medicare [Centers for Medicare and Medicaid Services, 2014] since my markets were defined as counties, which are smaller than CBSAs and likely more appropriate for a non-emergent, elective procedure such as colonoscopy. The occupational-adjusted wage index was obtained from the fiscal year 2010 Final Rule, which covers the time periods from October 1, 2005 to September 30, 2006.

[12] System status can be found in the AHA data and was cross-checked on hospital websites and on Becker's Hospital Review, available at http://www.beckershospitalreview.com/ (accessed March 27, 2014). Ambulatory surgery center affiliations were found in searches of individual ASC websites, hospital system websites, and Becker's ASC Review, available at http://www.beckersasc.com/ (accessed March 27, 2014).

4.2 Methods

This study had two primary aims: first, to evaluate the relationship between a facility's colonoscopy price and its market share, controlling for facility, system, and county characteristics; and second, to evaluate the relationship between within-county price variation and market concentration, controlling for county-level characteristics.

The first step was to ascertain facilities' negotiated colonoscopy prices from the claim-level allowed amounts. It is possible to observe several allowed amounts for a given CPT code at a given facility, the result of a complex set of pricing rules. For example, some prices are higher when paired with a modifier for severity, and others are halved or reduced to $0 when paired with other procedures. Since the contract and all of the pricing rules were not directly observed, price was defined as the higher mode price (the lower may be the halved or $0 price). Allowed amounts were trimmed at the first and ninety-ninth percentiles, after truncating the $0 prices, to eliminate outliers that may have come from hospitals with only one or two very complex patients or patients for whom colonoscopy was a secondary procedure (and thus may have had very low prices). For comparability across the study period, all prices were deflated using the seasonally adjusted medical care consumer price index for all urban consumers [Bureau of Labor Statistics, 2014]. I focused on facility prices as opposed to professional fees since facility prices are targeted in reference pricing schemes and are generally the larger proportion of hospital bills (for colonoscopy, they constituted roughly 85 percent of the bill on average, [not shown]).

Next, to address the first aim, I used a measure of price common in the literature, relative price (e.g. Dunn et al. [2013]), the facility's negotiated colonoscopy price divided by the mean price within the market. Because relative price normalizes prices across counties by dividing through by the mean market mean, it is advantageous compared to levels of prices in facilitating comparability across counties with widely varying mean prices.

As discussed in the previous chapter, negotiated price is theorized to be a function of a facility's bargaining power; in turn, bargaining power is a function of a vector of exogenous characteristics **Z**. Price can thus be written as a function of exogenous facility characteristics, system characteristics (for those facilities that are affiliated with a system), and market characteristics:

$$p_{smct} = \beta_0 + bedshare_{smct}\beta_1 + \mathbf{X}_{sm}\beta_2 + \mathbf{X}_m\beta_3 + \gamma_c + \mu_t + \epsilon_{smct}, \quad (4.1)$$

where s indexes system, m indexes market, c indexes CPT code, and t indexes time. In cases where facilities are unaffiliated with systems, facility-level characteristics were used. The variable $bedshare_{smct}$ is the regressor of interest and signifies the proportion of beds (or operating rooms, in the case of ASCs) in market m attributable to system or individual facility s for CPT code c at time t.

$\mathbf{X}_{sm}$ is a $1xj$ matrix of facility characteristics including whether the facility was an ASC versus a HOPD; system versus unaffiliated; teaching versus non-teaching; and whether it was a critical access facility;[13] and dichotomous variables for ownership type: for-profit and government-owned, with non-profit facilities as the reference group. Also included were average age, proportion of females, and number of diagnoses of patients undergoing colonoscopy, to account for case mix.

$\mathbf{X}_m$ is a $1xk$ matrix of county-level variables theorized to impact facility wages (and thus price), including occupational-adjusted wage index, county population (theorized to affect price through demand), the percentage of high school graduates 25 years or older, median household income, average travel time to work in minutes, the percentage of residents who are female, and the percentage of residents who are black, American Indian or native Alaskan, Asian, native Hawaiian or Pacific Islander, or multiracial, with percentage white only (any ethnicity) as the excluded category. The justification for including county-level controls in addition to the facility controls (rather than just county fixed effects) was to evaluate the relationships between these variables and prices. For example, wages are theorized to be a substantial proportion of marginal costs and thus to have a large and positive coefficient. Additionally, a high county population is necessary to support demand (for all services), and thus should be positively correlated with price as well [Bresnahan and Reiss, 1991]. Variables such as the percentage of high school graduates, median household income, travel time to work, and county demographics address socioeconomic factors of both workers and patients in the market and thus were also theorized to influence price.

γ_c are CPT fixed effects, with diagnostic colonoscopy (CPT 45378) as the excluded category. Unobserved market-invariant time shocks may also introduce bias in the model, so I included time fixed effects, μ_t, as well. ϵ_{smct} is an error term.

Addressing the second aim, evaluating the relationship between price variation and market concentration, I constructed a measure of price variation that is also commonly used in the literature, coefficient of variation [Skinner, 2012], the standard deviation of negotiated prices in a county over the mean. Like relative price, this measure is advantageous compared to standard deviation alone because it facilitates comparisons among counties with different mean prices.

Price variation within a county is a function of county characteristics and can be written as:

$$cov_{mct} = \rho_0 + hhibeds_{mct}\rho_1 + \mathbf{X}_m\rho_2 + \alpha_c + \tau_t + \eta_{mct}. \quad (4.2)$$

Here, the outcome measure is the coefficient of variation, cov_{mct}, the standard deviation

[13] Critical access hospitals are designated as such by the Centers for Medicare and Medicaid Services and are rural hospitals that receive cost-based reimbursement from Medicare.

of prices for market m and CPT code c in time t divided by the mean price. The regressor of interest is $hhibeds_{mct}$, the HHI calculated based on the number of beds (or operating rooms for ASCs) for market m for CPT code c in time t. $\mathbf{X}_m$ is a $1xl$ matrix of county characteristics including occupational-adjusted wage index, county population (theorized to affect price through demand), the percentage of high school graduates 25 years or older, median household income, average travel time to work in minutes, the percentage of residents who are female, and the percentage of residents who are black, American Indian or native Alaskan, Asian, native Hawaiian or Pacific Islander, or multiracial, with percentage white only (any ethnicity) as the excluded category. α_c and τ_t are CPT and month fixed effects, respectively, and η_{mct} is an error term.

4.3 Empirical Model Summary

I used a unique proprietary dataset to test the specific aims laid out in the previous chapter. The data were claims from a single large commercial insurer for adult outpatient diagnostic and therapeutic colonoscopy occurring between October 2005 and December 2012, and were supplemented with data on outpatient facilities and their markets. Ordinary least squares regressions with CPT and month fixed effects were used to test the relationships between market share and prices, as well as the relationship between market concentration and the coefficient of variation.

Chapter 5

Results

In this chapter, I describe the results of the empirical specification in several sections. In the first section are descriptive statistics across all claims. In the second section, the claims were collapsed down to the facility level, and the descriptive statistics are across systems or facilities where appropriate. In the third section are the regression results. The fourth section contains robustness checks.

5.1 Claim Level Descriptives

Table 1 summarizes the number of observations at both the claim and facility levels. During the study period, there were 178,433 claims (and 156,133 patients, [not shown], indicating that some patients had more than one claim) from 169 facilities. There were 132,541 HOPD claims from 149 HOPDs and 45,892 ASC claims from 20 ASCs and 113,477 system claims from 104 chains and 64,956 unaffiliated facility claims from 65 unaffiliated facilities.

Table 2 reports the claim-level characteristics. The mean age among claims was 53 (standard deviation [SD]=9) across all types of facilities and at each type of facility. Because only adults were included, the minimum age was 18 at all facilities, and the maximum age was 109 at all facilities except system facilities (100) and ASCs (87). Slightly over half of claims at all facilities were female. The average number of claim-line diagnoses was 3 (SD=2). It was higher at HOPDs than at ASCs (3, SD=2 compared to 2, SD=1, p-value for difference in means < 0.01) and at unaffiliated facilities than at system facilities (4, SD=2, compared to 3, SD=2, $p < 0.01$). The minimum number at all facilities was 1, and the maximum was 12, except for at ASCs where the maximum was 10.

The mean price for all colonoscopy claims was $1,302 (SD=372). The minimum was $152 and the maximum was $2,749. Mean prices for claims were higher at HOPDs ($1,359, SD=426) than at ASCs ($1,154, SD=101, $p < 0.01$) and at unaffiliated facilities ($1,388, SD=376.26) compared to system facilities ($1,253, SD=368, $p < 0.01$).

Included in the analysis were CPT codes 45378 to 45387; 45391 to 45392; and G0105 and G0121. The codes were distributed asymmetrically across the data (not shown). There were 106,557 claims (41.87 percent) for CPT 45378, diagnostic colonoscopy; 32 claims for CPT 45379 (0.01 percent), colonoscopy with foreign body removal; 66,345 claims (26.07 percent) for CPT 45380, colonoscopy with biopsy; 1,626 claims (0.64 percent) for CPT 45381, colonoscopy with submucosal injection; 328 claims (0.13 percent) for CPT 45382, colonoscopy with control of bleeding; 5,192 claims (2.04 percent) for CPT 45383, lesion removal colonoscopy by ablation; 20,173 claims (7.93 percent) for CPT 45384, lesion removal colonoscopy by hot biopsy forceps or bipolar cautery; 43,389 claims (17.05 percent) for CPT 45385, lesion removal colonoscopy by snare; 173 claims (0.07 percent) for CPT 45386, colonoscopy with balloon dilation; 19 claims (0.01 percent) for CPT 45387, colonoscopy with transendoscopic stent placement; 20 claims (0.01 percent) for CPT 45391, colonoscopy with endoscopic ultrasound examination; 6 claims (less than 0.01 percent) for CPT 45392, colonoscopy with transendoscopic ultrasound guided needle aspiration or biopsy; 3,022 claims (1.19 percent) for CPT G0105, colonoscopy for individuals at high risk; and 7,584 claims (2.98 percent) for CPT G0121, colonoscopy for individuals not at high risk. The distribution was similar between HOPDs and ASCs and between system and unaffiliated facilities.

5.2 System and Facility Level Descriptives

Next, data were collapsed down to the system level (Table 3). The unit of analysis is the system- or facility-CPT-month, but not all systems had observations for all 14 CPT codes over each of the 87 months of the study period, so there were 35,781 observations total. Two measures of market share were constructed: one was the share of claims attributable to a system in each county across the study period; the other was the share of system beds in each county across the study period. The mean market share by number of beds across CPT codes across months was 76 percent (SD=0.34). The mean market share by claims was 78 percent (SD=0.31). The two measures were highly correlated (r=0.74, not shown). The analysis proceeds using bed share as the measure of market share since this measure is theoretically more appropriate, as it captures systems' bargaining power via other procedures in addition to colonoscopy. The mean HHI was 8,343 (SD=2,186) with a minimum of 3,849 and a maximum of 10,000. In theory, the HHI may take on values from 0 to 10,000, with 0 representing a perfectly competitive market and 10,000 representing a monopolist. The Department of Justice (DOJ) merger guidelines suggest that hospital markets with an HHI over 2,500 are concentrated [United States Department of Justice and United States Federal Trade Commission, 2010], though this threshold is never used dogmatically; rather, the HHI scale should be understood as a spectrum of market concentrations.

Mean prices across systems and across all CPT codes were $1,363.33 (SD=374.38), with a minimum of \$169.28 and a maximum of \$2,748.95. Although the spread of prices in the dataset was large, low and high prices were not outliers; the pricing spread represented a continuous distribution across systems (Figure 2). The mean relative price was \$1.00 by construction. The standard deviation was \$0.18, with a minimum of \$0.14 and a maximum of \$2.39. Zero-dollar prices were truncated to avoid counting patients undergoing colonoscopy as a secondary procedure; these prices accounted for about a quarter of all prices. Zero-dollar claims were compared to non-zero-dollar claims and found to come from patients with similar demographics (not shown). The coefficient of variation, representing the within-county variation in prices across all CPT codes across all months, could theoretically range from 0 (no variation, all the same price) to a little over ten in this case, though the latter would be an extreme case with all but one county having a price of \$0 and just one outlier county with a non-zero price [Abdi, 2010]. In my data, the mean coefficient of variation was 0.15 (SD=0.14), with a minimum of 0 and a maximum of 1.0. The best way to understand the magnitude of the coefficient of variation for commercial spending is to compare it with that of other sectors of the economy. A report by the U.S. Congressional Budget Office (CBO) examined variability for Medicare spending per beneficiary in 2004 to 2005, weighted by MSA population, and compared it to that of other sectors [Congressional Budget Office, 2008]. The coefficient of variation for Medicare spending was 0.148 (0.140 adjusted for MSA income). Compared to other sectors, Medicare had the highest level of variability (commercial spending was not included in the study). The coefficient of variation was 0.143 for transportation (also 0.143 adjusted); 0.143 for housing (0.071 adjusted); and 0.120 for food (0.098 adjusted). Because counties are smaller than MSAs, weighting Medicare spending by county would have resulted in lower coefficients of variation. A mean commercial coefficient of variation of 0.15 at the county level is therefore large not only compared to Medicare but also compared to other sectors of the economy as well.

The mean age at all facilities was 54 (SD=7). Age was slightly higher at HOPDs (54, SD=7) than at ASCs (53, SD=6, $p < 0.01$) and similar at systems (54, SD=7) compared to unaffiliated facilities (54, SD=7, $p = 0.09$). Facilities had on average 49 percent female patients. ASCs had higher proportions of female patients on average (52 percent) than HOPDs (49 percent) and unaffiliated facilities had higher proportions of female patients (50 percent) than system facilities (49 percent). The average number of diagnoses across all facilities was 3 (SD=2). HOPDs had higher average number of diagnoses (3, SD=2) compared to ASCs (3, SD=1, $p < 0.01$) and unaffiliated facilities had higher average number of diagnoses (3, SD=2) than system facilities (3, SD=2, $p < 0.01$).

The average number of beds (accounting for systems) was 94 (SD=150) across all types of facilities. As expected, HOPDs had more beds than ASCs had operating rooms (109, SD=158 compared to 4, SD=2, $p < 0.01$). System facilities had more beds

(115, SD=179) than unaffiliated facilities (58, SD=158, $p < 0.01$).

Just six percent of HOPDs were in teaching hospitals (SD=0.2). Seven percent of HOPDs (SD=0.3) and zero percent of ASCs were teaching, while 10 percent of system facilities (SD=0.3) and zero percent of unaffiliated facilities were teaching. Over half of facilities were critical access: 60 percent of HOPDs (SD=0.49), 50 percent of system facilities (SD=0.50) and 52 percent of unaffiliated facilities (SD=0.50). Fifty-eight percent of facilities were non-profit, 15 percent were for-profit, and 28 percent were government-owned. Sixty-six percent of HOPDs compared to ten percent of ASCs were non-profit ($p < 0.01$); two percent of HOPDs compared to 90 percent of ASCs were for-profit ($p < 0.01$); and 32 percent of HOPDs compared to zero percent of ASCs were government owned ($p < 0.01$). Sixty-four percent of system facilities compared to 47 percent of unaffiliated facilities were non-profit ($p < 0.01$); 15 percent compared to 14 percent were for-profit ($p < 0.01$); and 21 percent compared to 39 percent were government-owned ($p < 0.01$).

The distribution of prices across CPT codes, as well as the number of system- or facility-CPT-months for each CPT code, are detailed in Appendix 1. Prices were fairly similar across CPT codes, ranging from a mean of $1,000 for transendoscopic stent placement (N=8) to $1,558 for lesion removal colonoscopy by hot biopsy forceps or bipolar cautery (N=4,533). The number of observations was asymmetrical across CPT codes, ranging from four for colonoscopy with transendoscopic ultrasound guided needle aspiration or biopsy to 10,748 for diagnostic colonoscopy. The next three most common procedures were: colonoscopy and biopsy (N=8,585); colonoscopy by snare (N=7,164); and colonoscopy by hot biopsy forceps or bipolar cautery (N=4,533). The distribution was similar for HOPDs versus ASCs (Appendix 2) and for system versus unaffiliated facilities (Appendix 3).

5.3 Regressions

Ordinary least squares regressions of relative price on bed share are reported in Table 4. Again, the unit of analysis is the system-CPT-month, and the number of observations is 35,781; not all hospitals had information on teaching status, so some observations dropped out when the variable *teach* was added to the regression equation. The outcome variable is *relativeprice*, the ratio of the system or facility's colonoscopy price divided by the mean county colonoscopy price. The independent variable of interest is *bedshare*, the proportion of beds (or operating rooms) in a county attributable to an affiliated group of facilities (or individual facility, in the case of unaffiliated facilities). Heteroskedasticity-robust standard errors clustered at the county level are presented in parentheses below all coefficients. Each regression contains a dummy variable for CPT type with CPT 45378 (diagnostic colonoscopy) as the excluded category, as well as month fixed effects with October 2005 (the first month of data) as the excluded category. Column 1 regresses *relativeprice* on *bedshare*. Each percentage point increase in the share of beds in a county was associated with a three percentage point increase in price over the mean ($p < 0.01$); so for a facility or chain increasing its market share by 25 percentage points, for example from 50 percent of the market to 75 percent of the market, the predicted relative price increase over the mean is 75 percentage points. Column 2 added facility controls, dropping the predicted increase to two percentage points over the mean ($p = 0.13$). Column 3 added occupational-adjusted wage index, restoring the prediction to three percentage points over the mean ($p = 0.10$). Column 4 added facility-level patient demographics, including average patient age, percent female patients, and average number of diagnoses of colonoscopy patients. The coefficient on *bedshare* remained stable across all four regressions, and indicates that for each percentage point increase in the share of beds in the market, relative price increases by three to four percentage points.

Finally, Columns 5 and 6 added additional county-level controls including population and the percentage of high school graduates 25 years and older (Column 5), median household income, mean travel time to work, and county demographics (Column 6). The addition of these controls did not substantially change the coefficient on *bedshare*, which remained statistically significant and stable. County population had the expected sign and was statistically significant but was small in magnitude; an additional 1,000 population in an entire county increased relative price by only 0.02 percentage points over the mean. ASCs, as expected, had a negative sign, decreasing relative price by three percentage points. This result is expected even when controlling for average patient demographics and CPT type since ASCs have lower overhead.

In Table 5, the second aim testing the relationship between county-level price variation and market concentration was addressed. Because the unit of analysis is now the county-CPT-month rather than the system-CPT-month, the number of observations was lowered to 28,517. The outcome variable in each column is the coefficient of variation, the standard deviation of price divided by the market mean. The primary regressor of interest is *hhibeds*, the sum of squared market shares of systems or facilities based on the number of beds within a county. Again, CPT and month fixed effects were included and heteroskedasticity-robust standard errors were clustered at the county level. In column 1, just two regressors were included: *hhibeds* and *wageindex*, the latter as defined in the previous table. It was important that wage index be included in the regressions on *hhibeds*, as both the bargaining and price dispersion literature suggest that price variation is commensurate with marginal costs. Consistent with theory, there was a statistically significant negative relationship between market concentration and price variation ($p < 0.01$). An increase in the HHI by 1,000 points is associated with a decrease in the coefficient of variation by 1.18 percentage points. This finding is small; increasing the HHI by 2,000, 3,000, or even

4,000 points (which then far exceeds the DOJ's merger guidelines for a concentrated market) does not begin to approach a one standard deviation increase in the coefficient of variation.

Column 2 added county-level variables including population and percentage high school graduates twenty-five and older. As in the previous table, population was statistically significant but small; in Column 3, the power to detect a difference from zero was lost. Column 3 added the remaining county-level variables including median household income, mean travel time to work, demographics, and average number of ASCs in the county. In adding more controls, the magnitude of the coefficient on *hhibeds* increased very slightly; in Columns 2 and 3, an increase in the HHI by 1,000 points was associated with a 1.6 percentage point increase in the coefficient of variation ($p < 0.01$). Again, however, the effect size did not begin to approach the standard deviation of the coefficient of variation.

5.4 Robustness Checks

5.4.1 Market Share Lags

Facility and insurers do not bargain over prices every year, but rather every three to five years. Thus current negotiated prices may be the result of past market conditions. Appendix 4 contains the results of ordinary least squares regression results of relative price on lags of market share in increments of one year. If these results are consistent with previous results, they should also have a positive sign, but all three lags (one-, two-, and three-year lags of market share) had negative signs. Yet only the two-year lag was statistically significant from zero and can be interpreted as: a one percentage point increase in bed share two years prior was associated with a one percentage point *decrease* in relative price over the mean in the current year. To determine whether this result genuinely reflects market realities, or is a fluke or indicative of conditions surrounding the recession–recall that the data are from 2005 to 2012)–would require more years of data or a greater effect size to estimate the proper lag structure. Coefficients on other variables besides market share were similar in magnitude and sign to those in Table 4.

5.4.2 Nonlinear Effects of HHI on Price Variation

There was a cluster of county[-CPT-months] well below an HHI of 8,000, and a cluster well above (Figure 3). Whether HHI has a different effect on price variation depending on its level is an empirical question; Appendix 5 addresses this question. Column 1 regresses *cov* on *hhibeds* for all HHIs less than 8,000, while Column 2 does the same for all HHIs greater than or equal to 8,000. While the association between HHI and price variation for less concentrated counties was slightly higher in magnitude and statistically significant, whereas the association for more concentrated counties was not statistically significant, there was scant evidence of nonlinear effects. The negative association was stable for both less and more concentrated counties (and as previously discussed, there were no competitive counties in the data by any definitional stretch, as the lowest HHI was 3,849).

5.5 Results Summary

Consistent with both the empirical and theoretical work in the bargaining and price concentration literatures, I found a substantial positive relationship between market share and a facility's colonoscopy price relative to the price in the market. I estimated that for every percentage point increase in a system or individual facility's bed share, relative price increases by three to four percentage points; this result was stable across a number of specifications and included controls for facility, system, and county characteristics. Further, I found that an increase in the HHI by 1,000 points was associated with a decrease in the coefficient of variation by only 1.6 percentage points. This finding, though small in magnitude, was robust to the addition of several county-level controls and did not appear to depend on the level of HHI. There was not enough statistical power to precisely estimate the effect of market share lags on price, or to test alternative specifications of market definition such as CBSA.

Chapter 6

Discussion

6.1 Summary

This chapter summarizes key findings, highlights both the research and policy implications of those findings, considers the limitations of this study, and indicates areas for future research.

The market that I studied was highly concentrated, with over three quarters market share attributable to one insurer and a highly concentrated system of providers (mean market share 76 percent, SD=0.34). Nevertheless, mean prices for colonoscopy varied widely in this relatively small geographic region. The mean price was $1,363 (SD=$374), with the lowest facility price $169 and the highest $2,749, with the distribution similar across facility types (HOPD versus ASC and system versus unaffiliated facilities). Neither the minimum nor the maximum price represented outliers in the data (Figure 2). The distribution of relative prices displayed similar variation to levels of prices, with the spread ranging from 0.14 to 2.39 around a mean of 1.0 (SD=0.18).

Consistent with both the empirical and theoretical work in the bargaining and price concentration literatures, I found a substantial positive relationship between market share and colonoscopy prices relative to the mean price in the market. I estimated that for every percentage point increase in a system or individual facility's bed share, relative price increases by three to four percentage points; this result was stable across a number of specifications and included controls for facility, system, and county characteristics. Considering that there are generally only a few facilities or systems in any given market, not only in this particular dataset but nationwide [Cutler and Morton, 2013], a potential merger could result in large percentage point increases in market share. These findings run contrary to the theory that mergers may lower prices due to efficiency gains that lower marginal costs, the results of which are passed onto payers.[14]

Another pattern in my findings was the positive and statistically significant

[14] The theory that hospital mergers could lower prices through such efficiency gains as economies of scale and reduction in the duplication of services was a major argument in court rulings in favor of several mergers in the 1990s [Capps et al., 2002].

relationship between price and county population. This finding is consistent with theory by Bresnahan and Reiss [1991] and Abraham et al. [2007] that the number of hospitals grows with area population because hospitals require a certain level of demand to cover variable profits. While population may be capturing some unobserved variables related to higher prices, it is also possible that population itself may have a positive effect, as demand for medical services may drive up prices, or social effects may be necessary for phenomena such as hospital reputation to exist.

Further, I found a statistically significant negative relationship between price variation and market concentration. This finding is consistent with the literatures in both bargaining and price dispersion. However, the relationship here was quite small in magnitude; an increase in the HHI by 1,000 points was associated with a decrease in the coefficient of variation by only 1.6 percentage points in my preferred specification. Increasing the HHI by 2,000, 3,000, or even 4,000 points (which then far exceeds the DOJ's merger guidelines for a concentrated market) does not begin to approach a one standard deviation increase in the coefficient of variation. This result, however, was robust to the addition of several county-level controls.

Small as it was, this negative relationship is not immediately intuitive. On the one hand, the negative relationship between provider concentration and price variation makes sense because variation should be commensurate with the spread of marginal costs in a market; the fewer the number of providers, the lower the potential spread of marginal costs. On the other hand, however, market concentration could imply widely varying marginal costs since a dominant provider might have a marginal cost advantage compared to smaller providers; marginal costs for this dominant provider would be much lower compared to the rest of the market. The role of insurers is important as well. How concentrated or competitive insurers balance the power providers may influence the relationship between market concentration and price variation, but I had data from just one dominant insurer.

In sum, more competitive markets for colonoscopy are associated with lower prices, but higher price *variation*. In a perfectly competitive market, higher prices reflect higher quality, but it is unclear whether there is such a correlation in the case of colonoscopy. I will discuss this issue further in the next section.

6.2 Implications

Colonoscopy is a well-defined procedure whose negotiated price within a given CPT code is highly variable and strongly dependent upon market variation. It is also an operator-dependent procedure in that whether a polyp is found and successfully removed depends on the technical skill of the physician performing the procedure. To the extent that facilities with greater market share are of higher quality, this variation is justified. I do not observe technical quality and it is not clear whether insurers do either. Policies such as reference pricing,[15] in which the insurer or employer pays the first $1,200 or $1,300 of the patient's facility fee for a colonoscopy, address price but not quality, unless the payer restricts patients to only high-quality providers.

Determining which "policy lever" (or market lever) to pull to address price variation in the commercial market will require data on more markets and procedures to understand whether price variation is justified. This study contributes to the literature on commercial price variation by evaluating a common outpatient procedure in a market that is representative of many in the U.S., with a concentrated set of providers [Cutler and Morton, 2013] and a concentrated insurance market [Kaiser Family Foundation, 2012]. For colonoscopy, price variation is driven by what would generally be considered unwarranted variation, that is, variation in market share, an indicator of bargaining power. But as previously discussed, if market share was associated with higher quality (we could not observe facility quality, particularly for ASCs), then price variation would be justified at least in part.

Unwarranted price variation as a result of bargaining power might be mitigated in a number of ways. The FTC and DOJ should more vigorously monitor provider anticompetitive behavior, both proactively and retroactively. Payers should implement policies for their enrollees that address quality simultaneously with high prices, to make shopping for medical care an attractive feature of a plan rather than a limiting one. Delivery system reforms should address price, not just utilization.

The positive relationship between market share and price is of particular policy significance in the current political climate. Hospital mergers were common in the 1990s (there were mergers involving over 900 facilities [Capps et al., 2002]), but there is reason to believe that a new wave of mergers may emerge as a result of the ACA, which permitted Medicare to reimburse ACOs, groups of providers responsible for coordinating patient care and subject to quality measurement. ACOs are eligible to keep a portion of any savings that might accrue. As with many policies, private insurers followed Medicare's example, and providers braced themselves for the potential financial rewards by combining forces at a rate of three-fold compared to before the ACA and the recession [Dafny, 2014].

This study is among the first to utilize commercial claims data to evaluate the drivers of actual transacted medical care prices, and to evaluate the role of a facility's market share in that negotiated price. I took the research a step further by evaluating the role of market concentration in the spread of prices in the market. While colonoscopy is a fairly common test because of its high sensitivity and the high rate of colorectal cancer vis-à-vis other cancers [National Cancer Institute, 2013], it is not a high-stakes procedure for most hospitals (for some small ASCs with a focus on

[15] The payer from this particular dataset does not use reference pricing.

general surgery or gastroenterology, this statement may not be true). For a hospital with hundreds of millions in revenue, however, a procedure that costs only a few thousand dollars even with physician fees may not be as important as, for example, cardiac surgeries, major spine surgeries, and joint replacements, which command tens of thousands of dollars. The relationship of market share to prices for these major procedures is likely more pronounced; mergers may thus have more of an effect on these prices than for colonoscopy.[16] Further, price is even more variable for these procedures [White et al., 2014], and so there may be more room for justification for raising prices after a merger for these procedures compared to colonoscopy.

6.3 Limitations

This study has many strengths. It utilizes actual price information from commercial claims for a common, well-defined procedure in assessing the relationship between market share and prices, rather than inferring prices from hospital charges or costs or backing out bargaining power from other information. In addition, it considers ASCs as competitors to HOPDs in a literature that has largely ignored them.

However, the findings of this dissertation must be understood within the context of the study limitations. Whether the OLS regression results can be interpreted causally is dependent on strict exogeneity; for example, a violation would occur if there were changes in state legislation during the study period that affected provider entry (there were almost no exits). Making causal inferences from a regression of prices on market share has been shown to be problematic because market share is endogenous [Kessler and McClellan, 2000]. However, without patient geographic information it is difficult to separate exogenous from endogenous information on market share. There was not enough statistical power to conduct robustness checks using larger markets such as CBSA (not shown).Yet in regressions of both prices on market share and price variation on HHI, I included county-level controls and time fixed effects to account for market-invariant time shocks, and coefficients remained robust to the addition of these variables.

This study used claims from only one payer, whose network may not contain all providers in the market. However, I am fairly confident that I had data on nearly all HOPDs and ASCs offering colonoscopy since the insurer had nearly three quarters market share by total enrollment, and therefore cannot exclude most facilities from

[16] I attempted to make the results of this study generalizable to other procedures by using a measure of market share, system beds, that captured bargaining power for all types of interventions, not just colonoscopy. If colonoscopy prices are correlated with prices for other interventions, then the effect size for market share should not be so understated compared to what it would be using prices for more intensive procedures; or conversely, overstated compared to less intensive procedures.

its network. Because of the capital required to perform colonoscopy, office-based procedures are becoming less common; there could, however, be selection bias associated with setting type. Physicians or patients in an area with a preference for a less invasive procedure such as fecal occult blood test, or physicians with a preference for more aggressive polyp removal could bias the results as well. For example, if physicians practicing at a facility with large market share also had an aggressive practice style, then the results might be upwardly biased.

As in any study, some of the variables included in OLS regressions may have been measured with error. Claims data are fairly accurate, though one concern is that some facilities may be more systematic "upcoders," or code colonoscopies more intensely than other facilities. If these facilities had both higher market share and higher prices, (a likely combination since upcoders would tend to be financially more successful than "normal coders"), then the relationship between price and market share would be spuriously inflated. Yet because there was not much of a difference in mean price across CPT codes, upcoding is not a large concern. Facility-level data should be accurate since it is administrative data from either the AHA or CMS; any measurement error would likely be random. System status may be measured with error since I did not have administrative data on system affiliation for every facility, but this error is also likely random rather than systematic, so if anything it would have attenuated the relationship between price and market share. Finally, measurement of county level variables would be a concern in some surveys, but the ACS is mandatory and intended to be representative of the U.S. civilian non-institutionalized population.

Finally, the external generalizability of these results is limited to markets similar to the one studied. The dynamics of a concentrated provider-concentrated insurer market may have influenced the relationship between price and market share (and price variation and market concentration) in a way that would be different with more unbalanced power between insurers and providers, or where both markets were relatively diffuse, a more rare occurrence in the U.S. To evaluate the nuances of these dynamics, researchers will need access to nationwide commercial claims data. This possibility will be explored in the next section.

6.4 Future Research

As commercial datasets become more readily available, more accurate inferences can be made about the drivers of price, on one hand, and volume, on the other, and the relative contribution of both to health care costs. For instance, the Health Care Cost Institute (HCCI) collects claims data from multiple commercial insurers and partners with academic institutions.[17] Future research on health care prices should focus on

[17] See http://www.healthcostinstitute.org/

identifying procedures whose quality is less variable, such as appendectomy, or whose quality information is available and known to the payer to determine whether quality is a source of price variation.

Further, this study focused on a market with both a concentrated set of providers and a concentrated set of insurers; while this market structure is typical of many states, there are others, such as Northern California (with a more diffuse insurance market) and New York (with a more diffuse insurance market and more diffuse provider market) that may have a different relationship between market share prices. States with different provider-insurer dynamics, as well as different employer dynamics, must be included in studies of medical care pricing in order to gain a complete understanding of how prices are determined.

Understanding the drivers of price and price variation will help payers and policymakers distinguish between warranted and unwarranted variations and contribute to a health care system that better reflects the quality of care delivered. Further, regulators must be aware of the price implications of health care mergers in the wake of new incentives from the ACA. Unchecked, higher prices will reflect bargaining power more so than quality.

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Tables, Figures, and Appendices

Table 1: Number of observations, claim and facility level data from a single insurer for patients undergoing colonoscopy between October 2005 and December 2012

	N
Claim level	178,433
HOPDs	132,541
ASCs	45,892
System	113,477
Unaffiliated	64,956
Facility level	169
HOPDs	149
ASCs	20
System	104
Unaffiliated	65

Table 2: Characteristics of commercial colonoscopy claims from a single insurer
for service occurring between October 2005 and December 2012

	Mean	SD	Min	Max	p (facility differences)
Patient Characteristics					
Age	53	9	18	109	
HOPDs	53	9	18	109	<0.01
ASCs	53	9	18	87	
System	53	9	18	100	<0.01
Unaffiliated	53	9	18	109	
Gender (prop female)	0.52				
HOPDs	0.51				
ASCs	0.55				
System	0.52				
Unaffiliated	0.52				
Number of diagnoses	3	2	1	12	
HOPDs	4	2	1	12	<0.01
ASCs	3	1	1	10	
System	3	2	1	12	<0.01
Unaffiliated	4	2	1	12	
Prices (across claims)					
Allowed amount	$1,302	$377	$152	$2,749	
HOPDs	$1,359	$426	$152	$2,749	<0.01
ASCs	$1,154	$101	$154	$2,452	
System	$1,253	$368	$152	$2,748	<0.01
Unaffiliated	$1,388	$376	$154	$2,749	

Table 3: Characteristics of systems and facilities treating patients undergoing colonoscopy between October 2005 and December 2012

System Market Concentration	Mean	SD	Min	Max	
Market share by bed size	76%	34%	0%	100%	
Market share by claims	78%	31%	0%	100%	
Hirschman-Herfindahl Index (by beds)	8,343	2,186	3,849	10,000	
Average real price across CPT codes	$1,363	$374	$169	$2,749	
Average relative price across CPT codes	$1.00	$0.18	$0.14	$2.39	
Coefficient of Variation across CPT codes	0.15	0.14	0	1.0	
Average Facility Patient Characteristics					p (facility differences)
Age	54	7	18	83	
HOPDs	54	7	18	83	<0.01
ASCs	53	5	19	80	
System	53	7	18	83	0.09
Unaffiliated	54	6	18	83	
Proportion female	0.5				
HOPDs	0.5				
ASCs	0.5				
System	0.5				
Unaffiliated	0.5				
Number of diagnoses	3	2	1	12	
HOPDs	3	2	1	12	<0.01
ASCs	3	1	1	8	
System	3	2	1	12	<0.01
Unaffiliated	3	2	1	12	

Continued on next page

Table 3, continued

Facility Characteristics	Mean	SD	Min	Max	p (facility differences)
Beds	94	150	2	680	
HOPDs	109	158	4	680	<0.01
ASCs (operating rooms)	4	2	2	8	
System	115	179	2	680	<0.01
Unaffiliated	109	158	4	680	
Teaching	6%	0.2	0%	100%	
HOPDs	7%	0.3	0%	100%	<0.01
ASCs	0%	0.0	0%	0%	
System	10%	0.3	0%	100%	<0.01
Unaffiliated	0%	0.0	0%	100%	
Critical Access	51%	0.5	0%	100%	
HOPDs	60%	0.5	0%	100%	<0.01
ASCs	0%	0.0	0%	0%	
System	50%	0.5	0%	100%	<0.01
Unaffiliated	52%	0.5	0%	100%	
Ownership					
Non-profit	58%	0.5	0%	100%	
HOPDs	66%	0.5	0%	100%	<0.01
ASCs	10%	0.3	0%	100%	
System	64%	0.5	0%	100%	<0.01
Unaffiliated	47%	0.5	0%	100%	
For-profit	15%	0.4	0%	100%	
HOPDs	2%	0.2	0%	100%	<0.01
ASCs	90%	0.3	0%	100%	
System	15%	0.4	0%	100%	<0.01
Unaffiliated	14%	0.3	0%	100%	
Government	28%	0.5	0%	100%	
HOPDs	32%	0.5	0%	100%	<0.01
ASCs	0%	0.0	0%	0%	
System	21%	0.4	0%	100%	<0.01
Unaffiliated	39%	0.5	0%	100%	

Table 4: Results of ordinary least squares regressions of relative price on bed share

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome variable:	*relativeprice*	*relativeprice*	*relativeprice*	*relativeprice*	*relativeprice*	*relativeprice*
bedshare	0.000303***	0.000243	0.000274*	0.000272*	0.000403**	0.000443**
	(0.000104)	(0.000161)	(0.000163)	(0.000161)	(0.000171)	(0.000172)
asc		-0.0114	-0.0105	-0.0143	-0.0310***	-0.0330***
		(0.0135)	(0.0118)	(0.0116)	(0.0111)	(0.0117)
system		-0.00324	-0.00306	-0.00383	-0.00735	-0.00837
		(0.00778)	(0.00783)	(0.00790)	(0.00779)	(0.00875)
teach		-0.0134	-0.0152	-0.0167	-0.0323	-0.0351
		(0.0277)	(0.0265)	(0.0262)	(0.0236)	(0.0277)
critical_access		-0.0126	-0.0118	-0.0144*	-0.00859	-0.00380
		(0.00841)	(0.00843)	(0.00852)	(0.00812)	(0.0105)
for_profit		-0.0133	-0.0133	-0.0148	-0.00517	-0.00406
		(0.0160)	(0.0144)	(0.0147)	(0.0121)	(0.0125)
govt		-0.00159	-0.00111	-0.00243	-0.00174	0.00106
		(0.00859)	(0.00867)	(0.00889)	(0.00855)	(0.00956)
wageindex			0.0843	0.0873	-0.0231	-0.0101
			(0.0547)	(0.0557)	(0.0729)	(0.0828)
age				0.000325*	0.000328*	0.000353*
				(0.000189)	(0.000190)	(0.000189)
female				0.000311	0.000666	0.000772
				(0.00273)	(0.00272)	(0.00269)
diagnum				-0.00363	-0.00401*	-0.00402*
				(0.00230)	(0.00226)	(0.00228)
pop2012_county					1.57e-07***	1.49e-07***
					(4.92e-08)	(2.97e-08)
hsgrad_county					0.000142	-5.41e-05
					(0.000483)	(0.000625)
hhinc_county						4.73e-07
						(4.69e-07)
worktravel_county						-0.000927
						(0.000744)
female_county						-0.000460
						(0.00264)

Continued on next page

Table 4, continued

black_county						0.00166
						(0.00275)
nativeamer_county						0.000213
						(0.000901)
asian_county						-0.00256
						(0.00185)
pacislander_county						-0.0140
						(0.0196)
multiracial_county						0.00487
						(0.00806)
CPT fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	35,781	35,473	35,473	35,473	35,473	35,473
R-squared	0.055	0.057	0.057	0.058	0.061	0.062

Note: Heteroskedasticity-robust standard errors clustered at the county level are in parentheses below coefficients.

Each regression contains CPT and month fixed effects and a constant. *** p<0.01, ** p<0.05, * p<0.1.

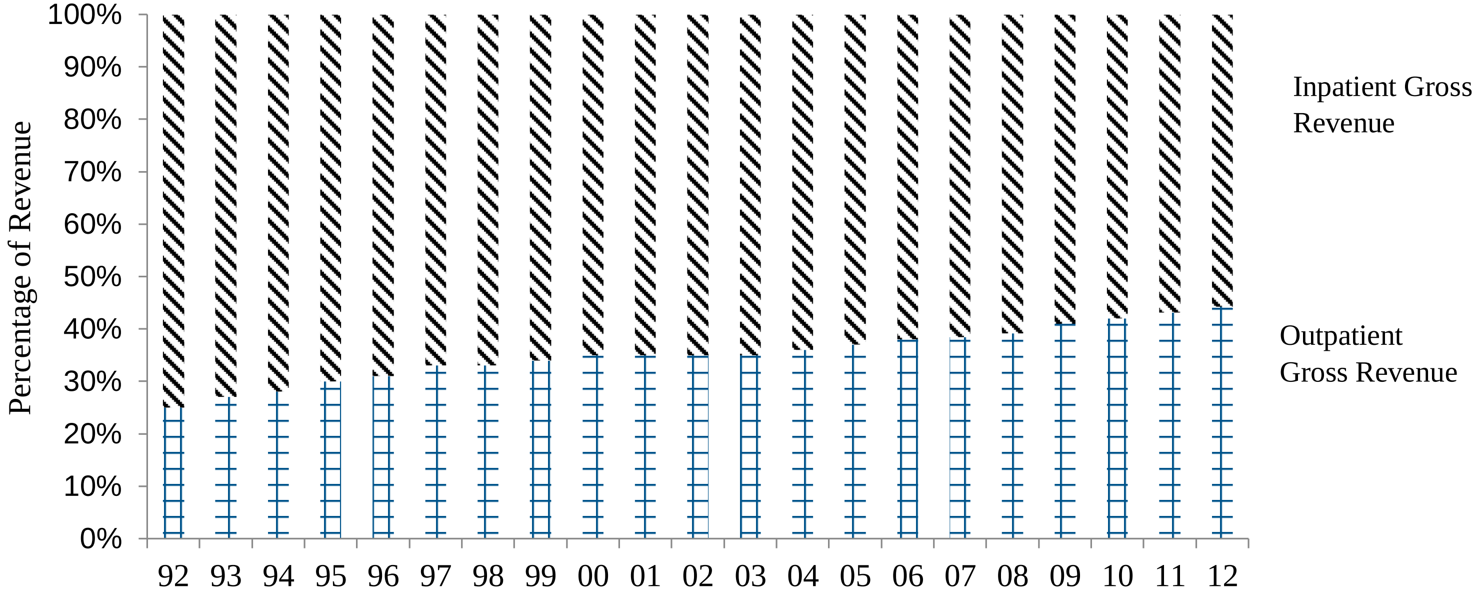
Table 5: Results of ordinary least squares regressions of coefficient of variation (COV) on HHI

	(1)	(2)	(3)
Outcome variable:	*cov*	*cov*	*cov*
hhibeds	-1.18e-05***	-1.63e-05***	-1.58e-05***
	(3.56e-06)	(3.94e-06)	(3.95e-06)
wageindex	-0.0524	0.0591	0.109
	(0.193)	(0.190)	(0.205)
pop2012_county		-2.52e-07***	-1.45e-07
		(8.59e-08)	(1.56e-07)
hsgrad_county		0.00122	0.00280
		(0.00195)	(0.00204)
hhinc_county			-1.01e-07
			(1.39e-06)
worktravel_county			-0.00361*
			(0.00202)
female_county			-0.000749
			(0.00571)
black_county			-0.00228
			(0.00911)
nativeamer_county			-0.00242
			(0.00193)
asian_county			-0.0111*
			(0.00582)
pacislander_county			0.0843**
			(0.0423)
multiracial_county			0.0125
			(0.0161)
asc_county			-0.0418*
			(0.0220)
CPT fixed effects	Yes	Yes	Yes
month fixed effects	Yes	Yes	Yes
Observations	28,517	28,517	28,517
R-squared	0.121	0.129	0.145

Note: Heteroskedasticity-robust standard errors clustered at the county level are in parentheses below coefficients.

Each regression contains CPT and month fixed effects and a constant. *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Distribution of Outpatient versus Inpatient Revenues, 1992 to 2012



Source: Avalere Health analysis of American Hospital Association Annual Survey data, 2012, for community hospitals.

Figure 2: Distribution of Real Mean Facility Prices Across County-CPT-Months

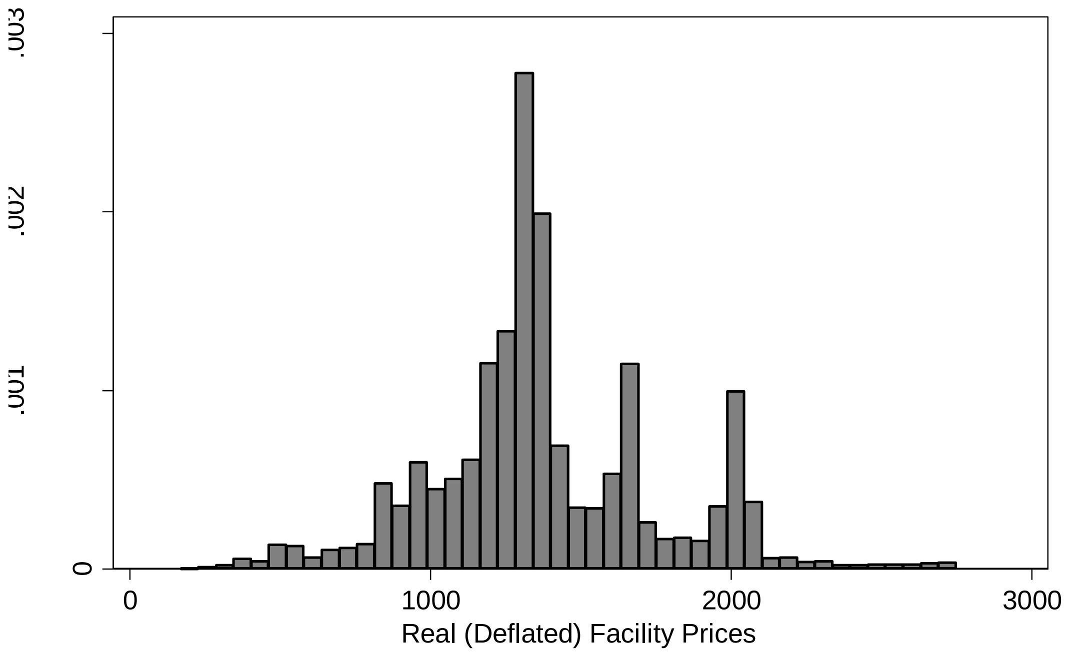
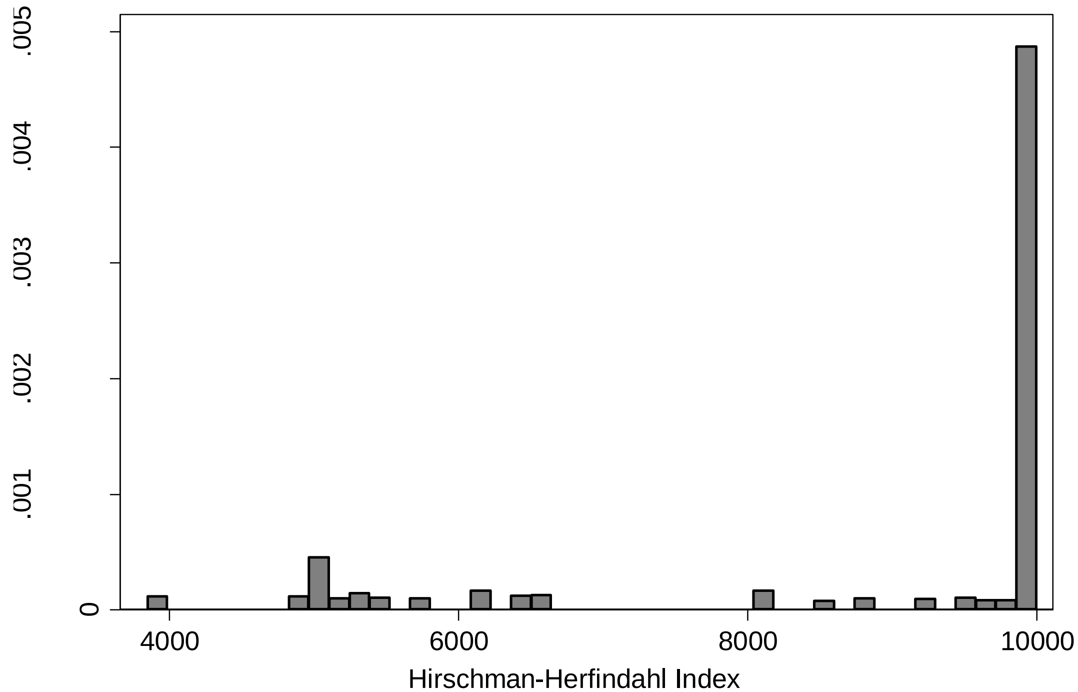


Figure 3: Distribution of Market Concentration over County-CPT-Months



Appendix 1: Distribution of average real prices across Current Procedural Terminology (CPT) Codes, October 2005 to December 2012

CPT Code	Code Name	N	Real price	SD	Min	Max
45378	Diagnostic colonoscopy	10,748	$1,316	$319	$199	$2,733
45379	Colonoscopy with foreign body removal	18	$1,346	$401	$445	$2,004
45380	Colonoscopy and biopsy	8,585	$1,350	$340	$236	$2,748
45381	Colonoscopy with submucosal injection	660	$1,199	$423	$183	$2,701
45382	Colonoscopy with control of bleeding	163	$1,310	$452	$273	$2,724
45383	Lesion removal colonoscopy by ablation	1,046	$1,452	$454	$206	$2,701
45384	Lesion removal colonoscopy by hot biopsy forceps or bipolar cautery	4,533	$1,558	$459	$236	$2,749
45385	Lesion removal colonoscopy by snare	7,164	$1,375	$355	$169	$2,744
45386	Colonoscopy with balloon dilation	100	$1,332	$425	$771	$2,717
45387	Colonoscopy with transendoscopic stent placement	8	$1,000	$115	$827	$1,230
45391	Colonoscopy with endoscopic ultrasound examination	11	$1,223	$314	$398	$1,575
45392	Colonoscopy with transendoscopic ultrasound guided needle aspiration or biopsy	4	$1,336	$18	$1,309	$1,350
G0105	Colonoscopy for individuals at high risk	950	$1,237	$368	$289	$2,618
G0121	Colonoscopy for individuals not at high risk	1,791	$1,258	$407	$184	$2,722

Appendix 2: Distribution of average real prices across Current Procedural Terminology (CPT) codes, HOPDs versus ASCs

CPT Code	Code Name	N	Real price, HOPDs	N	Real price, ASCs
45378	Diagnostic colonoscopy	9,360	$1,336	1,388	$1,180
45379	Colonoscopy with foreign body removal	15	$1,374	3	$1,205
45380	Colonoscopy and biopsy	7,191	$1,380	1,394	$1,194
45381	Colonoscopy with submucosal injection	434	$1,221	226	$1,158
45382	Colonoscopy with control of bleeding	86	$1,480	77	$1,121
45383	Lesion removal colonoscopy by ablation	882	$1,483	164	$1,280
45384	Lesion removal colonoscopy by hot biopsy forceps or bipolar cautery	4,187	$1,578	346	$1,320
45385	Lesion removal colonoscopy by snare	5,897	$1,412	1,267	$1,205
45386	Colonoscopy with balloon dilation	77	$1,371	23	$1,200
45387	Colonoscopy with transendoscopic stent placement	7	$1,013	1	$908
45391	Colonoscopy with endoscopic ultrasound examination	11	$1,223	0	.
45392	Colonoscopy with transendoscopic ultrasound guided needle aspiration or biopsy	4	$1,336	0	.
G0105	Colonoscopy for individuals at high risk	863	$1,253	87	$1,080
G0121	Colonoscopy for individuals not at high risk	1,668	$1,268	123	$1,119

Appendix 3: Distribution of average real prices across Current Procedural Terminology (CPT) codes, system versus unaffiliated facilities

CPT Code	Code Name	N	Real price, system facilities	N	Real price, unaffiliated facilities
45378	Diagnostic colonoscopy	6,813	$1,235	3,935	$1,457
45379	Colonoscopy with foreign body removal	12	$1,259	6	$1,521
45380	Colonoscopy and biopsy	5,511	$1,273	3,074	$1,487
45381	Colonoscopy with submucosal injection	521	$1,199	139	$1,200
45382	Colonoscopy with control of bleeding	81	$1,382	82	$1,239
45383	Lesion removal colonoscopy by ablation	602	$1,377	444	$1,553
45384	Lesion removal colonoscopy by hot biopsy forceps or bipolar cautery	2,770	$1,541	1,763	$1,585
45385	Lesion removal colonoscopy by snare	4,659	$1,304	2,505	$1,508
45386	Colonoscopy with balloon dilation	80	$1,325	20	$1,358
45387	Colonoscopy with transendoscopic stent placement	2	$952	6	$1,016
45391	Colonoscopy with endoscopic ultrasound examination	11	$1,223	0	.
45392	Colonoscopy with transendoscopic ultrasound guided needle aspiration or biopsy	4	$1,336	0	.
G0105	Colonoscopy for individuals at high risk	510	$1,151	440	$1,337
G0121	Colonoscopy for individuals not at high risk	968	$1,188	823	$1,340

Appendix 4: Results of ordinary least squares regressions of relative price on year-increment lags of bed share

	(1)	(2)	(3)
Outcome variable:	*relativeprice*	*relativeprice*	*relativeprice*
lagbedshare1	-3.12e-05		
	(5.64e-05)		
lagbedshare2		-0.000108**	
		(5.47e-05)	
lagbedshare3			-5.77e-05
			(7.26e-05)
wageindex	-0.0723	-0.0775	-0.0741
	(0.0732)	(0.0719)	(0.0739)
pop2012_county	1.11e-07***	1.03e-07***	1.08e-07***
	(3.04e-08)	(3.08e-08)	(3.02e-08)
hsgrad_county	0.000160	0.000205	0.000176
	(0.000523)	(0.000519)	(0.000517)
hhinc_county	4.06e-07	3.59e-07	3.90e-07
	(4.71e-07)	(4.79e-07)	(4.65e-07)
worktravel_county	-3.79e-05	6.52e-05	-3.20e-06
	(0.000696)	(0.000703)	(0.000719)

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Appendix 4, continued

asc	-0.0327**	-0.0323**	-0.0326**
	(0.0129)	(0.0130)	(0.0129)
system	-0.00457	-0.00451	-0.00455
	(0.00848)	(0.00840)	(0.00845)
teach	-0.0312	-0.0311	-0.0311
	(0.0282)	(0.0282)	(0.0282)
critical_access	-0.00483	-0.00428	-0.00463
	(0.00970)	(0.00959)	(0.00962)
for_profit	-0.0222*	-0.0233*	-0.0225
	(0.0133)	(0.0133)	(0.0136)
govt	0.00168	0.00189	0.00175
	(0.00880)	(0.00876)	(0.00879)
age	0.000332*	0.000327*	0.000331*
	(0.000191)	(0.000191)	(0.000191)
female	0.000770	0.000746	0.000752
	(0.00263)	(0.00262)	(0.00263)
diagnum	-0.00389*	-0.00388*	-0.00388*
	(0.00232)	(0.00232)	(0.00232)
county demographics	Yes	Yes	Yes
cpt fixed effects	Yes	Yes	Yes
month fixed effects	Yes	Yes	Yes
R-squared	0.059	0.059	0.059

Note: Heteroskedasticity-robust standard errors clustered at the county level are in parentheses below coefficients.

Each regression contains CPT and month fixed effects and a constant. *** p<0.01, ** p<0.05, * p<0.1.

Appendix 5: Results of ordinary least squares regressions of coefficient of variation (COV) on segments of HHI

	(1)	(2)
Outcome variable:	*cov*	*cov*
hhibeds<8000	-3.33e-05***	
	(1.14e-05)	
hhibeds≥8000		-1.17e-05
		(1.29e-05)
wageindex	0.882***	0.258
	(0.214)	(0.219)
pop2012_county	-8.12e-07	-4.54e-07**
	(4.79e-07)	(1.87e-07)
hsgrad_county	-0.0267	0.00342*
	(0.0282)	(0.00204)
hhinc_county	1.96e-05	8.75e-07
	(1.42e-05)	(1.73e-06)
worktravel_county	0.0263	-0.00499**
	(0.0164)	(0.00229)
asc_county	-0.0496***	-0.0461
	(0.00926)	(0.0278)
county demographics	Yes	Yes
CPT fixed effects	Yes	Yes
month fixed effects	Yes	Yes
Observations	6,241	22,276
R-squared	0.436	0.119

Note: Heteroskedasticity-robust standard errors clustered at the county level are in parentheses below coefficients. Each regression contains CPT and month fixed effects and a constant. *** p<0.01, ** p<0.05, * p<0.1.