The Effects of Physician Practice Acquisitions on Hospital Competition *

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Abstract

Consolidation between hospitals and physician practices is a ubiquitous feature of health care markets across the US. This paper examines the impacts of hospital-physician practice acquisition on physician referrals, hospital prices, and welfare using detailed administrative claims data from the Massachusetts APCD. I find that the effects of acquisitions vary substantially across large and small hospital systems in the state. Among small and mid-size hospitals, acquisition leads to a 20 percentage point increase in within-system referral rates and a 6 - 20% increase in hospital prices. In contrast, physician practices acquired by a dominant hospital neither meaningfully shift referrals nor raise negotiated hospital prices. I then develop a bargaining model of competition and use the estimates to evaluate the effects of changes in physician practice ownership. The model demonstrates how changes in referral demand due to practice consolidation enhances the bargaining leverage of the acquiring hospital system. I then simulate the hospital acquisition of every physician practice in the state, and I find that hospital prices counterfactually would increase by .72 percent or nearly $200 per admission, though effects are larger across non-dominant firms. Higher payments to hospitals decrease insurer surplus by 19% or approximately $18,000 per enrollee. Patient welfare declines by 22%, or $185 per individual, due to shifts in physician referrals post-acquisition.

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I Introduction

This paper examines the impact of hospital-physician practice consolidation on physician referrals, hospital-insurer bargaining, negotiated prices, and welfare. The hospital ownership of physician practices has emerged as a recent and widespread trend in provider consolidation across health care markets in the United States. Nearly 41% of physicians in the U.S. work in a hospital-owned practice, and this share has grown by nearly one-third from 2012-2022.[1] The trend in hospital-physician practice ownership accelerated over the years of the COVID-19 pandemic.[2] Since the health care industry comprises nearly one-fifth of the United States GDP, understanding how vertical consolidation between hospitals and physician practices affects health care prices and spending is of the utmost importance.

Theoretical literature argues that vertical integration can harm competition by generating incentives to foreclose rivals and raise rivals' costs (Salop and Scheffman (1983), Krattenmaker and Salop (1986), Hart and Tirole (1990), Ordover, Saloner, and Salop (1990)). [3] This paper focuses on the potential anti-competitive effects of integration in a market with a large, dominant upstream firm. In particular, I examine the effects of hospital-physician practice acquisition that stem from physicians' roles as intermediaries in the market for health care services. Individuals seeking specialized care typically follow a physician's referral to choose a provider (Brot-Goldberg and Vaan (2018), Chernew et al. (2018)). In this way, physician referral incentives are an important determinant of hospital choice, and control over physicians' referral incentives presents a potential avenue by which hospitals may capture patient volume and foreclose rival hospitals from access to patient referrals.

This paper studies the impact of hospital-physician practice acquisitions on physician referrals, hospital-insurer negotiations, negotiated prices, and welfare using the Massachusetts All-Payer Claims Database (APCD), a large and highly detailed administrative database of medical claims for Massachusetts residents enrolled in private health insurance plans. This setting and data offer several empirical advantages. First, the Eastern Massachusetts hospital market contains a large, dominant hospital system, Partners Health Care. Partners Health Care negotiates prices that are nearly 30% higher than the average hospital in Massachusetts; receives nearly one-third of the entire admission volume in the region; and acquires the largest number of physicians relative to other hospitals and hospital systems

[1] Kane (2022)

[2] Physicians Advocacy Institute (2022)

[3] While economic theory also weighs potential efficiencies from integration, such as improved coordination and incentives to invest in complementary inputs (e.g. Rey and Tirole (2007), Grossman and Hart (1986)), the assessment of efficiencies from integration is beyond the scope of this paper.

over the sample time frame. This feature of the Massachusetts hospital market allows me to contrast responses across dominant and non-dominant firms. Second, each claim line of the APCD reports transaction prices (i.e. paid amounts) between insurers and hospitals, along with detailed information on patients' clinical diagnoses and demographics. The observed paid amounts allow me to analyze the impacts of acquisitions on hospital prices, accounting for differences in clinical case mix and patient demographics.

I begin with two empirical observations about the impact of hospital-physician practice acquisition on physician referrals and hospital prices. I first show that physicians respond to acquisition by non-dominant hospitals by referring patients within-system at higher rates. In contrast, acquisitions by the dominant firm, Partners Health Care, do not meaningfully shift physicians' referrals. Using variation in physician referral choices across hospital-acquired versus independently owned physicians over time, I find that physicians acquired by small and medium-volume hospital systems are 20 percentage points more likely on average to refer to the owning hospital. This effect remains stable over time, and represents an approximately 30% increase relative to the acquired physicians' pre-merger referral rates to the acquiring hospital system.

Second, I document a strong and positive relationship between hospital-physician ownership levels and hospital prices for non-dominant hospital systems. Using longitudinal variation within hospital system and insurer, I estimate that a 1% increase in the number of hospital-owned physicians is associated with a .06% to .2% increase in the average negotiated price of the acquiring hospital system. However, this average effect masks substantial heterogeneity across hospital systems. The effect size is largest for medium-volume hospitals, and smallest for Partners Health Care (i.e. the dominant system) hospitals. Taken together, these empirical observations suggest that physician practice acquisitions increase bargaining leverage more for hospitals that are on the margin of being chosen than for hospitals are that attract relatively high, or relatively low, market shares at baseline.

To assess the impacts of hospital-physician practice acquisitions on demand for hospitals, hospital insurer-negotiations, and hospital prices, I develop a model of patient demand and hospital-insurer bargaining. This framework closely follows standard models of Nash Bargaining in bilateral oligopoly, e.g. Ho and Lee (2017), Gowrisankaran, Nevo, and Town (2015), and Horn and Wolinsky (1988). In the first stage of the model, hospital systems and insurers jointly negotiate over prices, taking as given individuals' value from insurer networks, patient demand for hospitals, and the equilibrium outcomes for all other hospital systems and insurers in the market. The resulting negotiated price is a function of each party's value from agreement relative to disagreement.

In the second stage of the model, individuals draw from a random distribution of health and chose among available hospitals for further care. I assume that hospital demand is a function of patient preferences over hospital characteristics, distance, and hospital specific fixed effects, as well as physician preferences over hospitals determined by whether their practice has been acquired. This model of hospital demand expands on existing frameworks (e.g. Ho and Lee (2017) and Gowrisankaran, Nevo, and Town (2015)) by including an indicator for whether or not the referring physician on each admission was acquired by the hospital system in which the admission took place. Based on the earlier descriptive evidence in this paper on physicians' referral responses, I take as given that hospital-acquired physicians re-direct referrals to the owning hospital system post-acquisition; I then use the model to explore how increases in hospital demand can impact the acquiring health system's bargaining leverage.

The first order conditions of the hospital-insurer Nash Bargaining problem imply that physician practice acquisition increases the bargaining leverage of the acquiring hospital and leads to higher negotiated prices. These effects are driven by the diversion in hospital-acquired physicians referrals from rival hospitals to the owning system. Changes in physician referrals due to acquisition enhances the value to insurers of including the acquiring hospital system in insurer networks. As referral rates to rival firms decrease, so does the insurer gains from including rival hospital systems. Both effects work in the same direction to increase the bargaining leverage of the acquiring hospital system. Acquisitions raise negotiated prices more when the acquiring hospital system has no close substitutes in an insurers network, when rival hospitals in the network negotiate higher prices, and when rival hospitals face steeper declines in referral rates post acquisitions. Moreover, the magnitudes of the effects vary by the size of the acquiring firm: I show that hospitals that are on the margin of being chosen for inclusion in an insurer's network face the largest impact of physician practice acquisition on demand, and therefore on bargaining leverage. This is consistent with my descriptive results on referral and price effects.

I estimate the parameters in the model using detailed claims data on hospital admissions from the Massachusetts APCD. The parameters of the demand model are identified by variation in patient characteristics, hospital attributes, and referring physicians' hospital ownership status over time. Using the parameter estimates, I compute individuals' willingness-to-pay for hospital networks, patient demand for hospitals, and the relative change in each object for each possible disagreement network by hospital system - insurer pair. These are key inputs to the second stage of estimation, in which I estimate bargaining weight parameters for each insurer. The insurer bargaining weights are identified from individuals' willingness-to-pay for hospitals, and from substitution patterns across hospitals in insurers' networks. I estimate a strong positive weight on physicians' ownership status, suggesting that hospital ownership of the referring physician is an important driver of hospital choice. The estimated bargaining weights range from 0.4 - 0.5 across insurers, implying that hospitals posses higher bargaining power in this market.

I use the parameter estimates to simulate the impact of changes in physician ownership on hospital price, hospital profits, insurer payments to hospitals, insurer surplus, and patient welfare. I assume that physicians' acquisition status affects hospital choice through physicians' influence on patients, and not via patient preferences. I first consider the counterfactual scenario in which all physician practices are independently owned. Relative to the baseline, I find that independent physician practice ownership leads to a decline in hospital profit and negotiated price: on average, hospital prices decline by approximately 4% and profits by 12.24%, and the effects are larger in magnitude among non-dominant firms. This result stems from a reallocation of patient demand from Partners Health Care hospitals to lower-priced hospitals in the Boston region. As a result, patient surplus per individual increases by 8.72%. This can be understood as the benefit to patients from choosing hospitals that more closely reflect their own preferences instead of hospital systems' interests. Insurer profits grow from \$22,461 to \$24,420 per enrollee, reflecting an 8.72% increase. Higher enrollee surplus combined with lower insurer payments to hospital systems drive a net positive impact on insurer surplus.

I next examine the effects of hospital-physician practice mergers. I assign every independent physician practice in the sample to counterfactual hospital ownership. I find that average hospital prices increase by .72%, or \$198.58 per admission when all physician practices are hospital-owned. However, this masks substantial heterogeneity across hospitals. The growth in price per admission ranges from \$143.14, or .42%, in Partners Health Care hospitals to \$4,228.28, or 16%, in non-dominant hospital systems. This effect is driven by changes in hospital demand that result from shifts in physician referrals. When all physicians are hospital acquired, referral demand for Partners hospitals diminishes relative to other hospital systems in the region. This results in higher insurer payments to small- and medium-volume firms in the region, and lower insurer payments to Partners hospitals. Consumer surplus decreases relative to the baseline and to the scenario in which all physicians practices are independent. This can be interpreted as the loss to patients from hospital referral admissions that do not align with their preferences, and instead reflect hospital interests.

This loss in enrollee surplus from inappropriate referrals, along with higher insurer payments to non-dominant firms, results in a 18.83% decline to insurer surplus per enrollee.

Related literature: Much of the existing literature on the industrial organization of health care markets models hospital-insurer bargaining and estimates the impacts of horizontal changes in market structure. For example, Gowrisankaran, Nevo, and Town (2015) estimate the impact of hospital mergers on negotiated price in counterfactual simulations; and Ho and Lee (2017) estimate the impact of changes in insurer market structure on enrollment, premiums, hospital demand, and negotiated prices. My contributions to this literature include estimating a model of hospital demand that incorporates a vertical component of health care provision, i.e. physicians' referral incentives. I argue that including the role of physician incentives in patient choice is important in order to understand how hospital-physician group integration affects hospital-insurer bargaining and negotiated prices. Finally, I use the estimates from this model to simulate the welfare impacts of changes in physician ownership.

This paper also adds to the empirical literature on the effects of vertical integration and other arrangements with a vertical component, e.g. Hastings (2004), Hastings and Gilbert (2005), Chipty and Snyder (1999), Chipty (2001), Crawford et al. (2018), Beck and Scott Morton (2021). This paper contributes to the literature by providing evidence about a novel avenue – changes to integrated physicians' referral incentives – by which a vertically integrated firm can foreclose rivals and harm competition. Moreover, this paper documents significant heterogeneity in the extent to which upstream hospital systems are able to act on incentives to foreclose rival hospitals and raise prices by exercising control over acquired physician referrals. To my knowledge, this is one of the first papers that study how responses vary by dominant vs non-dominant upstream firms.

In addition, this paper contributes to a large literature that estimates the average effects of hospital-physician practice acquisition on health care utilization, prices, spending, and clinical outcomes. Much of this literature estimates merger effects using a regression framework. For example, Capps, Dranove, and Ody (2017) show that physician prices increase post-acquisition using a sample of medical claims for privately insured patients; Baker, Bundorf, and Kessler (2014) document an association between hospital-physician ownership and hospital prices; Koch, Wendling, and Wilson (2017) provide evidence that hospital-physician practice leads to higher utilization and spending among Medicare beneficiaries without improvements in clinical outcomes of patients (Koch, Wendling, and Wilson (2021)). While prior work (e.g. Lin, McCarthy, and Richards (2021a), Baker, Bundorf, and Kessler (2014)) also examines the effects of acquisition on spending and hospital prices, much of this literature has relied on estimates of hospital transaction prices based on charges, or cross-sectional variation in hospital-physician ownership patterns to estimate price effects. [4]

My paper builds on this literature in several ways. First, I observe hospital transaction prices (i.e. paid amounts) at an extremely granular level in the medical claims data. This critical feature of the data allows me to quantify how acquisitions impact the bargaining leverage of the acquiring hospital system, and its subsequent effects on negotiated prices. Second, I develop a theoretical model of hospital competition that demonstrates how hospitals can use physician group acquisition as a strategy to foreclose rival hospital systems from receiving patient referrals, increase bargaining leverage vis-a-vis insurers and subsequently negotiate higher prices. Using estimates from this model, I am then able to estimate the impact of hospital-physician group acquisition on hospital profits, prices, spending, and welfare. Finally, my results uncover substantial heterogeneity in responses across hospital systems, suggesting that dominant and non-dominant firms leverage physician acquisitions for different ends.

Roadmap: The remainder of the paper is organized as follows. In Section II, I outline my data sources, and I describe how I measure hospital-physician practice acquisitions, estimate negotiated prices, and construct an analytic sample of referral admissions. I also present summary statistics about the hospitals, physicians, and patients in my sample. In section III, I document descriptive results about the relationships between hospital-physician practice acquisition, physician referrals, and hospital prices. Section IV presents a theoretical model of hospital competition and derives bargaining equations that relate negotiated prices to hospital and insurer gains-from-trade. Given the descriptive evidence in Section III, I focus on how physician referral steering toward the acquiring hospital system can disadvantage rival hospital systems and impact negotiations via insurers' gains-from-trade. In Section V, I outline the identification and estimation of the model. Section VI presents counterfactual simulations that estimate the impact of changes in physician practice ownership. Section VII concludes.

[4] Cooper et al. (2019) document that prices estimated with hospital charges information are weakly correlated with transaction prices.

II Data and Summary Statistics

II.A Data

The primary source of data in this paper is the Massachusetts All-Payer Claims Database (APCD) from 2014-2017. I use the APCD to infer hospital-physician practice mergers, estimate negotiated prices, and construct a sample of hospital referrals for elective inpatient admissions. The Massachusetts APCD contains the universe of medical claims along with information about patients' age, sex, zip code, and plan enrollment for all Massachusetts residents enrolled in a commercial health insurance plan. I take several steps to clean the data and to construct a sample of elective inpatient admissions for patients ages 18-64 at general acute care hospitals in Massachusetts. I classify each admission event into one of the following clinical categories: labor and delivery, cardiac, orthopedic, cancer-related, or other using the diagnosis and procedure codes on each claim line. The Appendix contains more details on data cleaning and admissions sample construction.

The APCD serves three important functions in my analysis. First, it allows me to infer physician practice ownership and track hospital acquisitions via physician billing patterns. Each claim line reports the billing provider that submitted the claim on behalf of the physician who provided the service. I use the billing provider field to leverage an administrative feature of physicians' claims submission process: physicians who practice in an independent medical group submit claims for physician services with the independent medical group in the billing provider field. On the other hand, physicians who practice in a hospital- or health system-owned practice submit claims for physician services using the corresponding hospital or health system in the billing provider field. I assign physicians to an independently-owned practice or a hospital system-owned clinic based on the billing provider organization under which the physician received the majority of her payments in each quarter. In this way, I use the APCD to develop a matched panel data set that links each physician in the sample to an independent practice or hospital-owned clinic in which she works by quarter. I label a physician as hospital-acquired if her practice changes from an independently-owned clinic in quarter t to a hospital-owned clinic in quarter $t + 1$. More details about my approach to track physician practice ownership are in the Appendix.

Second, the APCD reports negotiated payments (i.e. "paid amounts") from insurers to hospitals for the medical service on each claim line, in addition to detailed information about the clinical procedure, diagnosis codes, patient age, sex, and zip code location. I use these fields to adjust the paid amounts for patient case mix. Following Cooper et al. (2019) and

Craig, Ericson, and Starc (2021), I regress observed paid amounts for each hospital admission on indicators for patients' clinical diagnoses, 10-year age group, and geographical location (i.e. zip code). I then use the estimated parameters from this regression and compute a hospital price index for each quarter at the sample means of each variable. This yields the price for each hospital and payer in each quarter, adjusted for the mix of treatments and mix of patients. The distribution of these casemix-adjusted prices contains a number of observations that appear to be outliers. I therefore winsorize prices at the 5% level. The Appendix contains more details on the inpatient price measurement.

Third, I use the APCD to develop a matched sample of referral admissions for elective inpatient procedures. I begin by identifying elective inpatient admissions in the APCD; and then match each elective hospital admission to the referring physician, if any, who was most likely to direct the patient to the admitting hospital. Specifically, for every admission in the sample, I collect the admitted patient's outpatient claims for physician evaluation and management services (i.e. physician office visits) in the 6 months prior to each admission. I then identify the physician who submitted the largest share of office visit claims as the referring physician on the given admission. I merge information about the referring physician's practice ownership status and hospital acquisition (if any). This results in a sample of hospital admissions matched to referring provider information and serves as the primary data set in my analysis of price and referral effects.

I augment the Massachusetts APCD with several supplementary data sources. I incorporate hospital costs data from Medicare cost reports (*Healthcare Cost Report Information System (HCRIS)* 2020). I obtain data on physicians, including sex, practice location, and specialty, from the Center for Medicare and Medicaid Services National Provider Identification (NPI) Directory (*NPI Files* 2020). In addition, I use hospital characteristics from the American Hospital Association Annual Surveys (*AHA Annual Survey* 2015). This includes information on teaching hospitals, service offerings for obstetric, cardiac, orthopedic, and cancer patients, and hospital location. The variable definitions for each service offering are in the Appendix.

II.B Summary Statistics

Table 1 summarizes individual demographics, clinical characteristics, and insurance enrollment across patients in the unrestricted sample of hospital admissions (Columns (1) and (2)) and the sample of hospital admissions matched to referring physician information (Columns (3) and (4)). While there are approximately 30,000 fewer admission cases in the referral-matched sample of admissions than in the unrestricted sample, there are no other significant differences in the patient demographics, clinical case mix, or enrollment.

Table 1: Descriptive Statistics on Patients with Elective Hospital Admissions

	Unrestricted Sample		Referral Sample	
	Mean	SD	Mean	SD
	(1)	(2)	(3)	(4)
Panel A: Patient Demographics				
Patient Age	41.37	(12.46)	42.41	(12.52)
Female	0.78	(0.42)	0.76	(0.43)
Panel B: Clinical Cohort				
Labor & Delivery	0.47	(0.5)	0.43	(0.49)
Orthopedic	0.12	(0.32)	0.14	(0.34)
Cancer	0.09	(0.29)	0.10	(0.3)
Cardiac	0.06	(0.24)	0.07	(0.25)
Other	0.26	(0.44)	0.27	(0.44)
Panel C: Health Insurance Enrollment				
BCBS	0.40	(0.49)	0.41	(0.49)
Harvard Pilgrim	0.21	(0.41)	0.22	(0.41)
Tufts	0.12	(0.32)	0.09	(0.29)
Anthem	0.06	(0.24)	0.06	(0.24)
NHP	0.04	(0.2)	0.04	(0.2)
Other payer	0.18	(0.38)	0.18	(0.39)
Panel D: Health Insurance Plan Type				
HMO	0.56	(0.5)	0.57	(0.49)
PPO	0.27	(0.44)	0.25	(0.44)
POS	0.09	(0.28)	0.09	(0.28)
Other plan	0.06	(0.23)	0.06	(0.23)
Number of admissions	183,701		153,333	

Notes: Values present summary statistics (standard deviations in parentheses) for all unique privately insured individuals in Massachusetts over the period 2014-2017. Columns (1) and (2) describe patients with at least one elective hospital admission. Columns (3) and (4) describe patients with at least one elective inpatient hospital admission that results from a physician referral.

Women constitute approximately 80 percent of the sample, consistent with the observation that the modal patient admission is for Labor and Delivery. In addition, the majority of enrollees are covered by a managed care organization, either through an Health Maintenance Organization (HMO), Preferred Provider Organization (PPO), or Point-of-Service plan (POS). The majority of individuals chose an HMO plan. The market for health insurance is relatively concentrated in Massachusetts during the sample time frame. Nearly 40 percent of patients are enrolled in a Blue Cross Blue Shield (BCBS) plan, and nearly four-fifths of the commercially insured population is enrolled in BCBS, Harvard Pilgrim, Tufts Health Plan, or Anthem plans. Fewer than 20 percent are enrolled in any other plan.

Table 2 summarizes physician characteristics by physician ownership status in the first quarter of 2014. Column (1) presents statistics about physicians who remain hospital-employed throughout 2014-2017, (2) presents statistics about physicians who practice in an independently-owned group throughout 2014-2017, and (3) presents statistics for physicians whose practices were independently-owned in the first quarter of 2014 but subsequently acquired by a hospital before the fourth quarter 2017. Table 2 suggests that the majority of the physician practice acquisitions in Massachusetts took place before the sample time frame. Nearly nearly 57 percent of physicians were hospital-acquired before the first quarter 2014, and remained so throughout. On the other hand, only 5% of the sample physicians were acquired by a hospital between 2014-2017.

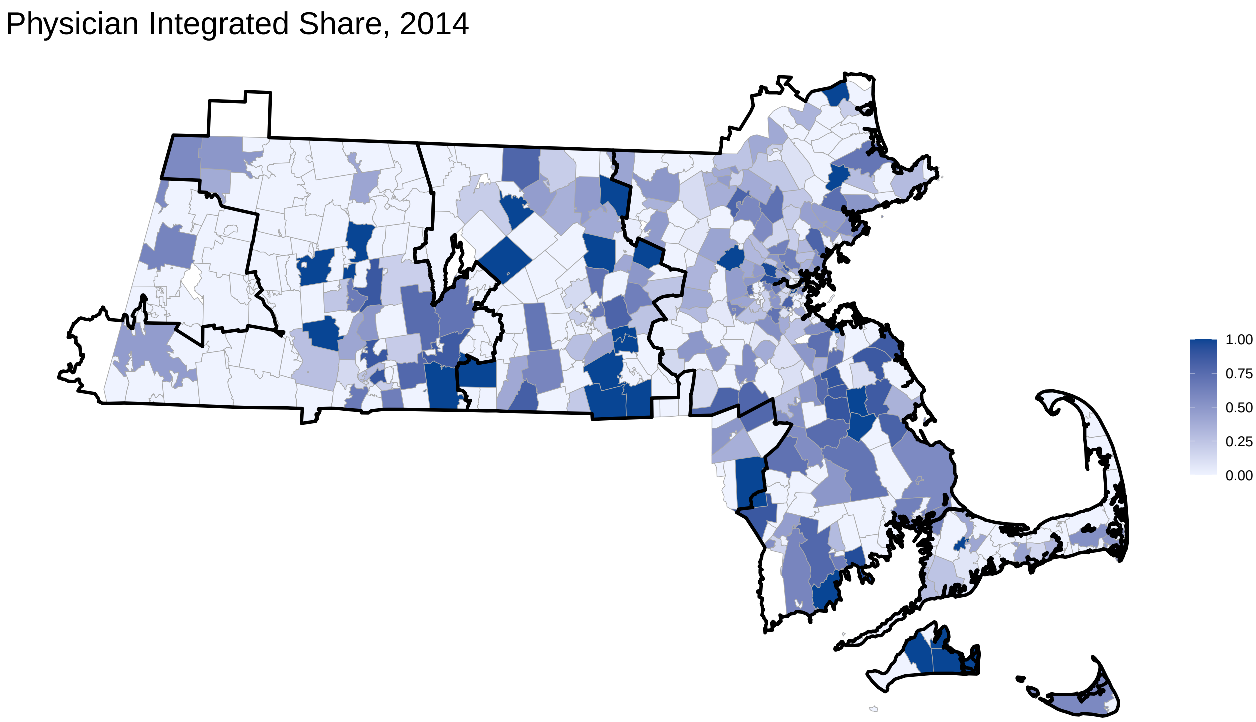
Hospital-acquired physicians differ markedly from independently-owned physicians in their referral choices to hospitals. In particular, Column (1) in Table 2 indicates that physicians who are owned by a hospital throughout 2014-2017 direct the vast majority of their referrals to the hospital system that owns their practice, while independent physicians do not. This is consistent with the presence of hospital managerial incentives to refer within-system. Physicians who are always hospital-owned are almost 30 percentage points more likely to refer to the owning hospital than are physicians who are acquired in subsequent quarters. Moreover, hospital-owned physician referrals are more concentrated, as measured by the Herfindahl-Hirschman Index (HHI). The HHI is the sum of the squared shares of physician referrals to each hospital. The HHI for hospital-acquired physicians' referrals is approximately 20 percent higher than the HHI for independently-owned physicians' referrals.

Table 2: Physician Summary Statistics in 2014, Q1

	(1) Always Hospital-Owned		(2) Never Hospital-Owned		(3) Hospital-Owned in 2014-17	
Male	0.60	(0.49)	0.68	(0.47)	0.61	(0.49)
Primary practice in Boston	0.62	(0.49)	0.36	(0.48)	0.41	(0.49)
Ever solo practioner	0.12	(0.33)	0.25	(0.44)	0.21	(0.41)
PCP	0.27	(0.44)	0.33	(0.47)	0.38	(0.49)
Cardiology	0.07	(0.26)	0.04	(0.20)	0.06	(0.24)
Ob/ Gyn	0.06	(0.23)	0.07	(0.26)	0.04	(0.19)
Orthopedics	0.03	(0.16)	0.06	(0.23)	0.04	(0.20)
Endocrinology	0.02	(0.13)	0.01	(0.11)	0.02	(0.16)
Dermatology	0.02	(0.12)	0.04	(0.20)	0.01	(0.11)
Other specialty	0.54	(0.50)	0.45	(0.50)	0.44	(0.50)
Paid amount in thousands	32.47	(34.51)	56.03	(102.18)	41.13	(67.43)
Hospital share of paid amount	0.95	(0.11)	0.01	(0.04)	0.03	(0.12)
Referral HHI	0.76	(0.20)	0.63	(0.23)	0.67	(0.22)
Pr(referral) to owning system	0.76	(0.31)			0.48	(0.39)
Physician contracting network	0.83	(0.38)	0.78	(0.41)	0.82	(0.39)
Observations	7457		5031		567	

Notes: Values are averages (standard deviations in parentheses) for the given physician characteristic in 2014 Q1, the first period of the sample time frame. Statistics are presented for each unique physician in 2014 Q1 by physician ownership status. The referral HHI measure is calculated at the physician-quarter level as the sum of squared shares of referrals directed to each provider to which the physician refers at least one patient. Physician contracting information is from the Massachusetts Health Policy Commission.

Figure 1: Hospital-Physician Practice Acquisition in Massachusetts, 2014



Notes: This map plots the share of hospital-owned physicians by zip codes across Massachusetts in the first quarter of 2014. The share of hospital owned physicians in each zip code is defined as the number of hospital-owned physicians in the zip code divided by the total number of practicing physicians based in the zip code. Darker regions represent values closer to 1, while lighter regions represent values closer to 0.

Hospital-owned and independent physicians also differ in their demographic characteristics. Hospital-acquired physicians are slightly more likely to identify as women. In addition, they are 25 percentage points more likely to practice in the Boston metro area. Figure 1 presents the variation in hospital ownership by zip code across Massachusetts. The Boston metro area has the largest share of hospital-integrated physicians, while physicians who practice in Western Massachusetts are more likely to practice in an independent group.

An interesting and important feature of the hospital market in Eastern Massachusetts is that it contains a single large, dominant hospital system, Partners Health Care. To illustrate,

Table 3: Descriptive Statistics on Hospital Systems in the Boston Hospital Referral Region, 2014

	Partners (1)	Mid-Size Hospitals (2)	Small Hospitals (3)
Number of Physicians per System	3231	645.5	109.091
		(137.08)	(74.605)
Physician Ownership Share	0.297	0.059	0.01
		(0.013)	(0.007)
Number of Acquisitions 2014-2017	114	55.75	10.273
		(15.478)	(7.564)
Inpatient Price Index (000)	21.923	17.243	16.741
		(0.782)	(1.512)
Percent Change in Inpatient Price 2014-2017	1.026	4.298	4.406
		(9.189)	(9.485)
Number of Payers	6	4.75	3.364
		(0.957)	(1.027)
Total Hospital Beds	2550	3815	3156
Hospital Beds per System	2550	953.75	286.909
		(383.569)	(154.07)
Total Inpatient Admissions (0000)	13.1057	20.8515	17.9043
Inpatient admissions (0000) / system	13.106	5.213	1.628
		(1.559)	(0.926)
Teaching Hospital	1	1	1
		(0)	(0)
Cancer Services	0.5	0.778	0.577
		(0.192)	(0.494)
Cardiac Services	0.667	0.778	0.577
		(0.385)	(0.494)
Obstetric Services	0.833	0.778	1
		(0.192)	(0)
Orthopedic Services	0.333	0.333	0.346
		(0.333)	(0.474)
Number of Hospitals	6	16	14
Number of Systems	1	4	11

Notes: Values are averages (standard deviations in parentheses) for the given hospital characteristic in 2014 Q1. The ownership share variable is defined as the fraction of physicians owned by each hospital system divided by the number of physicians practicing in the Boston Hospital Referral Region. The number of acquisitions 2014-2017 indicates the number of physicians acquired from 2014-2017. The clinical services variables reflect the share of hospitals offering specialized care for each clinical condition (cancer, cardiac, orthopedic, and labor / delivery) as described in the main text.

I group hospitals in the Boston Hospital Referral Region (HRR) into one of three categories based on the number of beds: (i) Partners Health Care, (ii) Mid-size hospitals, including Lahey Health, Steward Health Care, Wellforce, and Beth Israel; and (iii) Small volume hospitals. Table 3 presents hospital summary statistics for hospitals in the Boston Referral Region separately by

Partners Health Care, mid-size hospitals, and the smallest hospitals in 2014. Partners Health Care attracts nearly 25% of the inpatient market share and houses 35 percent of hospital beds. On average, mid-size hospitals draw nearly half as many admissions as Partners, and the smallest hospitals draw approximately one-tenth. Partners Health Care also owns nearly 30% of the physicians in the Boston HRR; in contrast, the mid-size hospitals own only 5% on average, and the smallest hospitals in the region own 1% on average. Moreover, Partners Health Care acquired 114 physicians over 2014-2017, the largest acquisition in the region. Partners maintains the largest number of payer contracts in the state with negotiated prices that are on average 27%-30% higher than mid-size and small hospitals' rates.

Yet, Partners hospitals experienced lower price growth from 2014-2017 than other firms in the region. Hospital prices negotiated by small- and mid-size firms increased by approximately 4 percent on average, or $741.02. Partners Health Care's rates increased by 1.02%, or approximately $224.93.

III Descriptive Evidence on the Effects of Hospital-Physician Practice Acquisition on Physician Referrals and Hospital Prices

The potential effects of hospital-physician group acquisitions on hospital bargaining leverage, and subsequently, on hospital prices, stem from an increase in physician referrals to the acquiring hospital induced by changes to physicians' referral incentives. This section provides descriptive evidence on how acquisition affects physicians' within-system referrals and negotiated hospital prices. I show that the effects vary across hospital systems: physicians who integrate with small and mid-size firms in the region refer within-system at higher rates post-merger. In contrast, the dominant hospital system, Partners Health Care does not induce meaningful changes in acquired physicians' referrals. Subsequently, physician group acquisition leads to higher negotiated prices in non-dominant hospital systems. These results suggest that physician practice acquisition can serve as a strategic tool for small and mid-size firms to capture patient referrals and enhance bargaining leverage.

III.A Physician Referrals

I first consider whether the change in physicians' incentives following acquisition affect physicians' referral decisions. To document referral effects, I assess changes in acquired physicians' referral choices from before to after the merger relative to a comparison group of physicians who are always independently owned. To implement this approach, I estimate the following event study regressions using the sample of referral admissions:

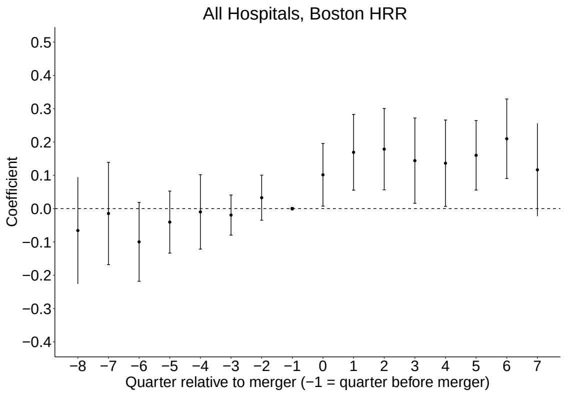
$$Y_{ijht} = V_{ijh} \times \sum_{y=-13, y\neq -1}^{12} \beta_y I(t - t_j^* = \tau) + \gamma_h + \gamma_t + \gamma_j + \eta X_{iht} + \epsilon_{ijht} \tag{1}$$

Each observation in the sample represents an admission i referred by physician j to hospital h in quarter t. Y_{ijht} is an indicator variable that is equal to 1 if the admission occurred at the hospital that owns the referring physician j's practice, and zero if otherwise. The variable V_{ijh} captures whether or not the referring physician was owned by the admitting hospital in the quarter of the admission; that is, V_{ijh} is an binary variable that equals 1 if the referring physician j was acquired by hospital h in 2014-2017 and zero if otherwise. Indicator variables $I(t - t_j^* = \tau)$ measure the time relative to the acquisition quarter of physician j, , t_j^*, and are equal to zero in all periods for physicians who practice independently. I exclude physicians who are hospital-owned throughout the sample time frame, as well as N% of physicians who are divested from hospital-owned practices. To examine effects separately by firm category, I estimate a fully-interacted version of equation (1) by interacting the first term on the right hand side of equation (1) with indicators for the hospital size category (i.e. Partners, mid-size, or small hospitals) of the acquiring hospital h.

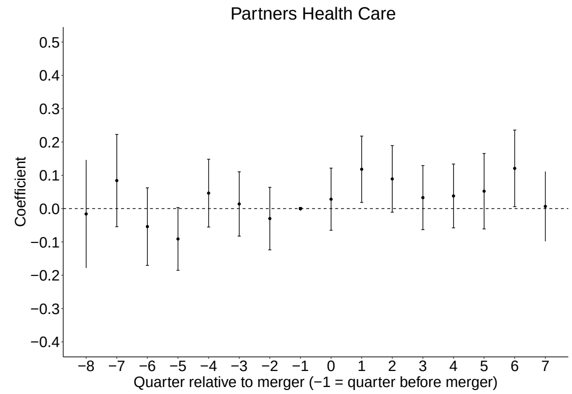
I control for admitting hospital fixed effects in γ_h. γ_t denotes quarter fixed effects, and γ_j denotes referring physician fixed effects. To address potential differences in the patient case mix post-acquisition, I control for a rich set of patient characteristics. X_{it} represents indicator variables for the principal procedure of the admission, patient age group in 10-year increments, sex, zip code, payer, and plan type. Apart from sex, each of these variables are constructed at the patient-quarter level.

The omitted category is $t = -1$, or the quarter prior to the acquisition. Therefore, each estimate of β_y provides the average change in acquired physicians' referral probabilities to the owning hospital during quarter t, as measured from the quarter immediately prior to the acquisition. The main identifying assumption in this analysis is that absent the acquisition, acquired and independent physicians' referral rates to the acquiring hospital would evolve in parallel over time. I estimate equation (1) with a linear probability model.

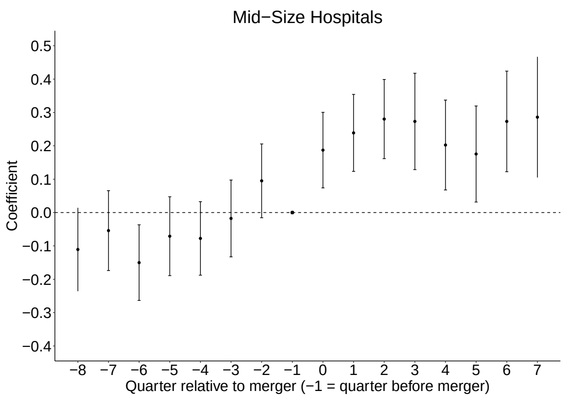
Figure 2: Event Study Analysis of Hospital-Physician Merger Effects on Physician Referrals



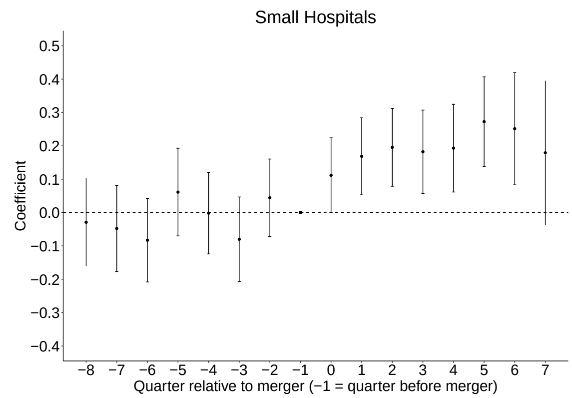
(a)



(b)



(c)



(d)

Notes: This figure presents event study estimates of referral effects for hospital-acquired physicians. Panel (a) plots estimates for the sample of physicians acquired by any hospital in the Boston HRR. Panel (b) plots estimates for the sample of physicians acquired by Partners Health Care hospitals. Panel (c) plots estimates for the sample of physicians acquired by Beth Israel, Lahey Health, Wellforce, and Steward Health Care. Panel (d) presents estimates for the sample of physicians acquired by smaller hospitals in the Boston HRR. All specifications include fixed effects for the admitting hospital, referring physician, patients' plan type, payer, principal diagnosis, and zip code. The vertical bars represent 95% confidence intervals derived from robust standard errors clustered at the hospital system level.

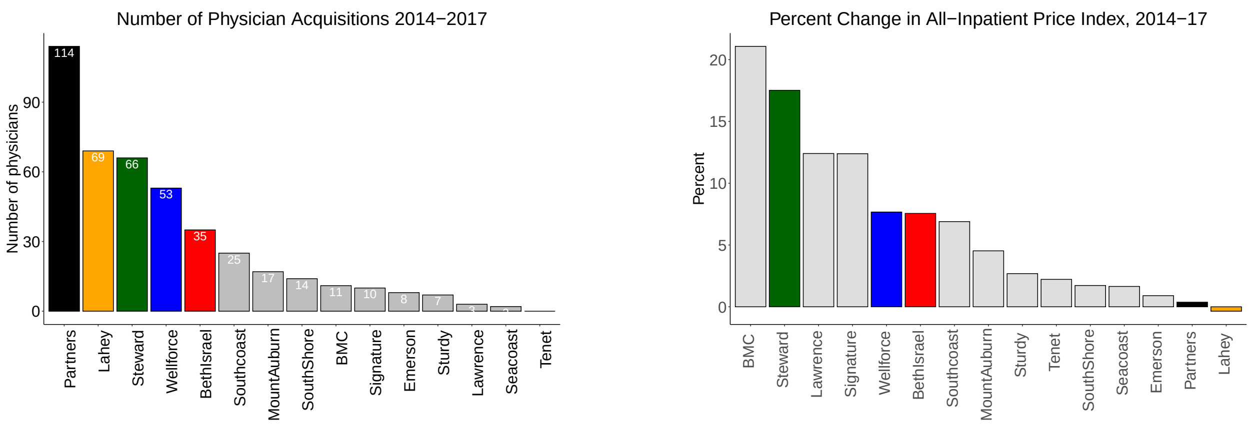
Figure 2 plots the estimates of β_y. Panel (a) depicts referral effects for the entire sample of acquiring hospitals in the Boston region, while panels (b), (c), and (d) plot the referral effects for physicians acquired by Partners Health Care, mid-size hospitals, and small hospitals separately. The panels in Figure 2 suggest that before hospital acquisition, referrals to the acquirer evolved similarly across independently-owned and target physicians: the pre-merger differences in referral rates are small in magnitude and not statistically significant. Once incentives change due to acquisition, integrated physicians refer within-system at substantially higher rates. Panel (a) shows that the average hospital-acquired physician is 16.7 percentage points more likely to refer to the owning hospital in the quarter immediately following the transition. This represents a 33.56% increase relative to the average pre-merger referral rate. This effect remains relatively stable over time, ranging from 11.6 to 21.1 percentage points in each quarter during the two years post-acquisitions.

Moreover, the referral effects are concentrated among non-dominant hospital systems in the Boston region. Panels (c) and (d) in Figure 2 show a substantial increase in within-system referrals in small- and medium-sized hospital systems. In the quarter immediately after acquisition, physicians are approximately 20 percentage points more likely to refer to the owning system. This effect is weakly increasing over time, as after two years post-merger, physicians are nearly 30 percentage points more likely to refer within-system. On the other hand, Partners hospitals' acquired physicians do not appear to re-direct referrals to the system post-merger as Figure 2, panel (b) depicts.

III.B Hospital Prices

I now turn to the effects of physician practice acquisition on hospital prices. Figure 3 provides preliminary visual evidence that hospital systems with among the largest acquisition sizes negotiated larger price increases. However, this relationship is not monotonic in firm size, and appears to differ for the dominant firm, Partners Health Care. Despite acquiring the largest number of physicians relative to any other hospital or hospital system in the state, Partners Health Care reports among the lowest increases in negotiated rates. I explore the average effect and the heterogeneity in price responses below.

Figure 3: Visual Evidence on Changes in Physician Acquisition vs Negotiated Price, 2014-2017



(a) Number of acquired physicans

(b) Percent change in hospital prices

Notes: This figure plots changes in physician practice acquisition and price growth at the hospital system level for hospitals located in the Boston HRR. Panel (a) plots the number of acquired physicians by hospital system from 2014-2017. Panel (b) plots the percent change in the inpatient price index by hospital system from 2014-2017. In both panels, the colored bars represent the dominant and mid-sized firms in the Boston, and the grey bars represent the smallest hospital systems and hospitals.

To formally examine the relationship between physician practice acquisition and negotiated prices, I estimate regressions of ownership levels on acquiring hospital systems' inpatient price. First, I regress the log of the hospital price index for hospital h - payer m in year t on the log of the hospital's physician ownership level in year t. I define the ownership level for hospital system h in year t as the number of physicians that the system owns in year t. To address the effects of any changes in hospital capacity that coincide with physician integration, I control for the number of hospital beds in each year. I include hospital system fixed effects to facilitate within-hospital comparisons; and I include year and payer fixed effects to account for the effects of time and payer-specific (but time-invariant) attributes. The first estimating equation is therefore:

$$\log(p_{hmt}) = \beta_1 \log(\text{Ownership})_{ht} + \delta \text{Beds}_{ht} + \gamma_h + \gamma_t + \gamma_m + \epsilon_{hmt} \tag{2}$$

where γ_h denotes hospital system fixed effects, γ_t denotes year fixed effects, and γ_m reflects payer fixed effects, and physician practice ownership levels are measured as the number of physicians who are owned by hospital h in year t.

To capture any heterogeneity in price responses to acquisition, I then estimate a version of equation (2) that permits different effects of hospital physician ownership by Partners Health

Care, mid-size, and small firms. Specifically, I replace the first term on the right hand side of (2) with indicator variables for Partners, mid-size, or small hospital systems interacted with the logged number of physicians working in each hospital system in year t. I replace hospital fixed effects in γ_h with fixed effects for the hospital category, $\gamma_{\text{Partners}}, \gamma_{\text{Mid-size}}$, and γ_{Small}. The estimating equation for the analysis by dominant (Partners), mid-size, and small hospital systems is therefore:

$$\begin{aligned}\log(p_{hmt}) = &\beta_{\text{Partners}} \cdot 1(h = \text{Partners}) \cdot \log(\text{Ownership})_{\text{Partners},t} \\ &+ \beta_{\text{Mid-size}} \cdot 1(h = \text{Mid-size firm}) \cdot \log(\text{Ownership})_{\text{Mid-size},t} \\ &+ \beta_{\text{Small}} \cdot 1(h = \text{Small firm}) \cdot \log(\text{Ownership})_{\text{Small},t} \\ &+ \delta \text{Beds}_{ht} + \gamma_{\text{Partners}} + \gamma_{\text{Mid-size}} + \gamma_{\text{Small}} + \gamma_t + \gamma_m + \epsilon_{hmt}\end{aligned} \tag{3}$$

Finally, I estimate fully interacted versions of equation (2). Instead of the three firm size interaction terms (i.e. the first three right-hand side terms of equation (3)), this specification interacts indicator variables for *every* hospital system with the hospital system's logged ownership levels. Specifically, I replace the first term on the right hand side of equation (2) with indicator variables for each acquiring hospital system, D_h, interacted with the hospital systems' logged ownership levels in quarter t.

$$\log(p_{hmy}) = \beta_h \cdot D_h \cdot \log(\text{Ownership})_{hy} + \delta \text{Beds}_{hy} + \gamma_h + \gamma_y + \tau_m + \epsilon_{hmy} \tag{4}$$

The estimands of interest are β_1 in equation (2); $\beta_{\text{Partners}}, \beta_{\text{Midsize}}$, and β_{Small} in equation (3); and the vector of β_h in equation (4). Each of these terms quantifies the effect of physician ownership levels on hospital prices, excluding the effects of time, and controlling for the payer and changes in hospital bed capacity. All regressions are weighted by the number of admissions in the hospital h - payer m - quarter y cell.

Table 4 presents the estimates from equations (2) and (3). Column (1) reports the estimate for β_1 from equation (2). It indicates that on average, physician group acquisition is associated with higher prices. A one percent increase in an average hospital system's logged physician ownership levels leads to a one percent increase in logged inpatient price levels. However, this masks substantial heterogeneity across hospital systems. Column (2) shows that this relationship is most pronounced in smaller and mid-size hospitals in the region: estimated effect sizes are largest among small hospitals. The price effects are large in magnitude but negative within the dominant firm, Partners Health Care: increases in log(ownership) lowers negotiated prices at Partners hospitals.

Table 4: Estimated Effects of Hospital Ownership Levels on Hospital Prices

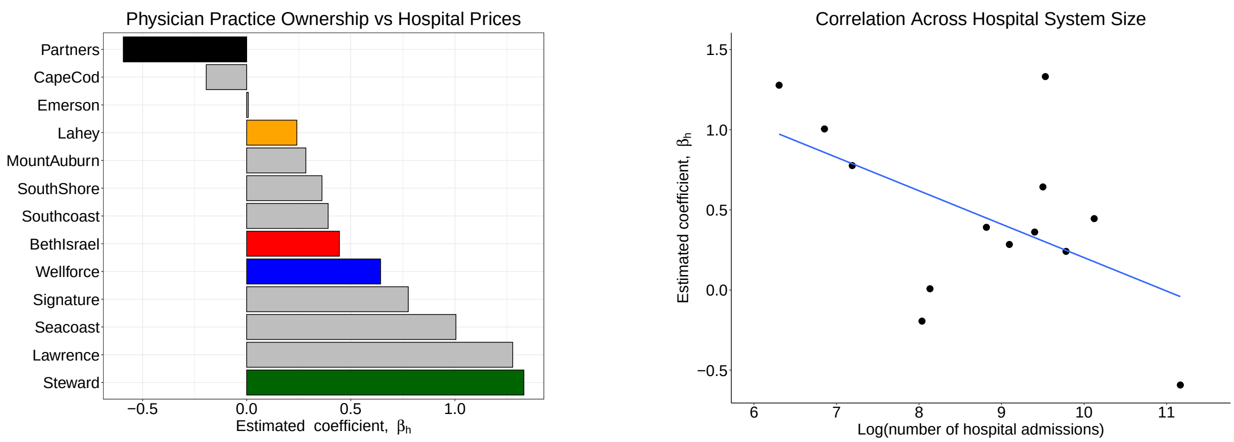
Variable	(1)	(2)
Log(Ownership)	0.446***	
	(0.008)	
Partners Health Care x Log(Ownership)		-1.495**
		(0.752)
Mid-size Hospital x Log(Ownership)		0.202***
		(0.032)
Small Hospital x Log(Ownership)		0.061***
		(0.016)

Notes: This table displays regression estimates of the effect of hospital physician ownership levels on hospital prices. Each column represents a separate regression with the risk-adjusted inpatient price index as outcome, and where each observation is a hospital-year-payer triad. Column (1) reports the results of estimating equation (2). Column (2) reports the results of estimating equation (3). All regressions are weighted by the number of admissions in the hospital-year-payer triad, and include controls for beds, payer and year fixed effects. Column (1) includes hospital fixed effects, and Column (2) includes fixed effects for hospital system category (i.e. Partners, mid-size, small). The price and ownership level measures are described in more detail in the Appendix. Heteroskedasticity-robust standard errors are in parentheses. Effects significant at 10% (*), 5% (**), and 1% (***).

Figure 4 plots the estimates from equation (4). Figure 4a plots the estimates of β_h. It shows that all else equal, the effects of physician ownership level on prices vary across hospital systems, ranging from -1.5% at Partners Health Care, to 1.3% at Steward Health hospitals. Moreover, smaller hospital systems experience a larger return to increases in physician ownership in terms of negotiated price. Figure 4b plots the estimated coefficient of β_h for each hospital system h against the logged average number of admissions at hospital h from 2014-2017. This graph documents an inverse relationship between the estimated price effect of physician practice acquisition and hospital system size.

Figure 4: Estimated Price Effects by Hospital System

(a) (b)



Notes: This figure presents estimates of the estimated effect of physician ownership levels on hospital price, or β_h in equation (4). Panel (a) presents the estimated price effects by hospital system. Panel (b) presents a scatter plot of the estimated price effects against the logged admission volume at each hospital system.

Taken together, sections III.A and III.B reveal that physicians respond to acquisition by referring at greater rates within-system; and that hospital systems with greater ownership levels negotiate higher prices. These results provide suggestive evidence that acquisition augments the bargaining leverage of the hospital system relative to insurers. However, the effects are primarily concentrated among small and mid-size hospitals. As the most popular health care system in the state, Partners Health Care does not induce changes in acquired physician referrals; and negotiated prices at Partners hospitals are in fact negatively associated with the system's physician ownership levels.

In the following section, I present a model of the market for hospital admissions that rationalizes the price effects of hospital-physician practice acquisition as well as the heterogeneity by firm size. In particular, I show how an increase in the acquirer hospitals' referral demand, stemming from changes in acquired physician incentives, can impact hospital-insurer negotiations by raising consumers' valuation for hospital networks that include the acquirer. I use the model to highlight how the price effects of physician practice acquisition diminish with the size of the acquirer hospital system.

IV Theoretical Framework

In this section, I develop a Nash Bargaining model of the interactions between hospitals, commercial insurers, and patients in a market for hospital admissions.[5] This model closely follows hospital-insurer bargaining models in the current literature, e.g. Ho and Lee (2017) and Gowrisankaran, Nevo, and Town (2015), and introduces vertical changes in hospital market structure. I use this model to examine how physician practice acquisition can alter hospitals' bargaining leverage and negotiated prices by inducing demand for the acquiring firm. I also highlight how the effects of acquisition vary with the baseline size of the acquirer.

IV.A Setup

Consider the set of commercial insurers $\mathcal{M}$ that offer insurance plans via employers in a given market. The set of hospitals in this market is denoted by $\mathcal{H}$. I assume that an individual who is enrolled in an insurance plan from insurer j can only visit hospitals in j's network. I denote the set of hospitals contracted with insurer j as $\mathcal{G}_j^M$. Similarly, $\mathcal{G}_i^H$ denotes the set of insurers that are contracted with hospital i. Taking employer contracts with insurers as given, I assume the following model timing:

1. All hospitals in $\mathcal{H}$ and insurers in $\mathcal{M}$ negotiate to determine hospital prices $\mathbf{p}$ and insurers' hospital networks, where p_{ij} represents the price per admission paid by payer j to hospital i. In the case of disagreement between a hospital i and insurer j, the hospital is excluded from the insurer's network, and all other prices remain unchanged.

2. After enrolling in a plan, individual k falls ill with some probability; those who require further care visit a physician and receive a referral to a hospital for an inpatient procedure. This determines $D_{ij}^H(\mathcal{G})$, the number of patients enrolled in insurer j's plans who visit hospital i following a referral (i.e. referral volume).

The following theoretical analysis takes patient demand for hospitals as a primitive of the model.

Hospitals maximize profits, and insurers maximize enrollee benefits less costs when negotiating prices. I assume that each insurer maximizes enrollees' willingness-to-pay from a given hospital network $\mathcal{G}_j^M$ and hospital prices $\mathbf{p}$ minus its costs. Thus, insurer j's objective

[5] Nearly 66% of individuals with health insurance in the U.S. have private health insurance. Of those with private health insurance, nearly 55% have employment-based health insurance plans (Katherine Keisler-Starkey and Lindstrom (2022)).

function is:

$$\pi_j^M(\mathcal{G}_j^M, \mathbf{p}) = \sum_{h \in \mathcal{G}_j^M} \left(\mathrm{WTP}_{jh} - p_{jh} D_{jh} - \phi_j\right) \tag{5}$$

where the first term on the right hand side of equation (5) represents the sum of insurer j's enrollees' willingness to pay for every hospital h in j's network. The second term, $p_{hj} D_{hj}$, represents insurer j's payments to all hospitals in the insurer's network. This is the price per admission negotiated with each hospital multiplied by the number of inpatient admissions to that hospital which resulted from a referral. The final term ϕ_j reflects the insurer's fixed costs of operation and does not vary with the insurer's provider network.

I assume that hospital profits given an insurer contracting network $\mathcal{G}_i^H$ and hospital prices $\mathbf{p}$ are:

$$\pi_i^H(\mathcal{G}_i^H, \mathbf{p}) = \sum_{n \in \mathcal{G}_i^H} (p_{in} - c_i) \times D_{in} - F_i \tag{6}$$

where c_i represents the cost for an average inpatient admission for hospital i and F_i represents the hospital's fixed costs. I assume that c_i represents the cost for the average basket of inpatient services, i.e. the average inpatient procedure. Thus, equation (6) aggregates, over all insurers n with which hospital i contracts, the number of patients enrolled in the insurer j's plans who visit hospital i, D_{in}, multiplied by the average margin per admission, $p_{in} - c_i$.

IV.B Insurer-Hospital Bargaining Over Hospital Prices

I assume that hospital prices $\mathbf{p}$ are determined via simultaneous bilateral Nash bargaining between hospitals and insurers.[6] If a hospital i and insurer j come to a disagreement, the new provider network will be $\mathcal{G} \backslash ij$, and all other prices $\mathbf{p}_{-ij}$ remain fixed. Disagreement profits for hospital i and insurer j are denoted by $\pi_i^H(\mathcal{G} \backslash ij, \mathbf{p}_{-ij})$ and $\pi_j^M(\mathcal{G} \backslash ij, \mathbf{p}_{-ij})$ respectively. Each negotiated price p_{ij} between hospital $i \in \mathcal{H}$ and insurer $j \in \mathcal{M}$ maximizes the product of hospital i and insurer j's gains from trade, taking as given the outcome of all other

[6] In the US commercial health care market for hospital services, prices are determined via negotiation between hospitals and insurers. I represent the negotiation process with a model of Nash bargaining.

negotiations (i.e. all other negotiated prices, $\mathbf{p_{-ij}}$):

$$p_{ij} = \arg\max_{p} \underbrace{\left[\pi_j^M(\mathcal{G}, \mathbf{p}) - \pi_j^M(\mathcal{G}\backslash ij, \mathbf{p_{-ij}})\right]^{\tau_j}}_{\text{Insurer gains from trade}} \times \underbrace{\left[\pi_i^H(\mathcal{G}, \mathbf{p}) - \pi_i^H(\mathcal{G}\backslash ij, \mathbf{p_{-ij}})\right]^{(1-\tau_j)}}_{\text{Hospital gains from trade}} \tag{7}$$

The Nash bargaining parameter for insurer j is τ_j, where $0 \leq \tau_j \leq 1$ for all insurers. The Nash bargaining parameter for hospitals is $1 - \tau_j$. When $\tau_j = 0$, hospitals have all of the bargaining power and compete à la Nash-Bertrand to determine prices separately for each insurer.

IV.C Equilibrium Negotiated Prices

I next derive the equilibrium first-order conditions for the hospital price bargaining equations in equation (7). For a given provider network $\mathcal{G}$ and vector of hospital prices $\mathbf{p}$, we can write the first order conditions of equation (7) as:

$$p_{ij}^* = \underbrace{\tau_j \cdot c_i}_{\text{Hospital avg. cost}} + (1-\tau_j) \times \left[\underbrace{\frac{\mathrm{WTP}_{ij}}{D_{ij}} + \sum_{h \in \mathcal{G}_j^M \backslash ij} \frac{\Delta \mathrm{WTP}_{hj}}{D_{ij}}}_{\text{"Enrollee surplus effect"}} - \underbrace{\frac{\Delta D_{hj}}{D_{ij}} p_{hj}^*}_{\text{"Price reinforcement effect"}} \right] \tag{8}$$

where $\Delta WTP_h = WTP_h(\mathcal{G}, \cdot) - WTP_h(\mathcal{G}\backslash ij)$ and $\Delta D_{hj} = D_{hj}(\mathcal{G}, \cdot) - D_{hj}(\mathcal{G}\backslash ij, \cdot)$. I use the term "$\Delta$" to denote the change in a particular object (i.e. demand or willingness to pay) when there is disagreement between a hospital and insurer. For tractability, I assume that there are no enrollment effects that result from the outcome of hospital-insurer negotiations, e.g. insurers' enrollment does not vary with provider networks. [7] [8]

Equation (8) summarizes the components of equilibrium hospital prices when insurer j and hospital i reach an agreement and hospital i is in j's network. The negotiated price depends on each firm's gains from trade. The first term on the right hand side, $\tau_j c_i$, implies that insurers weight hospitals' average cost per admission with τ_j in price negotiations. If insurers have complete bargaining power, the negotiated price is equal to hospitals' average

[7] An example of a model that fully accounts for enrollment effects in hospital-insurer bargaining is Ho and Lee (2017). They model household enrollment in insurance plans as a function of insurer networks, hospital prices, and premiums.

[8] For example, hospital i's demand from insurer n's enrollees does not change if hospital i and insurer $j \neq n$ disagree.

cost per admission.

The second term in brackets on the right hand side in equation (8) reflects the gains from trade for insurer j when hospital i is included in its network. The gains to insurer j from agreement with a hospital i come from the increase in enrollees' value from the insurer's hospital network. The insurer gains from trade may expressed with two terms. The "enrollee surplus effect" represents the effect of hospital i's inclusion in insurer j's network on patients' value from insurer j's hospital network. This effect depends on enrollees' value for hospital i along with the degree to which other hospitals in the insurer's network are substitutes for hospital i. The more that enrollees value a hospital, the greater that hospital's leverage in determining negotiated prices and insurer profits. In addition, this term indicates that hospitals with fewer close substitutes in the insurer's network presents a greater loss to enrollee surplus upon exclusion, and therefore negotiate higher prices.

Second, the "price reinforcement effect" reflects the change in payments per admission that j makes to other hospitals in the disagreement network (excluding hospital i). In addition to hospitals' substitutability, this term is a function of the equilibrium negotiated prices of all the other hospitals in j's network. This is very similar to the "price reinforcement effect" term in Ho and Lee (2017) . It implies that hospitals with lower negotiated prices and without close substitutes in insurer j's network have greater bargaining leverage with the insurer. That is, the negotiated prices between hospital i and insurer j are decreasing in the diversion between hospital i and other hospitals in j's network in the case i is excluded from the network; moreover, the hospital prices are increasing in the implied valuation of hospital i.

IV.D The Impact of Hospital-Physician Practice Acquisition on Hospital Prices

I use the first-order conditions given by equation (8) to decompose the effects of hospital-physician practice acquisition on bargaining leverage and negotiated per-admission prices. These effects stem from the diversion in acquired physicians' referrals toward the acquiring firm and away from rival hospitals.[9] Given the shift in physicians' referral rates induced by hospital acquisition, I focus on how an increase in the referral volume, D_{ij}, for a particular acquiring hospital i impacts an insurer j's gains-from-trade in equation (8).[10]

[9]Figure 2 documents this increase in physicians' referral rates toward the owning hospital post-acquisition, relative to independently-owned physicians.

[10]The impact of physician practice acquisition on negotiated prices due to a change in hospitals' average costs is limited in this model, as I do not assume that hospital costs per admission are a function of hospital

First, an increase in physicians' referral probability toward the acquiring hospital i raises the implied value of having a hospital in a network. That is, as hospital i becomes a more popular choice for physician referrals, the magnitude of willingness-to-pay for hospital networks that include i increases, thus augmenting the acquiring hospital's bargaining leverage with insurers. The increase in hospital i's leverage raises negotiated prices and lowers insurer j's surplus.

Second, shifts in physician referral volume toward the acquiring hospital i lowers the magnitude of willingness-to-pay for the other hospitals in insurer j's network. As the acquirer becomes a more popular choice for physician referrals due to its practice acquisitions, enrollee demand for other hospitals in insurer j's network falls. This is because patients are less likely to be referred to the rival hospitals in j's hospital network.[11] Thus, the implied value from the rival hospitals diminishes as hospital i purchases more physician groups. The signs of the effects of hospital i's physician group acquisitions on the acquirer's bargaining leverage and negotiated prices with insurer j are therefore positive. The magnitudes of the effects depend upon the substitutability and the negotiated prices of rival hospitals in j's network. The presence of one or more rival hospitals that are close substitutes to the acquirer within the insurer's hospital network can constrain the effects of physician practice acquisition on the acquirers' bargaining leverage; similarly, insurer networks that include hospitals with lower negotiated prices than the acquirer can mitigate the increase in the acquiring hospital's bargaining leverage.

Equation 8 implies that the magnitudes of the effects vary by the size of the acquiring firm. More specifically, since equation 8 is concave in the demand of hospital i, the returns to hospital i from physician practice acquisition in terms of bargaining leverage and negotiated prices are decreasing in the size of the hospital. This feature of the model supports my empirical observation in 3 that the largest hospital system in Massachusetts, Partners HealthCare, acquires the largest number of physician groups yet faces smaller increases in negotiated prices post-acquisition than small- and mid-size hospitals in the same region. The intuition behind this result is that a further increase in the attractiveness of a highly popular firm, i.e. due to physician group acquisition, has little effect on its demand; on the other hand, the marginal hospitals face the largest returns to physician practice acquisition in terms of demand, since making even a small improvement in patients' utility from the hospital would be enough to induce patients to choose it.

demand.

[11] In other words, changes in referral patterns for hospital admissions are zero sum.

In summary, hospital-physician group acquisitions increase hospital bargaining leverage and raise negotiated prices with insurers. The effects stem from a shift in acquired physicians' referrals toward the acquiring firm and away from rival hospitals. First, the shift in referral demand toward the acquirer i increases the implied value of having the hospital in an insurer's network and therefore insurer surplus from hospital networks that include i. Second, a reduction in referral volume at rival hospitals in the insurer's network diminishes insurers' gains from the inclusion of the rival hospitals in the insurer's network. The signs of both of these effects on hospital bargaining leverage and negotiated prices are positive. Acquisitions raise negotiated prices more when hospital i has no close substitutes in insurer j's network, when other hospitals in the network do not have lower negotiated prices, and when rival hospitals face lower referral rates post i's acquisitions. Moreover, the magnitude of these effects are decreasing in the size of the acquiring firm.

V Identification and Estimation

V.A Hospital Demand

In this section, I present a discrete choice model of hospital demand. This model builds on the existing hospital choice literature (Ho and Lee (2017), Gowrisankaran, Nevo, and Town (2015), Ho (2006), Gowrisankaran, Nevo, and Town (2015)) by modeling choice as a function of referring physicians' hospital acquistion status. The model allows preferences to vary across hospitals and with differences in patients' attributes, and the parameter estimates are used to compute expected utility from insurer networks, demand for hospitals, and counterfactual objects used in the estimation of the bargaining stage.

Consider an individual k who faces a diagnosis l and is enrolled in a commercial health insurance plan with payer j. The possible diagnoses are Cancer-related, Cardiac, Musculoskeletal, Labor and Delivery, or Other. The probability that patient k is diagnosed with clinical condition l is γ_{kl}. I group patients into 10-year age groups - sex categories, and I assume that patient k's choice set consists of all hospitals within a 50 mile radius of her residential zip code and within her insurance provider j's network. [12] Patient k is referred to hospital i if the following objective function takes its maximum value at hospital i:

$$u_{k,j,l,i} = \beta_1 Acq_{Ref(k),i)} + \beta_1 v_{k,j,l} X_i + \beta_2 d_{i,k} + \beta_2 d_{i,k}^2 + \gamma_i + \epsilon_{k,j,l,i} \tag{9}$$

[12] I infer hospital networks by selecting hospital-insurer pairs with at least 10 claims indicating an in-network code in the APCD.

where $Acq_{Ref(k),i)}$ is a variable that is equal to 1 if the referring physician for patient k's admission is integrated with hospital i. The term $v_{k,j,l}X_i$ represents observed hospital characteristics (teaching status, variables summarizing the cardiac, cancer, orthopedic, and birth services provided by the hospital) interacted with the appropriate patient diagnostic categories. $d_{i,k}$ and $d^2_{i,k}$ represents the distance and squared distance between patient k's residential zip code and hospital i respectively. γ_i are a vector of hospital fixed effects.

I assume that this is a function of patient preferences over hospital characteristics, distance, and hospital specific fixed effects, and physician preferences over hospitals determined by whether their practice has been acquired. Assuming that $\epsilon_{k,m,j,l,i}$: has an i.i.d Type 1 Extreme Value distribution, the predicted probability that individual k, who is enrolled in insurer j's plan, visits hospital i conditional on clinical condition l is

$$\sigma_{k,j,i|l}(\mathcal{G}_j^M) = \frac{\exp\left(\beta_1 Acq_{Ref(k),i)} + \beta_1 v_{k,j,l}X_i + \beta_2 d_{i,k} + \beta_2 d^2_{i,k} + \gamma_i\right)}{\sum_{h \in \mathcal{G}_j^M} \exp(\beta_1 Acq_{Ref(k),h)} + \beta_1 v_{k,j,l}X_h + \beta_2 d_{h,k} + \beta_2 d^2_{h,k} + \gamma_h)} \tag{10}$$

where $\mathcal{G}_j^M$ is the hospital network for insurer j's plans. There is no outside option since our admissions data consists of patients who are ill enough to receive a referral or direction from a referring provider to go to a hospital for a particular procedure. I estimate this model via maximum likelihood using the referral admissions data. I normalize the hospital fixed effect for Partners Health Care to zero.

Identification of the parameters relies on variation in hospital attributes, patient types, and referral choices across time. The coefficient β_1 is identified from variation in hospital choice probabilities across patients whose referring physicians are owned by the admitting hospital vs. not owned by the admitting hospital. The distance coefficient is identified from choice probabilities of patients who live at various distances from the hospital across the zip codes in the sample of admissions. This assumes that negotiated prices are not observable and do not impact patients' choice of hospitals.

V.A.1 Willingness to Pay for Hospital Networks

Following Ho and Lee (2017), I use the estimated demand model to compute a measure of patients' expected utility, or willingness-to-pay (WTP), for insurers' hospital networks. This object will be used to calculate insurer surplus for each counterfactual network configuration.

Patient k's WTP for the hospital network offered by plan j, $\mathcal{G}_j^M$, is

$$WTP_{kj}(\mathcal{G}_j^M) = \gamma_k^a \sum_l \gamma_{kl} \log\left(\sum_{h \in \mathcal{G}_j^M} \exp(\beta_1 Acq_{Ref(k),h)} + \beta_1 v_{k,j,l} X_h + \beta_2 d_{h,k} + \beta_2 d_{h,k}^2 + \gamma_h) \right) \tag{11}$$

where γ_k^a is the probability that a patient k is admitted; and γ_{kl} is the probability that patient k receives diagnosis l. Therefore, the WTP of patient k for insurer j's network is a risk-weighted average of patient k's expected utility that she derives from each hospital in j's network, scaled by the probability that the patient is admitted. Patients' WTP is estimated separately by patient type, i.e. patient age and gender. I aggregate over patient types to estimate total willingness-to-pay for a given insurer j's hospital network ($\mathcal{G}_j^M$):

$$WTP_j(\mathcal{G}_j^M) = \sum_{k \in \mathcal{K}} N_{kj} WTP_{kj}(\mathcal{G}_j^M) \tag{12}$$

where N_{kj} is the number of individuals of type k enrolled in plan j.

V.A.2 Implied Willingness-to-Pay

Given the parameter estimates from the above demand model, I calculate the demand for hospital i from patient type k enrolled in insurance plan j, conditional on the hospital network $\mathcal{G}_j^M$ as:

$$\hat{D}_{kji}(\mathcal{G}_j^M) = N_{kj} \gamma_k^a \sum_{l \in \mathcal{L}} \gamma_{kl} \hat{\sigma}_{k,j,i|l} \tag{13}$$

$\hat{\sigma}_{k,j,i|l}$ is the estimated predicted probability that an individual k enrolled in insurer j's plan chooses hospital i, conditional on diagnosis l. It is constructed using equation (10). The total hospital demand for each hospital i from patients enrolled in plan j for a given network configuration ($\mathcal{G}_j^M$) sums the individual demands (13) over all patient types:

$$\hat{D}_{ij}(\mathcal{G}_j^M) = \sum_{k \in \mathcal{K}} \hat{D}_{kji}(\mathcal{G}_j^M) \tag{14}$$

V.A.3 Demand Model Estimates

Table 5 provides estimates from the specification in equation (9). I omit hospital fixed effects from the table. In general, the results are consistent with the hospital choice literature. The

Table 5: Hospital Demand Model Estimates

Variable	Coef	Std. Err.
Referring physician acquired	3.035***	(0.012)
Distance to hospital	-0.239***	(0.001)
Distance squared	0.003***	(0)
Patient in labor x labor services	0.136***	(0.014)
Cardiovascular diagnosis x cardiac services	0.505***	(0.12)
Musculoskeletal diagnosis x orthopedic services	-0.275***	(0.024)
Cancer diagnosis x cancer services	0.28***	(0.069)
Patient in labor x teaching hospital	0.767***	(0.037)
Cardiovascular diagnosis x cardiac services	1.687***	(0.051)
Musculoskeletal diagnosis x orthopedic services	1.476***	(0.041)
Cancer diagnosis x teaching hospital	1.918***	(0.05)
Other diagnosis x teaching hospital	1.517***	(0.038)
Number of observations	1,887,563	

Notes: This table presents results from the estimated hospital demand model in equation (9). The specification includes hospital system fixed effects (not reported). The omitted category is Partners Health Care. Unadjusted standard errors in parentheses. Effects significant at 10% (*), 5% (**), and 1% (***).

estimated distance coefficient is negative, with similar magnitudes to those in Ho (2006) and Ho and Lee (2017). The interactions between teaching hospitals and patients' clinical condition indicators are relatively large in magnitude and positive, which suggests that patients with specialized conditions place a positive weight on hospitals that have the expertise to treat them. Patients in labor as well as patients with cardiovascular or cancer diagnoses are more likely to chose hospitals with the respective services. Notably, the estimated coefficient on the referring physician's hospital ownership status has the largest magnitude. This suggests that referrals from hospital-acquired physician are an important determinant of hospital choice.

V.B Hospital-Insurer Bargaining

I now turn to the estimation of insurers' Nash bargaining weights, τ_j. I begin by describing each input to the bargaining estimation. I then discuss the identification and estimation of parameters τ_j.

V.B.1 Hospital Demand and Insurer Surplus

Equations (14) and (12) construct hospital demand and insurer willingness-to-pay conditional on a given hospital-insurer network. Using these equations, I calculate demand for every hospital i-payer j pair, along with insurer surplus for every payer j, for three separate network configurations: (i) insurer j's complete hospital network; (ii) insurer j's hospital network excluding each hospital in its network; and (iii) insurer j's hospital network excluding every *pairwise* combination of hospitals in its network. Each of these objects are used to form the moment conditions that determine τ_j.

First, using the hospital demand estimates and equation (13), I compute the demand for every hospital i, insurer j, and patient k conditional on (i) insurer j' s complete hospital network, $\hat{D}_{kji}(\mathcal{G}_j^M)$, (ii) the disagreement network that results if hospital i and insurer j fail to reach an agreement $\hat{D}_{kji}(\mathcal{G}_j^M \backslash ij)$, and (iii) the disagreement network that results if every pairwise combination of hospitals $h \neq i$ is excluded from j's network, $\hat{D}_{kji}(\mathcal{G}_j^M \backslash ih, j)$. These terms allows me to calculate the change in demand from individuals of type k for each hospital i in insurer j's network when every *other* hospital $h \neq i$ is excluded from the network; and when hospital i itself is excluded from the network. I aggregate these differences to the hospital i-insurer j level by taking a weighted sum over patient types $k \in \mathcal{K}$, in which the weights are equal to the number of individuals of each type enrolled in plan j.

Second, I use the the willingness-to-pay equations (11) to calculate each patient k's willingness-to-pay for (i) the complete network of insurer j, $WTP_{kj}(\mathcal{G}_j^M)$; (ii) for every disagreement network that is possible if a single hospital i, is excluded from j's network, $WTP_{kj}(\mathcal{G}_j^M \backslash ij)$; and (iii) for every disagreement network that is possible if every *pairwise* combination of hospitals i and h, where $i \neq h$, is excluded from insurer j's network, $WTP_{kj}(\mathcal{G}_j^M \backslash ih, j)$. As above, I aggregate these estimates of willingness-to-pay to insurer j by taking a weighted sum over patient types, where the weights are equal to the number of patients of each type. These objects allow me to compute the change in insurer surplus for each j when each hospital i in j's network is excluded from the network, and when every other hospital $h \neq i$ is excluded.

V.B.2 Identification and Estimation of Bargaining Parameters

The identification of the bargaining parameters τ_j for each insurer j relies on the equilibrium price conditions in equation (8). In particular, each τ_j is identified from the degree to which hospitals in j's network are substitutes; and the degree to which hospitals' average admission costs c_i contributes to the observed price. More formally, I follow Ho and Lee (2017) and assume that for any admission a in the set of referral admissions between hospital i and insurer j, the estimated price $\hat{p}_{ij}$ is measured with error ϵ_{ij} :

$$\hat{p}_{ij}(a) - p^*_{ij}(a) = \epsilon_{ij} \tag{15}$$

$\hat{p}_{ij}$ is the estimated inpatient price index negotiated by hospital i and insurer j. [13] I assume that ϵ_{ij} is mean zero, and represents an admission-specific price shock that reflects unanticipated severity, procedures, or costs of the admission. Therefore, the average admission price shock for patients enrolled with payer j admitted to hospital i can be written as:

$$\epsilon_{ij} = \sum_{a \in \mathcal{A}_{ij}} \hat{p}_{ij}(a) - p^*_{ij}(a) \tag{16}$$

The expression for p^*_{ij} comes from the Nash Bargaining first order conditions in equation (8). Thus, each hospital-insurer pair that reaches an agreement forms one moment to the estimation. The pricing equations in (8), stacked for all hospitals $i \in \mathcal{H}$ and insurers $j \in \mathcal{M}$, form the basis of the following moment conditions:

$$p^*_{ij} D_{ij} = (1-\tau_j) \underbrace{\left[WTP_{ij} - \sum_{h \in \mathcal{G} \setminus i} \Delta WTP_{hj} - p^*_{hj} \Delta D_{hj} \right]}_{X_1} - (\tau_j) \Big[c_i D_{ij} \Big] \tag{17}$$

We can rewrite the above as an explicit function of ϵ_{ij}:

$$\omega_{ij} = -D_{ij}\epsilon_{ij} + (1-\tau_j) \sum_{h \in \mathcal{G}_j \setminus i} \Delta D_{jh} \epsilon_{jh} \tag{18}$$

V.B.3 Estimates

I use constrained OLS regression to estimate the equations in (17). Table presents estimates of τ_j for each insurer along with standard errors bootstrapped at the hospital-payer level. I implement linear constraints on the bargaining weights to be between 0 and 1. The bargaining weights for each insurer are generally lower than .5, which suggests that hospitals have slightly more bargaining power in negotiations on average. In addition, the estimates are correlated with the number of enrollees in each insurer's plans: Harvard Pilgrim and BCBS are the largest insurers in the state with a combined market share of .61 (Table 1); the estimated weights are among the largest in the sample, .49 and .47 respectively. Fallon,

[13] More details on how I estimate the hospital inpatient price index are in the Appendix.

as the insurer with the smallest number of enrollees in the state, has the lowest estimated bargaining power.

Table 6: Bargaining Parameter Estimates

Payer	(1) Estimate	(2) Std. Err.	(3) Number of moments
NHP	0.526***	(0.064)	5
HarvardPilgrim	0.497***	(0.067)	16
BCBS	0.47***	(0.089)	18
Cigna	0.467***	(0.05)	10
Tufts	0.466***	(0.069)	14
Anthem	0.419***	(0.087)	12
Fallon	0.386***	(0.071)	6

Notes: Table presents OLS estimates of Nash bargaining parameters using moment estimating equations in equation (17). Unadjusted standard errors are in parentheses. Column (3) shows the number of hospital-insurer moments used to estimate the corresponding insurer weight.

VI Counterfactual Simulations

In this section, I use the estimated model to simulate the impact of changes in physician ownership. I consider two counterfactual scenarios: (i) where all physicians in the market practice independently; and (ii) all physicians in the market are hospital-owned. In each scenario, I develop and impose a decision rule to assign physicians to counterfactual ownership. Holding fixed hospital costs, hospital characteristics, enrollment, and insurers' hospital networks, I re-compute the implied equilibrium prices, profits, payments and welfare in each scenario and provide comparisons to the baseline levels.

I assume that physicians' acquisition status does not affect patient welfare outside its potential impact on patient demand for hospitals. This implies that any changes in patient welfare due to physician practice independence or hospital acquisition arise from a reallocation of patient demand across hospitals. More specifically, when calculating patient welfare in each exercise, I re-estimate hospital demand along with the expected utility from insurer hospital networks, taking into account patients' referring physician's ownership status. However, I exclude the impact of the referring physician's ownership status when performing patient welfare calculations.[14]

[14] In other words, I include the term $\beta_1 Acq_{Ref(k),i}$ from the demand model in equation (9) to simulate hospital demand and equilibrium prices; but exclude the term from patient surplus calculations.

In addition, this analysis makes several core assumptions. I assume that hospital-physician acquisition does not induce hospitals to meet capacity constraints; and that changes to physician markets do not lead to the entry or exit of additional physicians, hospitals, or insurers. I also assume that insurer premiums remain fixed, and that insurer margins do not change due to hospital-physician acquisition. I also assume that acquisition does not alter hospitals' admission costs.

Simulated Ownership Data

I begin by constructing simulated ownership data for each counterfactual exercise. In the first scenario, where I examine the effects of independent ownership, I reassign physicians who are hospital-acquired during the baseline sample time frame to an independent practice instead. This is equivalent to setting the variable $Acq_{Ref(k),i}$ equal to 0 in the demand model specified in equation (9).

In the second scenario, where I examine the effects of hospital ownership, I develop a logit-based decision rule to assign physicians who practice independently throughout the baseline sample time frame to a counterfactual hospital system ownership. For each independent physician n, I use the following model to predict hospital ownership choice:

$$u_{nh} = \delta_1 dist_{nh} + \gamma_h + \epsilon_{nh} \tag{19}$$

where $dist_{nh}$ is the distance between hospital h and physician ns' primary practice location, and γ_h is a hospital-specific indicator. I assume that ϵ_{nh} has a Type 1 Extreme Value distribution, and I condition on the set of hospitals that are within 50 miles of the physician n's practice zip code. I estimate (19) with MLE.

With the simulated ownership data in hand for each counterfactual exercise, I re-estimate hospital demand and patients' willingness-to-pay for insurer networks and compute the implied prices, profits, spending, and welfare estimates.

VI.A Counterfactual 1: All Physicians are Independent

Table 7 presents hospital payments and prices, insurer surplus, and patient welfare estimates in the baseline setting and across the two counterfactual exercises. In addition to average effects, I report hospital price, profit, and payment results separately by Partners, mid-size hospitals, and small hospitals to analyze heterogeneous impacts across firms. Columns (2) and (3) describe the impacts when all physicians are independently owned.

Hospital Prices, Profits, and Payments

The first panel of Table 7 indicates that negotiated prices are lower across hospitals. While inpatient prices at the average hospital system decline by approximately 4%, this effect is concentrated among the smallest hospitals. Small hospital systems reduce prices by an average of 12.85%, nearly six times the reduction in mid-size hospital systems. In comparison, Partners' hospital prices are relatively unaffected, declining by less than 1%. The decline in negotiated prices across hospital systems in this scenario are driven by changes to patient demand due to un-integrated physicians' referrals. This reduces hospitals' bargaining leverage vis-a-vis insurers in equation (8) and leads to lower negotiated prices.

Furthermore, average hospital profits decline by 12.24%, and insurer payments to hospitals decline by 10.14%. This result stems from lower negotiated prices in Partners hospitals along with a re-allocation of patient demand away from Partners hospitals and toward lower-priced alternatives (i.e. Mid-size and small-volume firms). As Partners hospitals can no longer rely on acquired physician incentives to direct referral volume within-system, patients are more likely to choose other hospital alternatives. This is consistent with the presence of hospitals that are close substitutes to Partners hospitals, and reflects the "price reinforcement effect" as in equation (8).

Welfare

Both patient welfare and insurer surplus are higher when physicians practice independently. As outlined above, I assume that patient surplus is unaffected by changes to physicians' ownership status outside its impact on patient choice of hospital. Thus, the increase in patient welfare can be understood as the benefits to patients from choosing hospitals that more closely reflect their own preferences. Higher patient surplus coupled with lower hospital payments yield a positive net impact on insurer surplus of nearly 9%.

VI.B Counterfactual 2: All Physicians are Hospital-Acquired

Hospital Prices, Profits, and Payments

Columns (4) and (5) of Table 7 summarize the impacts of hospital acquisition of all physician practice in the sample. Panel A reveals that on average, negotiated prices across hospitals rise by .72%. However, small hospitals' negotiated rates grow by nearly 16%; in contrast, Partners Health Care and mid-size hospitals' prices grow by less than 1%. This result suggests that an increase in acquiring hospitals' referral demand –due to changes in acquired physician incentives – enhances the acquirer's bargaining leverage, and leads to higher equilibrium negotiated prices between insurers and the acquiring firm. At the same time, changes in insurer payments to rival hospitals that are close substitutes to the acquiring firm, on average, do not offset the acquirers' gains in bargaining leverage. In other words, an increase in the "enrollee surplus effect" term in equation (8) outweighs any changes in the "price reinforcement" term, i.e. the countervailing effects of rival hospitals.

While average hospital profits decline by -3.9% relative to baseline, this effect masks hetereogeneity across hospital systems. Partners Health Care profits decline by 22.5%, while profits at small- and mid-volume firms instead grow by 31% and 16% respectively. This reflects the re-allocation of demand across hospital systems due to shifts in physician practice acquisition. When all physicians are hospital-acquired, referral incentives shift toward the acquiring firm; the resulting change in referral demand across firms diminishes Partners' referral volume relative to baseline, while augmenting small and mid-size firms' referral volume. Therefore, the hospital acquisition of all physician practices yields a relative advantage to small and mid-size hospitals. This drives higher negotiated prices for those firms.

Welfare

Both insurer profits and consumer surplus are diminished when hospitals own all physician practices. Insurer surplus declines because higher payments to small- and mid-size firms outweigh the benefits to patients (i.e. enrollees) from referrals to in-network hospitals. Consumer surplus decreases relative to baseline and to the scenario in which all physicians practices are independent, as patients are referred to hospitals that they would not have chosen in the absence of a referral from a hospital-acquired physician.

VII Conclusion

This paper studies the impact of hospital-physician group mergers on hospital prices and welfare. I focus on how changes in physicians' referral incentives induced by hospital acquisition affects patient demand for hospital services. Using detailed claims data from the Massachusetts APCD from 2014-2017, I show that physician practice acquisition shifts referral demand to non-dominant firms and leads to higher negotiated prices for non-dominant hospital system.

First, my results suggest that physician agency is an important component of patient demand for hospitals. Hospital-physician group mergers lead to changes in physician in-

Table 7: Counterfactual Ownership: Summary Results

	Hospital	(1) Baseline	(2) All Indep.	(3) Pct Change	(4) All Acquired	(5) Pct Change
Hospital Price (000)	Partners	34.08	33.77	-0.90	34.22	0.42
	Mid-size hospitals	25.10	24.70	-1.63	25.23	0.49
	Small hospitals	26.66	23.24	-12.85	30.89	15.86
	All hospital average	27.58	26.49	-3.97	27.78	0.72
Hospital Profits (millions)	Partners	1251.39	984.86	-21.30	970.25	-22.47
	Mid-size hospitals	269.72	279.79	3.73	353.92	31.22
	Small hospitals	137.22	136.76	-0.34	159.15	15.98
	All hospital average	469.52	412.03	-12.24	451.22	-3.90
Hospital Payments (millions)	Partners	300.05	235.89	-21.38	294.31	-1.91
	Mid-size hospitals	91.23	94.43	3.51	112.57	23.39
	Small hospitals	54.44	54.63	0.34	71.04	30.49
	All hospital average	131.71	118.35	-10.14	143.38	8.86
Consumer Surplus ($)		237.24	267.58	12.79	185.25	-21.91
Insurer Surplus ($)		22460.99	24420.56	8.72	18231.50	-18.83

Notes: This table presents results from simulating private ownership (columns (2) and (3)) and hospital acquisition (columns (4) and (5)) using demand and bargaining weight estimates from tables 5 and 6. Surplus figures represent total insurer and consumer surplus per individual and are measured in dollars.

centives that in turn directs patients toward the acquiring firm. In the absence of hospital integration, referring physicians and patients jointly choose hospitals that are more closely aligned with patients' preferences.

Second, the results suggest that dominant and non-dominant hospital systems leverage physician group mergers for different ends. Less dominant firms experience larger returns to physician practice acquisition in terms of referral and price effects. In contrast, the dominant firm in this setting, Partners Health Care, does not face substantial increases in referral rates or negotiated price. This suggests that less dominant hospital systems may leverage physician practice acquisition as a strategy to enhance their bargaining leverage and compete more effectively with dominant firms in the region.

There are several potential extensions to this research. In this paper, I assume that hospitals' average admission costs remain fixed with acquisition, and I do not explore potential efficiencies that may result from physician practice acquisition. One direction for future work is to explore the improvements in provider coordination, complementary investments, and other benefits to patients that may arise from integration. Second, the theoretical framework in this paper does not incorporate insurer margins or employer-insurer bargaining. As Ho and Lee (2017) show, these are likely important to capture the effects of changes in hospital competition on prices. Finally, my theoretical analysis does not account for the impact of hospital systems simultaneously acquiring physician groups. The impact of acquisitions in markets where all upstream firms engage in consolidation at the same time remains an open question.

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VIII Appendix

VIII.A Data Cleaning and Sample Construction

I take a number of steps to clean and process the claims data from the Massachusetts APCD. I select the final version of each claim line, drop denied claims, refunded claims, and claim lines that report a negative allowed amount. I select commercial claims for patients ages 18-64 to ensure that Medicare patients are not included in the analysis as they may be a selected population. I also drop claim lines that do not report a valid ICD procedure code. I also exclude all claims where either the patient lived, or the provider was located, outside of MA.

I select inpatient hospital claims from the APCD using the place of service and bill type codes on each claim line. We then group the inpatient claims into distinct episodes of care using the member identification number, dates of service, and principal diagnoses codes reported on each line. I exclude inpatient cases in which the patient was admitted to multiple hospitals, since hospital transfers often arise in emergency situations and may give rise idiosyncratic pricing. I also exclude cases in hospital emergency departments.

I incorporate information from the American Hospital Association (AHA) Surveys to build a sample of general acute care hospital facilities located in Massachusetts. To select inpatient claims, I use the provider ID fields along with the place of service and facility bill type codes on each claim line. We also use the AHA Surveys as a source hospital and hospital system characteristics, including location, teaching hospital status, and various service offerings.

I use data from the Center for Medicare and Medicaid Services (CMS) National Plan and Provider Enumeration System in 2017 (NPPES) to build a sample of physicians and physician practices in the MA APCD. Specifically, I select physicians who report a majority of their annual medical claim volume in each year in Massachusetts. I also merge information about each physicians' specialty and practice locations(s) from the NPPES data. I use the provider taxonomy labels constructed in Agha, Ericson, Kimberley H Geissler, et al. (2018) to classify each physician into specialties.

VIII.B Inpatient Price Index

To study the effects of acquisitions on hospital prices, I develop a risk-adjusted measure of the average inpatient price for a hospital-payer pair. In particular, I estimate a price index at the hospital-payer-quarter-HRR level for hospital-payer pairs with at least 10 admissions recorded in the sample. I follow Cooper et al. (2019) and Craig, Ericson, and Starc (2021) in my approach and estimate regressions of the form:

$$price_{ihptm} = X_i + \gamma_{hptm} + \gamma_{d(i)} + \epsilon_{ihpt} \tag{20}$$

Where $price_{ihptm}$ is the observed admission-level paid amount for patient i in Hospital Referral Region m between hospital h and payer p in quarter t. X_i denotes dummy variables for the 10-year age group and for the sex of patient i. γ_{hptm} are fixed effects for the hospital-payer-quarter-HRR of the admission, and $\gamma_{d(i)}$ represent fixed effects for the the primary clinical procedure reported in the admission.[15]

I recover the vector of hospital-payer-HRR-quarter fixed effects in $\hat{\gamma}_{htpm}$ and then compute a hospital price index for each quarter at the sample means of the patient characteristic ($\bar{X}$) and principal procedure indicators (i.e. an average basket of procedures).

$$\hat{p}^{INDEX}_{hptm} = \hat{\gamma}_{hptm} + \hat{\pi}\bar{X} + \hat{\delta}_{d(i)}\hat{\gamma}_{d(i)} \tag{21}$$

$\hat{\pi}$ is a vector that contains the state-wide prevalence of each patient characteristic in X_i, and $\hat{\gamma}_{d(i)}$ is a vector that contains the sample-wide prevalence of each procedure. This yields the price for each hospital and payer in each HRR-quarter, adjusted for its mix of treatments and mix of patients. I winsorize prices at the 5% level on both sides of the distribution.

VIII.C Measuring Hospital-Physician Practice Acquisitions

In this section, I detail my approach to track and document physician hospital acquisitions and outline how I infer the practice ownership status of each physician in the sample. Specifically, I leverage an administrative feature of physicians' claims submission process: physician bills report the identification number of the provider organization that submits the claim to insurers [16]. Physicians who practice in an independent medical group typically submit claims with the billing identification number of the independent medical group. On the other hand, physicians who practice in a hospital- or health system-owned practice submit bills using the billing identification of the corresponding hospital or health system.

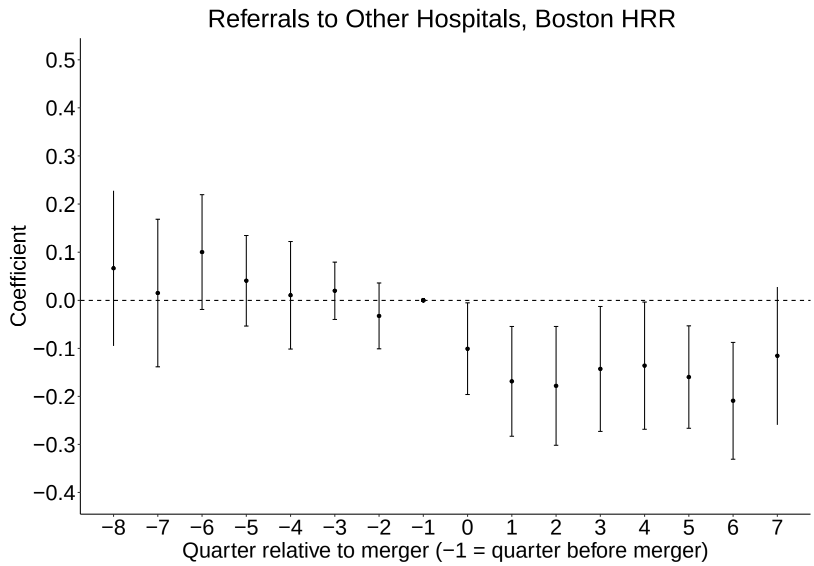
I label each physician in the sample with the hospital or hospital system that owns their

[15] I identify the primary clinical procedure on each admission as the procedure line with the largest paid amount.

[16] This is recorded in the MA APCD in the billing provider field.

practice (if any). For each physician and in each quarter t I identify the provider organization with which the physician billed a majority of her claims. If a physician shifts from submitting a majority of claims with an independent practice in quarter t to a hospital or health system in the subsequent quarter $t + 1$, I label the physician as acquired by the hospital or health system in quarter $t + 1$. Physicians who bill the majority of claim volume using a hospital or health system identification number typically earn over 80% of their annual revenue from medical claims at the given hospital or health system.

Figure 5: Event Study Analysis of Hospital-Physician Mergers on Physician Referrals to Other Hospitals



Notes: