Owning the Agent: Hospital Influence on Physician Behaviors*

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Abstract

Differential financial incentives between hospitals and physicians, alongside the prevalence of physician agency problems, create an incentive and opportunity for hospitals to influence physician behaviors toward their own financial objectives; however, the extent to which hospitals can achieve this goal depends on its underlying relationship with its physicians. Using the population of Medicare inpatient and institutional outpatient claims from 2008 to 2015, we estimate that hospital ownership of physician practices would lead to an increase in Medicare expenditures of $75 to $200 per patient ($55mm to $146mm per year), explaining 4-10% of within-physician variation in Medicare expenditures across hospitals. This effect is driven almost entirely by changes in treatment intensity rather than reallocation of patients across hospitals.

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1 Introduction

Hospital and physician services constitute the two largest components of U.S. health expenditures and jointly accounted for nearly $1.8 trillion in U.S. health spending in 2017 (53% of total health expenditures). With such money at stake, hospitals as downstream firms have clear incentives to influence physician behavior where possible to improve profitability (Gaynor & Town, 2012; Gaynor *et al.*, 2015; Post *et al.*, 2018). Moreover, the opportunity to influence treatment patterns for financial gain exists so long as patients remain at an informational disadvantage and insurer monitoring of physician decisions is incomplete;[1] however, traditional physician-hospital relationships rely heavily on informal arrangements and often incomplete incentive alignment, thereby limiting a hospital's direct control over its revenue streams. This paper aims quantify the extent to which hospitals appear to influence physician behaviors, where we use hospital acquisitions of physician practices to capture incentive alignment between hospitals and physicians.

Our analysis is based on a panel of all office-based physicians in the U.S. that operate on Medicare patients from 2008 to 2015. We measure expenditures and utilization using Medicare fee-for-service (FFS) inpatient and institutional outpatient claims for planned and elective procedures over this time period, and we supplement the claims data with information on hospital characteristics and county demographics from a variety of sources. As discussed in more detail in Section 3, our final analytic dataset consists of over 78,000 unique physicians operating at over 4,700 unique hospitals. These physician-hospital pairs account for over 7.5 million (47% of total) planned and elective inpatient surgeries as well as over 24 million (33% of total) outpatient procedures associated with a hospital provider number.

Data on hospital ownership of physician practices comes from the SK&A physician survey database. These data offer several advantages compared to other common measures of alignment, such as a hospital's self-reported classification within the American Hospital Association (AHA) annual surveys (Cuellar & Gertler, 2006; Ciliberto & Dranove, 2006; Baker *et al.*, 2014). For example, measures of integration at the hospital level cannot identify variation across physicians operating at the same hospital. Our unique combination of data can overcome this challenge and

[1] There is now a substantial literature showing that a large share of spending is not driven by patient preferences. See, for example, Wennberg & Gittelsohn (1973), Skinner & Fisher (1997), Wennberg *et al.* (2003), Baicker & Chandra (2004), and Gottlieb *et al.* (2010), among others. More recently, Finkelstein *et al.* (2016) exploits patient migration to estimate that 50-60% of geographic variation in spending is due to supply-side factors. Molitor (2018) likewise uses cardiologists' migration patterns to show that 60-80% of the variation in treatment styles can be explained by characteristics of the local physician practice.

is therefore a clear improvement in this regard. The SK&A data also contain detailed information on each physician practice, including practice size, group affiliation (i.e., horizontal integration), and single or multi-specialty status.

In Section 2, we motivate our empirical analysis with a simple model of a physician and hospital jointly optimizing some combination of perceived patient preferences and profits. This framework suggests a two-stage approach to estimating hospital influence on physician behaviors. In stage one, we identify a joint physician-hospital fixed effect based on data at the patient level and incorporating information on patient utilization patterns, demographic characteristics, and diagnosis codes. This first stage therefore provides a risk-adjusted measure of the joint influence of physicians and hospitals on patient-level outcomes, after adjusting for the patient's relative health care consumption in prior years. We estimate this physician-hospital fixed effect separately by year, where our primary outcomes of interest include Medicare payments, hospital costs, and total inpatient and outpatient stays per patient.[2]

We then decompose the first-stage effects by regressing the joint physician-hospital fixed effects on a physician fixed effect, a hospital fixed effect, and time-varying observable practice and hospital characteristics (among other variables). After conditioning on physician and hospital fixed effects, the remaining variation for a given physician-hospital pair is intuitively similar to an employee-employer "match value" (Abowd *et al.*, 2002; Card *et al.*, 2013), where variation in this match value derives from physicians who admit patients to more than one hospital over the length of our panel. By exploiting within-physician variation, our identification strategy is similar to the study of physician migration in Molitor (2018) and even more closely related to the identification strategy in Sacarny (2018).[3]

The key variable of interest in our second-stage analysis is an indicator for whether the physician practice is owned by the hospital system, which we interpret as a proxy for incentive alignment between physicians and hospitals and thus the potential for institutional influence on physician decisions. Our initial results show a positive and statistically significant increase in total Medicare

[2]Our measure of Medicare payments includes all Medicare expenditures observed in the inpatient and institutional outpatient claims data. This includes Part A claims as well as some Part B claims, but does not include payments made specifically for physician services. We refer to this as "Medicare payments" for brevity, but more precisely, this outcome reflects hospital-specific Medicare payments. Since our measure of Medicare payments does not include billable physician services, we consider hospital costs as an additional outcome to more fully capture changes in resource utilization for a given physician-hospital pair.

[3]In Section 2, we discuss the merits of our two-stage approach relative to a single-stage estimation at the patient/year level.

facility payments, total inpatient and outpatient stays, and total hospital costs per patient among vertically integrated physician-hospital pairs. Specifically, we estimate that vertically integrated hospitals and physicians generate Medicare payments of at least \$75 more per patient per year, with additional hospital costs of \$130 per patient per year and at least 1.4 additional inpatient and outpatient visits per 100 patients. This extrapolates to a total increase of \$55mm in Medicare payments per year, an increase in hospital costs of \$95mm per year, and an increase in total inpatient and outpatient visits of around 10,200.[4]

A key causal assumption in our analysis is that any unobserved component of patient preferences is uncorrelated with time-varying, unobserved reasons for hospital acquisitions of physician practices. Our results and sensitivity analyses suggest this is plausible in our empirical context; however, a hospital's acquisition of a given physician practice may still be influenced by time-varying unobserved factors that are correlated with physician outcomes, such as changes in the composition of the physician practice and administrative staff.[5] We address this concern empirically in three ways.

First, we present an event study in which we focus on a specific cohort of physician-hospital pairs that were integrated in 2011, and we estimate differential effects of vertical integration by year. These results support the hypothesis of common trends between integrated and non-integrated physician-hospital pairs, albeit over a small two-year pre-period. The magnitude of the estimated effect of integration is also larger than our initial estimates, with an average estimated increase in Medicare expenditures of \$200 per patient per year (\$146mm in total Medicare payments per year) and an estimated increase of \$350 per patient per year in hospital costs (\$255mm in total hospital costs per year).

Second, we exploit physicians that operate in multiple hospitals, where the physician is vertically integrated with at least one hospital and non-integrated with at least one other hospital. Among this group of physicians, we can separately identify an overall effect of integration and an effect of being integrated specifically with a given hospital. From this analysis, we estimate an increase in Medicare expenditures of approximately \$185 per patient per year specifically for

[4]Our measure of Medicare payments does not account for revenue from billable physician services.

[5]Vertical integration may also improve quality of care and subsequently influence patient preferences for a given physician-hospital pair. We address this empirically with a supplemental analysis of vertical integration and physician-hospital quality (as measured by 30-, 60-, and 90-day mortality). Here, we estimate an economically small and statistically insignificant positive relationship between vertical integration and mortality, suggesting that vertical integration does not appear to improve quality of care. These results are presented in the supplemental appendix.

the acquiring hospital, with no significant change in Medicare payments to hospitals for which the physician is not integrated. Since the increase in Medicare payments is isolated among the acquiring hospitals, we interpret this as evidence of hospital influence on physician behaviors.

Third, we propose an instrumental variable (IV) estimate for vertical integration based on predicted hospital acquisitions of physician practices. To implement the IV approach, we construct the set of all possible physician practice acquisitions based on the set of hospitals where a given physician has operated within the 2008-2015 period. The outcome in this analysis is an indicator for whether the physician practice is vertically integrated with a given hospital system, and the independent variables include practice and hospital characteristics, the average differential distance of the patients of a given practice between a hospital and the nearest hospital in their choice set, and interactions between differential distance and practice/hospital characteristics. Predictions from this analysis then provide a generated instrument for the observed vertical integration indicator as part of a fixed effects instrumental variables (FE-IV) estimator. Our generated instrument ultimately exploits the differential distance among a physician's set of patients previously receiving care at a given hospital as a source of independent variation in the probability of a hospital taking formal ownership of the physician practice. The underlying intuition is that a practice with existing patients further away from a given hospital (relative to the nearest hospital in their choice set) will be less willing to vertically integrate with that hospital. Our FE-IV estimator yields larger effects across all outcomes considered, suggesting that our prior estimates are perhaps conservative.

Collectively, our results reveal a range of between \$75 and \$200 more in Medicare payments per patient per year among vertically integrated physician-hospital pairs, with an increase in hospital costs of between \$130 and \$350 per patient per year. These estimates imply that hospital influence on physician behaviors can explain between 4% and 10% of the total estimated within-physician variation (across hospitals) in spending per patient, or as much as 40% based on our FE-IV estimates.

We then aim to quantify the relative importance of two central channels that could lead to these spending increases: 1) an increase in treatment intensity for the same patient; and 2) a reallocation of procedures for the same patient to the acquiring hospital, as opposed to an alternative hospital.[6] Through a series of additional outcomes and patient populations, we find that increases in per-

[6]Selection of patients across hospital-physician pairs may also be of concern (i.e., integrated physicians may attracted different types of patients); however, by exploiting a rich set of patient observables as well as a secondary analysis specifically examining cross-patient reallocation, we find no evidence that integration leads to sufficient changes in patient severity for the same physician-hospital pair.

patient Medicare payments, hospital costs, and inpatient/outpatient visits are almost entirely driven by increased treatment intensity rather than redirecting the flow of services for a given patient to the acquiring hospital. Importantly, this is not to say that reallocation does not happen; rather, such reallocation occurs across patients instead of within patients. For example, when examining changes in total physician-level patient allocations across hospitals, we indeed find evidence that hospitals receive a larger share of a physician's patients following formal integration, which is consistent with Baker *et al.* (2016) and Koch *et al.* (2017).

Our findings contribute to two related literatures. Our first contribution is to the broader literature on physician agency problems. In documenting physician agency problems, authors typically examine changes in physician treatment choices due to relative differences in financial incentives across services. For example, Clemens & Gottlieb (2014) study physician responses to changes in Medicare reimbursement rates, finding that physicians increase the amount of care and shift toward more profitable treatments after a relative reduction in Medicare payments. Afendulis & Kessler (2007) similarly show that patients receive significantly more care, with no discernable quality improvement, when physicians have the authority to both diagnose *and* operate relative to physicians restricted to diagnostic competencies. Relatedly, Gruber & Owings (1996) demonstrate a movement toward more profitable services (in their case, an increase in cesarean section deliveries) following a reduction in demand for labor and delivery services, and Iizuka (2012) finds that physicians in Japan are more likely to prescribe drugs for which they share some portion of the markup. The presence of physician agency problems is also implicit in studies of unexplained geographic variation in health care utilization (e.g., Finkelstein *et al.* (2016) and Molitor (2018), among many others).

Rather than exploiting differential payments across services, our analysis exploits heterogeneities across hospitals (cross-sectionally and over time) for which the same physician performs surgical care. Sacarny (2018) is perhaps most closely related to our study in terms of identification strategy; however, he studies coding changes and only briefly examines the role of vertical integration on such coding behaviors. We deliberately capture health care utilization more generally (conditional on observed diagnosis codes) and are specifically interested in whether hospitals can influence physician treatment decisions—which has direct and potentially substantive implications on both medical spending and health outcomes. One caveat here is that our analysis considers just one specific mechanism for hospital influence (i.e., ownership of a physician practice). There are many other mechanisms by which hospitals may attempt to influence physician behaviors, such as joint partnerships or less stringent contractual relationships in which hospitals offer some marketing or administrative support with no ownership stake in a physician practice. While we consider these other mechanisms as important avenues for future work, we focus on hospital ownership of physician practices because this offers arguably the strongest opportunity for hospitals to influence physician behaviors and because this offers a more discrete change in physician-hospital relationships that we can directly observe in the SK&A data.

Our work also clearly connects to the recent literature on the effects of vertical integration throughout the health care sector, which span a variety of empirical settings and associated outcomes. For example, Baker *et al.* (2016) study physician-level admitting patterns among practices owned by hospitals, and Baker *et al.* (2014) examined changes in market-level spending due to hospital ownership of physician practices (as reported in AHA survey data). Capps *et al.* (2018) similarly consider the effects of vertical integration on an overall physician price index, which is composed of inpatient and outpatient claims activity. Finally, Koch *et al.* (2017) examine the effect of vertical integration on physician-level behavior in the clinic and outpatient setting, focusing specifically on acquisitions of 27 large physician practices.

Our central contribution to the vertical integration literature is that we isolate effects on treatment intensity per patient for a given physician-hospital pair, which is separate from changes due to reallocation of procedures across hospitals, upcoding behavior, or location-based billing policies. We are able to do so by exploiting a unique and extensive combination of data that we believe is novel to the literature. In these ways, our findings nicely complement existing studies and offer further motivation for careful regulatory scrutiny of hospital-physician relationships.

2 Motivation

We motivate our empirical analysis with a simple model of physician behavior, following closely that of Finkelstein *et al.* (2016). We assume physician j provides some amount of care, y_{ijk}, to maximize the perceived utility of patient i as well as the profits of the physician, the physician's practice, and hospital k.[7] We assume that this maximization problem takes place separately at each time t, and

[7] To simplify notation, we let the subscript j denote physician j within a given practice. Our empirical analysis ultimately restricts the sample to physicians that operate in a single practice, so that we can uniquely assign practice characteristics (including ownership by a hospital system) to the physician.

we therefore suppress notation for time. Denote physician/hospital profits by $\pi\left(y_{ijk};\Gamma_k,\Gamma_j,\kappa_i\right)$, which generally captures some effect of y_{ijk} on profits conditional on a set of physician, hospital, and patient characteristics. Similarly denote by $\tilde{u}\left(y_{ijk};\Gamma_k,\Gamma_j,\kappa_i\right)$ the physician's perception of patient utility from care y_{ijk}, assumed to depend on hospital (Γ_k), physician (Γ_j), and patient (κ_i) characteristics. We further assume that the physician's objective is additively separable in perceived patient preferences and profits.

The observed amount of care (all defined at time t) is then:

$$y_{ijk} = \arg\max_{y} \theta_u \tilde{u}\left(y;\Gamma_k,\Gamma_j,\kappa_i\right) + \theta_\pi \pi\left(y;\Gamma_k,\Gamma_j,\kappa_i\right), \tag{1}$$

where θ_u and θ_π reflect different weights that the physician and hospital place on perceived patient preferences versus profitability of treatment. Assuming $\tilde{u}$ and π are additively separable in i and (j,k), a reduced-form analog to the solution to Equation 1 is

$$y_{ijk} = \alpha_i + x_i\beta + \Gamma_{jk} + \epsilon_{ijk}, \tag{2}$$

where α_i denotes unobserved patient characteristics; x_i denotes observed patient characteristics; Γ_{jk} denotes a risk-adjusted measure of joint influence of physicians and hospitals on patient-level health care utilization, composed of observed and unobserved physician and hospital characteristics; and ϵ_{ijk} denotes an error term.

Our primary empirical question then relates to the structure of Γ_{jk}. With estimates of Γ_{jk} in each year t, we then parameterize Γ_{jkt} as follows:

$$\Gamma_{jkt} = \gamma_j + \gamma_k + \tau_t + z_{jkt}\delta + \eta_{jkt}, \tag{3}$$

where γ_j denotes unobserved, time-invariant physician characteristics such as practice style; γ_k similarly denotes unobserved, time-invariant hospital characteristics; τ_t denotes unobserved factors affecting all physicians and hospitals at time t; z_{jkt} denotes observed, time-varying physician and hospital characteristics; and η_{jkt} denotes an error term.

An obvious mechanism by which hospitals may gain influence on physician treatment patterns is by acquiring the physician practice. The effects of such vertical integration, however, are theoretically ambiguous. In terms of total care provided (inpatient and outpatient procedures), more procedures translates to more revenue for the hospital and physician, but due to much higher costs in the inpatient setting, the marginal procedures gained may not increase profit to the hospital. The hospital may therefore have a preference for additional procedures in the outpatient versus inpatient setting. At the inpatient level, hospitals receive a fixed DRG-based payment from CMS and therefore have an incentive to reduce costs without overly sacrificing quality; however, if a hospital directly employs physicians on a salaried contract, then the hospital becomes the residual claimant on all billable physician services, which creates an incentive for additional billable physician services even within a given inpatient stay.[8]

For example, consider the Medicare payment for a total hip replacement without complications or comorbidities (DRG 470).[9] Values will differ by location and hospital, but on average, CMS will pay the hospital a DRG-based payment of just under \$12,000. CMS will also pay the orthopedic surgeon approximately \$1,400 based on the HCPCS code 27130. If this physician is employed with a salary arrangement by the hospital, then the marginal revenue from the \$1,400 physician fee would go to the hospital (although still billed separately and thus not included in the available Medicare inpatient claims data). If instead the physician is not employed by the hospital, then this payment will go straight to the physician or the physician practice.

2.1 Estimation Strategy

Our expository model suggests a straightforward two-step estimation strategy. In stage one, we form an estimate of Γ_{jk} from Equation 2 based on data at the patient level. In stage 2, estimates of Γ_{jkt} are used as outcomes in our estimation of Equation 3. Since we condition on physician and hospital fixed effects (as well as adjusting for patient variables in the first stage), the remaining variation is akin to a "match value" in Abowd *et al.* (2002) and Card *et al.* (2013). Unlike other settings in which the match value is estimated based on few observations for a given employee/firm match, our first-stage analysis is based on data at patient/procedure level, where we have many observations for the same physician-hospital pair. Results from Equation 3 therefore offer an estimate of the effects of physician and hospital characteristics on physician-hospital match values.

[8]Several recent policy changes further increase the incentive for hospitals to attempt to influence physician behaviors. For example, as part of the Value Based Purchasing (VBP) program and other incentives introduced through the Affordable Care Act (ACA), hospitals are penalized based on their performance across a range of clinical and non-clinical measures.

[9]More detailed payment information is available at the CMS Inpatient Payment Website and the CMS Physician Fee Schedule.

Our estimation strategy achieves two goals. First, the two-stage approach adjusts for measures of patient preference, exploiting data on all inpatient and institutional outpatient claims as well as patient demographics. Residual variation in health care expenditures and utilization should therefore be driven predominantly by supply-side factors. Second, our two-stage approach estimates effects specifically on the interaction between a given physician and hospital (i.e., conditional on the overall practice patterns of a given physician or hospital). Our analysis can therefore speak to how vertical integration changes physician behaviors at the acquiring hospital, as distinct from an aggregate effect driven by the hospital's acquisition of already high-intensity physician practices.

We could alternatively estimate the effect of physician-hospital integration in a single stage at the level of the patient/year; however, there are at least two concerns with this strategy. First, a single-stage approach would not align with the underlying treatment assignment we have in mind. Specifically, we are interested in the effect of affiliating with a hospital on a physician's behavior at that hospital. This means that the treatment is at the physician/hospital level, not at the patient level. Second, a two-stage estimation allows for a much richer specification in which all patient-level coefficients are allowed to vary by year. The equivalent single-stage estimation would include interactions between each patient variable (i.e., the components of α_i and x_i) and year dummies. Estimating this model along with multi-dimensional fixed effects on even a small sample of our full claims data (over 20mm patient/year observations in our combined inpatient/outpatient dataset) is computationally infeasible.

3 Data

3.1 Dataset Construction

Our analysis is based on the population of Medicare inpatient and institutional outpatient claims from 2008 through 2015. We focus on planned procedures in which we observe the National Provider Identifier (NPI) of the operating physician. In the inpatient setting, we define a planned admission as an "elective" admission type that is initiated by a physician, clinic, or HMO referral. This excludes, for example, transfers from other hospitals or inpatient stays initiated through the emergency department, urgent care center, or trauma center. We implicitly assume that all outpatient procedures are elective. In focusing on procedures with an observed operating physician NPI, note that our analysis only includes operations and therefore excludes basic services, lab testing, imaging, etc.

The purpose of focusing on elective procedures is twofold: 1) conditional on diagnosis and procedure codes, we anticipate less unobserved variation in Medicare expenditures and hospital costs among planned procedures relative to inpatient stays initiated through an emergency department or transferred from another hospital; and more importantly, 2) treatment for elective procedures is more likely to be at the physician's discretion, offering a better opportunity to study changes in physician behavior due to integration. Our sample construction is therefore similar in spirit to Card *et al.* (2009) in that we limit our sample according to the reason for admission rather than a specific underlying diagnosis or procedure.[10]

From the inpatient claims, we construct a dataset of all observed physician-hospital pairs for each year from 2008 through 2015. The physician-hospital data include the number of procedures for each physician/hospital pair in a given year; hospital characteristics including zip code, NPI, total admissions, total charges, total reimbursements from Medicare, and total diagnosis related group (DRG) weights; and physician characteristics including office zip code, NPI, primary specialty, practice tax ID, and total inpatient and outpatient stays across all hospitals.

The resulting unit of observation is a physician-hospital-year. From the claims data we have 765,172 total physician/hospital pairs from 2008–2015, or about 96,000 pairs per year. We observe 228,302 unique physician/hospital pairs in the data, based on 5,070 unique hospital NPIs and 120,041 unique physician NPIs. We drop physicians operating outside of the contiguous U.S., which reduces our total number of observations to 760,181. We also drop observations in which the physician operated at a hospital more than 120 miles from the physician's primary office location. This leaves 689,400 total observations over our time period.

We incorporate additional hospital-level data from the provider of service (POS) files and the AHA annual surveys, which we merge to the physician-hospital data using the Medicare provider number. These data include the number of staffed hospital beds and indicators for hospital teaching status, membership in a larger hospital system, and for-profit/not-for-profit ownership. We then incorporate hospital financial information and data on total discharges from the Healthcare Cost Report Information System (HCRIS), again merged based on the Medicare provider number.

[10]For example, Card *et al.* (2009) focuses on unplanned admissions through the ED for "non-deferrable" conditions. The sample construction in Card *et al.* (2009) helps in the validity of their regression discontinuity research design by focusing on patients who must be admitted to the hospital regardless of timing or insurance status. Similarly, our sample construction helps to focus on patients for which the physician is more likely to have some influence over the treatment decisions, or at least focus on patients that are likely to have consulted a physician before pursuing the operation.

Finally, we incorporate local demographic and other county-level variables from the American Community Survey (ACS), merged based on county FIPS codes observed in the AHA data.

We then merge data on hospital ownership of physician practices from SK&A, a commercial research firm that regularly surveys the ambulatory physician practice landscape. The SK&A database approximates a near-universe of U.S. office-based physician practices and provides detailed information regarding practice ownership affiliations (including the health system name for those vertically integrated), practice specialty, practice size, and practice location. The SK&A data also includes each physician's NPI, which we use to merge to the claims data. Note that the SK&A data excludes hospital-based physicians. For 30,753 unique physicians in the claims data (152,625 total observations), we do not observe a matching physician NPI in the SK&A data. We drop all such physicians from the analysis, leaving 536,775 observations.

Note that our SK&A data are bi-annual so that we only observe ownership affiliations for odd-numbered years — 2009, 2011, 2013, and 2015. We therefore do not know the precise timing of some acquisitions. As an example, consider a practice that is observed to be owned by a hospital system in 2011 but not in 2009. This practice could have been acquired in 2010 or 2011. In our analysis, we assign treatment status based on data from the prior year, which means that the vertical integration indicator in this example is set to 1 beginning in 2011 and 0 in 2010.[11] This ensures that any purchase of a practice is accurately indicated as such in the data (i.e., no false positives).

Finally, we restrict the sample to individuals aged 65 and above, and we drop claims in which Medicare payments or charges fall in the highest or lowest one-percent of all observed amounts in a given year.[12] We lose another 18,377 physician-hospital pairs when applying these restrictions, which yields a final dataset of 518,398 physician-hospital pairs from 2008 through 2015, consisting 78,890 unique physician NPIs and 4,754 unique hospital NPIs. This set of hospitals and physicians accounts for 7,546,313 total inpatient stays in the underlying Medicare claims data, approximately 47% of all elective inpatient stays (with nonmissing operating physician NPIs) observed over this time period.

Since we are interested in physician/hospital interactions, we only incorporate outpatient proce-

[11]To be clear, we can only assign treatment status based on data from the prior year if the practice is observed in both years. If instead the practice in our example is observed in 2010 but not in 2009, then we assign treatment status based on 2011 data.

[12]We drop these observations because we present estimated physician-hospital fixed effects as an intermediate step in our analysis, the estimation of which is more sensitive to outliers in the underlying claims. Our fixed effects estimates and final results are unchanged if we winsorize our sample instead of dropping these observations entirely.

dures for physician/hospital pairs with matching NPIs to the inpatient data.[13] Our final outpatient data are therefore comprised of the same physician/hospital pairs as the inpatient data and account for approximately 24mm total outpatient procedures.

3.2 Dependent Variables

In estimating our first stage (Equation 2), we focus initially on Medicare payments, hospital costs, and inpatient and outpatient stays per patient-year. We measure Medicare payments as the sum of all Medicare payments for inpatient and institutional outpatient procedures for each patient/physician/hospital combination. Importantly, this measure of Medicare payments does not include payments for billable physician services, which we do not observe in our data. To more fully capture changes in resource utilization (including physician services), we also consider total hospital costs, calculated as the sum of inpatient and outpatient charges multiplied by the hospital cost-to-charge ratio (CCR).[14] We consider several additional outcomes as we decompose the full effects into mechanisms of reallocation across locations of care versus changes in underlying intensity of treatment. We discuss the details of these outcomes as they are introduced.

3.3 Independent Variables

Since the same patient will not (on average) have several elective operations in a given year, it is infeasible to estimate Equation 2 with patient-specific fixed effects using the standard within-estimator. We instead specify α_i as a flexible function of total utilization for patient i in years prior to time t. Specifically, we sum all inpatient and institutional outpatient claims and Medicare payments for each patient in all years before t, calculate (separately) the quartiles for each of these two variables, and form six indicator variables for whether the patient falls in the 2nd, 3rd, or 4th quartile of each variable.[15] α_i denotes the vector of all such indicator variables.

[13]Among all outpatient procedures with an observed operating physician and organization NPI in the claims, approximately 40% (nearly 73mm procedures) are also matched to a hospital NPI. The remaining outpatient procedures are performed in centers that do not share a common NPI with an inpatient hospital.

[14]Since our analysis is based on Medicare claims, we use the Medicare-specific CCR for each hospital, which are available as part of the inpatient PPS final rule impact files. Guidance from the Research Data Assistance Center (ResDAC), which is a CMS contractor that provides assistance for researchers using CMS data, further suggests that hospital CCRs can also be applied to hospital outpatient services. See ResDAC presentation available at http://resdac.umn.edu/sites/resdac.umn.edu

[15]In calculating total Medicare payments or claims, we make no restrictions on the type of procedures and include all observed inpatient and outpatient claims for each patient. This reflects substantially more observations per patient for two reasons: 1) inpatient stays are not restricted to be planned and elective procedures; and 2)

We also include in the first-stage regression a set of dummy variables for each unique diagnosis code across inpatient stays for a given patient. We focus on diagnosis codes for inpatient stays because these are validated by CMS, while diagnosis codes listed on the outpatient claims are not validated. There are over 10,000 possible ICD-9 diagnosis codes. We therefore collapse these codes into 18 different disease categories (e.g., ICD-9 codes in the range of 390-459 reflect diseases of the circulatory system) plus an additional dummy for missing codes.[16] We further limit our collection of diagnosis codes to the first 5 ICD-9 diagnosis codes listed on any given claim. As an example, consider a patient with two inpatient stays in the year. In her first stay, she is indicated with an ICD-9 diagnosis code of 715.15 (osteoarthrosis, hip), a diagnosis of 401.9 (hypertension, unspecified), and a diagnosis of 531 (gastric ulcer). In her second stay, she is indicated with these same three diagnosis codes as well as 487 (influenza). All four diagnosis codes would then be grouped based on disease categories and included as dummy variables in a first-stage regression of total utilization.

In our second-stage estimation of Equation 3, we include in z_{jkt} the following physician and hospital characteristics: 1) physician practice characteristics, such as practice size, an indicator for an independent versus group practice, an indicator for whether the practice is single or multi-specialty, an indicator for whether this is a surgical practice, the average experience among physicians in the practice, and the percentage of female physicians in the practice; 2) hospital characteristics, including the number of full-time equivalent (FTE) nurses, the number of FTE physicians,[17] the number of FTE residents, the number of FTE other medical staff, the number of FTE non-medical staff, and indicators for whether the hospital is part of a larger system, for-profit versus not-for-profit ownership, and designation as a major teaching hospital; and 3) an indicator for whether physician practice j is owned by hospital k (or the system to which hospital k is a member). We also include a set of county characteristics that capture the county's distribution of age, income, gender, education, and race, as well as indicators for whether the county hospital market is a monopoly, duopoly, or triopoly.

outpatient visits are not restricted to have a physician and hospital NPI that matches a pair in the (elective) inpatient data.

[16] Details of the disease categories are presented in the supplemental appendix.

[17] We include the number of FTE physicians as an independent variable under the assumption that most of these physicians are part of hospital-based physician practices rather than office-based physician practices as reflected in the SK&A data.

3.4 Descriptive Statistics

Descriptive statistics of our physician-hospital variables are provided in Table 1. Our final data are based on 48 patients per physician-hospital pair per year on average. These patients account for just over 15 inpatient stays for each physician-hospital pair and 53 outpatient procedures. Recall that these inpatient stays reflect planned and elective procedures that were initiated by a physician, insurer, or clinic. As such, these counts do not reflect the total number of operations performed by a given physician in each year. Nonetheless, the descriptive statistics in Table 1 show that the number of elective procedures per physician/hospital pair is relatively stable over time.

The inpatient and outpatient share variables in Table 1 show the average share of each physician's operations performed at a given hospital, where we see that the average share of a physician's inpatient operations going to a given hospital has increased from 69% in 2008 to 74% in 2015 based on planned & elective operations studied in our data. In other words, an average physician operates 74% of the time in one hospital in 2015 compared to 69% in 2008. We see a similar increase in the share of outpatient procedures, from 73% in 2008 to 77% by 2015.

Relatedly, we see an increase in the percentage of physician-hospital pairs for which the physician practice is owned by the hospital or hospital system, with just 13% of all such pairs in 2008 up to 33% in 2015. These summary statistics in Table 1 also suggest a large degree of physician affiliation even in the absence of formal vertical integration. For example, while the percentage of physician-hospital pairs that are vertically integrated nearly tripled from 2008 to 2015, the average share of a physician's operations performed at a given hospital (row 1 of Table 1) exceeds 70% in most years.

Tables 2–3 present descriptive statistics for individual physicians and hospitals, respectively. From Table 2, our final data consist of just over 21 total inpatient operations per physician per year and 69 total outpatient procedures. Also from Table 2, we see that around 15% of physicians in our data were integrated with a hospital or hospital system in 2008 compared to nearly 38% in 2015. Recall that integration is defined at the hospital system and practice level, so that physicians can operate at multiple hospitals within the same system that owns their practice. Physicians may also (and do) operate at hospitals outside of the system that owns their practice, such that the percentage of integrated physician-hospital pairs in Table 1 should be slightly lower than the percentage of integrated physicians in Table 2.

Table 3 describes the average hospital at which physicians operate in our claims data (with the sample restrictions discussed previously). From Table 3, our final data consist of 265 planned and elective inpatient stays per hospital and 858 outpatient procedures. The hospitals in our final sample have an average of 197 staffed beds. The percentage of hospitals that are designated as for-profit has increased slightly from 18.6% in 2008 to 21.5% in 2015, as has the percentage of hospitals reporting membership in a larger hospital system (from 58% in 2008 to 68% in 2015). Similarly, the percentage of hospitals that are identified as owning at least one physician practice (or hospitals affiliated with a larger system that owns a practice) has increased from 39% in 2008 to 63% in 2015.

3.5 Preliminary Evidence

Recall that our ultimate goal is to relate physician-hospital integration (as measured by hospital ownership of the practice) specifically to within-physician variation in care. Achieving this goal requires that our analysis adjust for some measure(s) of patient preference, which helps to motivate the two-stage approach presented in Section 2. Before proceeding to that analysis, a natural first question is whether there exists *any* meaningful variation in health care utilization across vertically integrated and non-vertically integrated physician-hospital pairs.

Initial evidence of such variation is presented in Figure 1 which plots total Medicare payments for a given physician-hospital pair, adjusted for observable physician and hospital characteristics as well as physician, hospital, and year fixed effects. Specifically, Figure 1 presents the residual from the regression:

$$y_{jkt} = \beta x_{jt} + \delta z_{kt} + \lambda_k + \lambda_j + \lambda_t + \varepsilon_{jkt},$$

where y_{jkt} denotes total Medicare payments provided by physician j at hospital k in year t; x_{jt} denotes physician practice characteristics; z_{kt} denotes hospital characteristics; and fixed effects for physician, hospital, and year are denoted by λ_j, λ_k, and λ_t, respectively. We present the mean residual among physician-hospital pairs that are vertically integrated (the dashed line) versus those that are not vertically integrated (the solid line) in any given year. As indicated in the figure, the first year for which we observe a potential change in vertical integration status is 2011 since any effects of integration prior to 2011 would be absorbed by the physician fixed effect.

As is evident from Figure 1, we see a sharp increase in total Medicare payments when a given physician-hospital becomes vertically integrated; however, this increase could be driven by several factors, including an increase in the total number of a physician's patients, a change in the profile of a physician's patients (e.g., those with higher demand for health care), reallocation of patients across hospitals, or a change in treatment intensity for observationally equivalent patients. We also see some decrease in spending among non-integrated physician-hospital pairs, although smaller in magnitude than the observed increase for integrated pairs. Such an observed reduction in spending is consistent with some reallocation of patients across hospitals. In the remainder of the paper, we attempt to isolate the observed increase in health care utilization and expenditure among these different components.

4 Estimates of Overall Effects per Patient

We begin by estimating the effect of vertical integration (per patient) for an average physician-hospital pair. This analysis adjusts for measures of patient preferences and other observable patient characteristics, therefore removing from Figure 1 the variation driven by changes in the total number of a physician's patients or changes in the profile of a physician's patients (including potential upcoding). As discussed in Section 2, we employ a two-stage estimator that intuitively mimics the estimation of a physician-hospital match value and ultimately the effect of vertical integration on this match value.

4.1 Within-physician Variation across Hospitals

Coefficient estimates from the first-stage estimation of Equation 2 are presented in the supplemental appendix. Here, we instead focus on the variation in our estimates of Γ_{jk}, which provides an interesting examination into the scope of within-physician variation across hospitals. This also provides some estimate of the potential agency exploitation opportunities from the hospital's perspective and serves as a reasonableness check of our second-stage estimates on the effect of physician-hospital integration.

We have in mind the following thought experiment. By how much would expenditures decrease if the same patient was treated by the same physician at the hospital for which average spending is lowest for that physician? In many ways, this thought experiment is akin to standard examinations of variation in health care utilization. Our contribution here is in the dimensions by which we quantify variation. Specifically, we are not simply comparing charges or costs for the same surgery across hospitals, but are instead measuring potential savings from *within-physician* variation across hospitals. Note that the same physician will not generally pursue completely different operations or completely different patient populations at different hospitals. As such, variation in patient mix is less of a concern here since all calculations are within the same physician. Our estimates are also adjusted for patient characteristics and diagnoses as discussed in Section 2.[18]

More formally, denote by $\hat{y}_{ijk}$ the predicted utilization for patient i, physician j, and hospital k. This prediction is available directly from our first-stage results, $\hat{y}_{ijk} = \hat{\alpha}_i + x_i\hat{\beta} + \hat{\Gamma}_{jk}$. We then need an estimate of y_{ijk} under the counterfactual of these procedures being performed at a different hospital k' but with the same physician j. Our estimate of this counterfactual is $\hat{y}_{ijk'} = \hat{\alpha}_i + x_i\hat{\beta} + \hat{\Gamma}_{jk'}$, and we are interested in the specific counterfactual hospital for which expenditures are lowest for a given physician j. Denoting this hospital as $\underline{\mathrm{k}}$, our estimated counterfactual for physician j is $\hat{y}_{ij\underline{\mathrm{k}}} = \hat{\alpha}_i + x_i\hat{\beta} + \min\left\{\hat{\Gamma}_{j1}, ..., \hat{\Gamma}_{jK}\right\}$, where $\min\left\{\hat{\Gamma}_{j1}, ..., \hat{\Gamma}_{jK}\right\}$ captures the minimum physician-hospital fixed effect for a given physician j. Finally, we take the difference in the predictions as our estimate of maximum feasible within-physician variation in utilization:

$$\begin{aligned} \Delta_k y_{ij} &= \hat{y}_{ijk} - \hat{y}_{ij\underline{\mathrm{k}}} \\ &= \hat{\alpha}_i + x_i\hat{\beta} + \hat{\Gamma}_{jk} - \hat{\alpha}_i - x_i\hat{\beta} - \min\left\{\hat{\Gamma}_{j1}, ..., \hat{\Gamma}_{jK}\right\} \\ &= \hat{\Gamma}_{jk} - \min\left\{\hat{\Gamma}_{j1}, ..., \hat{\Gamma}_{jK}\right\}. \end{aligned} \tag{4}$$

We sum $\Delta_k y_{ij}$ across all procedures for physician j in year t. This yields a measure of total within-physician variation for each physician. Figure 2 presents the inter-quartile range and mean of the resulting totals across physicians (in 2008 dollars), focusing on total hospital costs and total Medicare payments. We restrict the calculations only to physicians that operated at least 5 times at two different hospitals in a given year. Since we are not interested in statistical inference based on these fixed effects, we make no adjustments for the standard errors of the estimated effects and instead focus only on the point estimates.[19]

[18]In the supplemental appendix, we present results specifically for orthopedic procedures, which are the most common elective procedures in our data. This helps to address concerns that patient profiles or types of procedures may differ across hospitals for the same physician.

[19]As in any fixed effects analysis, the point estimates of the fixed effects are noisily estimated and potentially susceptible to outliers and small numbers of observations for a given physician-hospital pair. In the supplemental appendix, we present alternative figures that apply an Empirical Bayes shrinkage estimator as in Sacarny (2018) and Chandra *et al.* (2016), as well as simply limiting the sample to physician-hospital pairs with sufficient numbers of observations. These alternative figures are similar to those of Figure 2.

The "physician cost differential" presented in the top panel of Figure 2 reflects our measure of within-physician variation in total costs (in \$1,000s). The line in 2008 is interpreted as follows: there are potential cost savings of between \$25,000 (25th percentile) and \$170,000 (75th percentile) per physician if every physician operated at the hospital for which costs are lowest (i.e., if we replaced the observed physician-hospital costs with the minimum physician-hospital costs, conditional on patient characteristics and diagnoses). The mean savings in 2008 was about \$150,000 per physician. As is evident from the top panel of Figure 2, the within-physician variation is heavily right-skewed and slightly increasing over time. The bottom panel of Figure 2 depicts the potential savings in Medicare payments. Similar to our analysis of hospital costs, we see increasing potential savings over time. Specifically, we estimate a mean potential savings in Medicare payments of about \$90,000 per physician in 2008 and about \$140,000 in 2015.

In general, our estimates reveal significant variation in Medicare payments and hospital costs across the different hospitals in which a physician operates, after adjusting for a large set of patient diagnoses and other observable characteristics. Quantifying the extent of variation also helps to bound the possible savings or additional costs that are to be expected from increased physician-hospital integration. For example, Figure 2 shows that the mean potential savings from within-physician variation in Medicare payments was about \$140,000 per physician in 2015. This should be interpreted relative to the total Medicare payments per physician of about \$448,000 in 2015 (see Table 2). Taking the ratio of these figures suggests that over 30% of per-physician Medicare payments can be explained by within-physician variation across hospitals. Given such variation, a natural question is whether some part of this variation is systematic and driven by observable physician and hospital characteristics. We turn to this question in the next subsection.

4.2 Effects of Vertical Integration on Match Values

We now present results from our second stage estimates of Equation 3. Recall that the estimated physician-hospital fixed effect in the first stage, $\hat{\Gamma}_{jk}$, is our dependent variable in these regressions, and our independent variables consist of a physician fixed effect, a hospital fixed effect, a time (year) fixed effect, and a set of practice and hospital characteristics.[20] We denote the practice and hospital characteristics by the vector z_{jkt} in Equation 3, the individual components of which are enumerated in Section 3. Our primary independent variable of interest is an indicator for whether

[20]Results are slightly larger in magnitude if we include joint hospital-year fixed effects.

physician j's practice is owned by hospital k or the larger system to which hospital k is a member.

We present initial results from a generalized within-estimator as described in Correia (2016) and implemented in Correia (2017), which is a refinement of the techniques in Guimaraes *et al.* (2010) and Gaure (2013). These results are summarized in Table 4, with estimated effects on total Medicare payments and hospital costs in columns 1 and 2, respectively. Estimates on the total count of inpatient and outpatient stays per patient are presented in column 3. Standard errors in all cases are clustered by physician.

Table 4 reveals a positive and significant effect on total Medicare payments, hospital costs, and inpatient and outpatient visits when physicians are vertically integrated with a hospital system. Since these effects represent changes in outcomes per patient, these magnitudes are economically meaningful. For example, an increase in Medicare payments of $75 per patient per year, with about 55 patients per integrated physician-hospital pair and 13,250 vertically integrated physician-hospital pairs each year, amounts to a total increase of nearly $55mm in Medicare payments per year. Similarly, we estimate a total increase in hospital costs of about $96mm per year and an increase in the number of inpatient and outpatient visits of 0.014 per patient (or 10,202 total visits). We interpret these estimates as a change in expenditures driven by physician and hospital incentives (i.e., not driven by underlying patient preferences).[21] A natural argument against this interpretation is that vertically integrated physician-hospitals may attract high utilization patients. We test this directly in Section 6 and find no such evidence of patient selection.

In the supplemental appendix, we also consider a simple falsification test based on outcomes that should not be affected by any physician-hospital interaction. Specifically, the Medicare prospective payment system is such that there is very little that a physician or hospital can do to influence hospital payments conditional on a given inpatient stay. Similarly, conditional on patient characteristics and DRG codes, there should be no change in the average DRG weight for the same physician-hospital pair. We therefore consider average Medicare payments and DRG weights per inpatient stay as two potential outcomes for which there should be no effect of physician-hospital vertical integration. As expected, we estimate economically small and statistically insignificant effects on these other outcomes. Also in the supplemental appendix, we re-estimate results in Table 4 with a balanced panel of physicians, with qualitatively similar findings and slightly larger

[21] One potential issue related to the interpretation of these effects concerns how an employed physician bill is incorporated into the hospital claims. Through discussions with the CMS Research Assistance Data Center (ResDAC), we understand that the hospital claims should not include payments for physician services. Such services should instead appear almost exclusively in the carrier claims files both before and after a practice is acquired.

coefficient magnitudes.

4.2.1 Event Study

Our identification strategy is similar but not identical to a two-way fixed effects estimator with time-varying treatment. We are therefore concerned about differential trends and potential selection into treatment. We are also concerned about the interpretation of our estimates in the presence of potentially heterogeneous treatment effects. As described in Goodman-Bacon (2018), the coefficient estimate on a treatment dummy in two-way fixed effects estimator can be written as a weighted average of all possible 2×2 difference-in-differences (DD) estimates. The weights, however, need not be positive, and the presence of negative weights may yield an uninterpretable coefficient estimate. An event study can then help to remove variation in the timing of treatment across the treatment groups and restore a more interpretable estimate. If estimates from such an event study are comparable to our full-sample estimates in Table 4, then we have some confidence in the interpretability of our full-sample estimates.

We therefore consider an event study in which the treated group is defined as any physician-hospital pair that becomes vertically integrated in 2011, and our control group consists of all physician-hospital pairs that are not vertically integrated at any point over our time period.[22] We form an indicator variable for treated practices and interact this indicator variable with year dummies. We exclude the 2010 interaction term so that all estimates are interpreted relative to 2010. The result, as depicted in Figure 3, is a separate estimated effect in each year before and after treatment.

The top panel in Figure 3 presents event study results for total Medicare payments, and the bottom panel presents results for total hospital costs. Focusing on Medicare payments, we estimate insignificant effects on the treatment dummies in the pre-treatment period, broadly consistent with a common trends assumption. We also estimate progressively larger effects in each year after the treatment period, with estimates of around a \$200 increase in Medicare payments for vertically integrated practices in 2014 and 2015. This pattern of results is consistent with a gradual effect of hospital relationships on physician behaviors. The results for total hospital costs reveal a similar pattern to those of Medicare payments in that we estimate an increasingly positive effect on costs

[22] While 2010 marks the beginning of a period of significant change in the U.S. health care system, this is the best treatment group for purposes of an event study in our case given the delayed effect of vertical integration estimated in our data. For completeness, we nonetheless present alternative event studies based on the 2013 treatment group in the supplemental appendix.

in the years after treatment with no evidence of differential pre-trends before physician practices are acquired. Specifically, we estimate that average per-patient costs increase by over \$350 per year in 2013–2015 among physician practices that are vertically integrated with a hospital system.

4.2.2 Multi-hospital Physicians

Our main effects of interest are identified off of two primary sources of variation: 1) variation across hospitals for the same physician; and 2) variation for the same physician-hospital pair over time. The latter is a common source of identifying variation in fixed effects models but does not alleviate bias due to time-varying unobserved factors associated with both physician-hospital integration and physician treatment decisions. The event study results in Section 4.2.1 partially address this concern by focusing on a specific treatment group and investigating potential deviations in pre-trends before a physician practice is purchased. To further address this concern, we consider an alternative specification intended to isolate within-physician variation across hospitals. Our strategy is to focus specifically on physicians that operate in both integrated and non-integrated hospitals in the same year. Among this group of physicians, we can separately identify an overall effect of vertical integration as well as the interaction effect of being vertically integrated with a given hospital.

We therefore re-estimate Equation 3 among the subsample of physicians that either: 1) operate (in the same year) in at least one hospital for which they are vertically integrated and another hospital for which they are not vertically integrated (about 7% of physicians on average in a given year); or 2) are never vertically integrated with a hospital system. In addition to the sample restrictions, we also include in Equation 3 an indicator for whether physician j is integrated with any hospital in that year, as well as an indicator for whether physician j is integrated specifically with hospital k. Coefficients on these indicators are separately identified since the treated (i.e., integrated) group consists only of physicians that operate across different hospital types (integrated and non-integrated) in the same year at some point from 2008 through 2015. Our specification is otherwise identical to that of our initial results.

We summarize the results in Table 5. The first row presents estimates on the effect of integration with a specific hospital k, and the second row presents the estimated effect of integration overall (across all hospitals in which the physician might operate). Analogous to our initial results in Table 4, we present results for total Medicare payments per patient in column 1, total hospital costs per patient in column 2, and total inpatient and outpatient stays per patient in column 3.

We estimate that integration leads to an increase of approximately $185 in Medicare payments per patient specifically at the integrated hospital. The point estimate of any integration is small and imprecisely estimated. This implies that the effects of integration on Medicare payments are isolated predominantly among the hospitals that acquire the physician practice. Our results on the number of inpatient and outpatient stays (column 3) mirror those of Medicare payments. Estimates on hospital costs follow a different pattern, where we estimate large and statistically significant effects from any integration but little additional effect specifically at the acquiring hospital.

The pattern of results in Table 5 is consistent with two underlying mechanisms. First, hospitals may play a larger role in determining the total number of procedures or total amount of billable physician services for the same patient. Second, physicians may play a larger role in determining the underlying resources used within a given procedure or inpatient stay. These mechanisms would combine such that any change driven by the physician will affect all hospitals equally while changes driven by the hospital would only affect the hospital that acquired the physician practice, which would explain the concentration of increases in Medicare payments to the acquiring hospital alongside an increase in hospital costs borne by both acquiring and non-acquiring hospitals. Our unconditional quantile regression results in the subsequent subsection reveal a similar pattern.

4.2.3 Heterogeneous Effects

Our final sample underlying Table 4 is limited to surgeons that operate in relatively large, general acute care hospitals; however, there remain several dimensions by which physician practices and hospitals in our sample may differ. In this section, we examine potential heterogeneities in estimated effects along the distribution of our outcomes of interest.[23]

Specifically, we estimate unconditional quantile regressions using the same empirical specification as in Equation 3 (Firpo *et al.*, 2009; Borgen, 2016). We present results in Figure 4, with results for Medicare spending in the top panel, results for hospital costs in the middle panel, and results for number of procedures in the bottom panel. Recall that all outcomes are measured as averages per patient for a given physician-hospital pair. Each panel in Figure 4 therefore reflects the estimated point estimate and 95% confidence interval of physician-hospital integration on the

[23]We also consider heterogeneities by disease categories. By construction, this analysis is limited to the inpatient level only, similar to the results in Table 8. The results are presented in the supplemental appendix, where we find increases in inpatient hospital costs among orthopedic and circulatory patients, and particularly large effects for DRGs related to the urinary system.

outcome of interest at the relevant quantile.

The pattern of results in Figure 4 shows that the largest effects on average Medicare spending and number of procedures arise for physician-hospital pairs with relatively low spending/utilization. Conversely, we estimate small and insignificant effects for Medicare payments among the highest spending physician-hospital pairs. This pattern of results therefore suggests that the largest opportunity for additional Medicare spending and utilization comes from physician-hospital pairs that are relatively low users at baseline. We also see little variation in estimated effects on hospital costs.

4.2.4 Instrumental Variables

Our event study is consistent with a parallel trends assumption; however, there are inherent limitations in the length of our pre-period for the 2011 treatment group. Moreover, as shown in the supplemental appendix, there is evidence of differential trends among the 2013 treatment group relative to physicians that are never integrated. We therefore pursue an instrumental variables (IV) estimator to further assess the potential role of endogenous integration. We employ as an instrument the predicted probability of vertical integration for each physician-hospital pair.

In generating our instrument, we first form the set of all possible physician-hospital pairs. We define this set, separately for each physician, as all hospitals to which a physician is observed to have operated throughout our panel. Next, we form the predicted probability of acquisition based on a logistic regression of the equation:

$$I_{jkt} = \lambda_1 z_{jkt} + \lambda_2 d_{jk,t-1} + \lambda_3 z_{jkt} \times d_{jk,t-1} + \omega_{jkt}, \tag{5}$$

where I_{jkt} denotes an indicator for whether physician j is vertically integrated with hospital k at time t; z_{jkt} denotes a vector of practice and hospital characteristics, including practice size, average experience among physicians in the practice, number of staffed hospital beds, for-profit ownership of the hospital, teaching status, and hospital system membership; and $d_{jk,t-1}$ denotes the average differential distance of the patients of physician j between a given hospital k and the nearest hospital in the choice set (measured at time $t-1$).[24] For example, assume that patient i lives 5 miles from Hospital A, 10 miles from Hospital B, and 12 miles from Hospital C. Further assume

[24]We refer to "patients of j" simply as all patients for whom physician j is the operating physician. We make no attempt to assign patients to specific practices or physicians based on patterns of care over time.

that physician j is observed to have operated at Hospital A and Hospital C over our panel. Patient i's differential distance for Hospital A is then 0 miles, and their differential distance for Hospital C is 7 miles. We then average this differential distance across patients for each physician-hospital pair in the prior year. The result is a lagged average distance of physician j's patients between hospital k and the nearest hospital in that patient's choice set. The intuition for our differential distance instrument is that physicians are less likely to vertically integrate with a hospital if their patients live sufficiently far from that hospital relative to the patient's nearest hospital.

With estimates of λ, we denote the predicted probability of physician j being vertically integrated with hospital k as $\hat{I}_{jkt}$. We then employ $\hat{I}_{jkt}$, which we estimate separately in each year, as a generated instrument for the vertical integration indicator in Equation 3. Results from this regression are presented in Table 6.[25]

The mean of our generated instrument is 0.170 with a standard deviation of 0.195, and the first-stage results show a positive and significant effect of the generated instrument on vertical integration, with an estimated coefficient on the generated instrument of 0.347 and an F-stat of over 500. We also estimate a positive and statistically significant effect of the generated instrument in the standard "reduced-form".[26] Additional details of our generated instrument regressions are provided in the supplemental appendix. In general, the IV results in Table 6 show much larger estimates of the effects of vertical integration on total Medicare payments, total hospital costs, and the total number of inpatient and outpatient visits. Given the interpretation of our IV results as a local average treatment effect (LATE), the increase in magnitude relative to our prior estimates is somewhat expected. For example, some hospitals are particularly aggressive in their acquisition of physician practices. Such aggressive purchasing practices will inherently involve some practices that were otherwise not considering a hospital acquisition of their practice. Our IV and subsequent LATE captures the effect of acquisitions specifically among the subset of practices that are more likely to integrate due to the average profile of their patients. Collectively, our takeaway from these results is that any matching between physicians and hospitals based on time-varying unobserved

[25] In addition to $\hat{I}_{jkt}$ as an instrument, we also consider the physician's relative probability of integration, where we define "relative probability" as the ratio of the predicted probability to the maximum of all predictions for the same physician in a given year. Similarly, we consider the hospital's relative probability of integration, defined as the ratio of predicted probability to the maximum of all predictions for the same hospital in a year. We present results in Table 6 using only the predicted probability, $\hat{I}_{jkt}$, as our generated instrument. Results when including the relative probabilities does not qualitatively change our results. Results are also unchanged when using the lagged prediction as an instrument rather than the concurrent prediction.

[26] We find a point estimate of 337 with a p-value of 0.036 in the reduced-form regression of Medicare payments on the instrument and all other covariates.

variables is likely to attenuate our estimates in Table 4.

5 Isolating Effects on Treatment Intensity

The results in Section 4.2 reflect changes in total expenditures and utilization per patient/physician/hospital/ye
This effect is composed of both a reallocation effect (i.e., directing the location of a patient's treatment toward the acquiring hospital) and a treatment intensity effect (i.e., treating patients differently upon integration). We want to distinguish between these two effects because a reallocation is simply a transfer of payments from one hospital to another. Such a transfer may increase Medicare payments to a given hospital, but may not change Medicare expenditures per patient. In this section, we attempt to isolate effects on the physician-hospital match value driven specifically by changes in treatment intensity.

We isolate the treatment intensity effect in two ways. First, note that any reallocation in our context must come from the same patient receiving care from the same physician at more than one location (in the absence of the acquisition of the practice). This is empirically rare regardless of the underlying physician/hospital relationship. For example, in the inpatient setting, fewer than 0.5% of patients underwent more than one procedure from the same physician at more than one location in the same year. Note also that our outpatient data are limited to procedures in which an operating physician NPI is listed in the claim. Such procedures cannot generally be substituted between physician clinics and outpatient facilities (as opposed to, for example, imaging). This means that any substitution between clinics and outpatient facilities should play little role in the estimates in Table 4.

Nonetheless, we re-estimate Equations 2 and 3 focusing specifically on patient-physician pairs whose procedures were isolated to a single hospital or outpatient facility in each year. Results are summarized in Table 7 and are almost identical in magnitude to our estimates based on the full sample in Table 4. This suggests that our initial estimates are not driven by reallocation of procedures (for the same patient) toward the acquiring hospital.

Second, we take advantage of the detailed information within a given inpatient stay and estimate effects on different components of the inpatient stay. Since we are focusing on the inpatient stay, our first-stage specifications (Equation 2) now include indicator variables for the primary DRG code as well as the first five ICD-9/10 codes and patient characteristics as discussed previously.

For our outcomes, we consider inpatient hospital costs and costs incurred across each of several different individual cost centers (e.g., medical supplies, operating room, anesthesia, radiology, laboratory, and MRI). We also consider the count of days in the ICU and number of distinct procedures within the inpatient stay. In this analysis, we hypothesize that increases in hospital costs (if due to hospital influence) should come from potentially billable physician services for which the hospital may be the residual claimant after purchasing the physician practice. Such a mechanism should intuitively be captured by the count of individual surgical procedures coded in the inpatient claims. Results based on these additional outcomes are summarized in Table 8.

Results in Table 8 are consistent with our hypothesis, where we estimate a positive and statistically significant increase of 0.030 procedures per inpatient stay among vertically integrated physicians and hospitals, along with an increase in hospital costs of about $180 per inpatient stay. Since these estimates are calculated per inpatient stay, the results provide additional evidence of an underlying change in treatment intensity when physicians become integrated with hospitals.

There are two additional mechanisms that may be thought to explain our results. First, our estimated increase in procedure counts within an inpatient stay may simply reflect more complete coding among vertically integrated physician-hospital pairs; however, if this were true, it would imply that physicians and hospitals are performing the same procedures as before integration and are now better documenting those procedures. Since we also estimate an increase in hospital costs per inpatient stay, we conclude that changes in procedure counts reflect (at least in-part) an underlying change in the number of procedures and are not due entirely to improved documentation.

Second, it may be that vertical integration improves quality of care, in which case added costs may ultimately confer some benefit to patients. To examine this possibility, we re-estimate our two-stage model using 30/60/90-day mortality as our first-stage outcomes. Results are summarized in the supplemental appendix, where we find no evidence that vertical integration improves mortality rates for the same physician-hospital pairs. Improvements in quality therefore do not appear to explain our estimated cost increases.

6 Reallocation of Patients across Hospitals

The preceding analysis speaks to the per-patient effects on risk-adjusted outcomes for a vertically integrated physician-hospital pair; however, there are other margins by which hospitals may seek to influence physician behaviors that may change the underlying risk profile of patients or are otherwise not defined on a per-patient basis. For example, hospitals may seek to increase the number of a physician's operations or attempt to influence the types of patients on which a given physician operates. We examine this potential behavior with a series of additional outcomes, with results summarized in Table 9.

The specification underlying the estimates in Table 9 is identical to that in Equation 3, but we replace the estimated dependent variable with other measures directly observed for each physician-hospital pair in each year. The outcomes in columns 1 and 2 are the physician's share of inpatient and outpatient procedures going to a given hospital. For example, assume a physician performed 15 elective operations (in an inpatient setting) at hospital A and 5 at hospital B, then the inpatient share would be 75% for hospital A and 25% for hospital B. An analogous measure calculated based on outpatient procedures constitutes the outcome in column 2. Results in columns 3-5 reflect estimates on the count of inpatient stays or institutional outpatient visits rather than the share.

The estimates on the vertical integration indicator show that physicians increase their share of elective inpatient operations going to the acquiring hospital by 8 percentage points, with a similar increase of 6 percentage points among outpatient procedures. These increases are driven by a small increase in the number of inpatient stays (approximately 1 additional operation at the acquiring hospital on average) and a large number of outpatient procedures (10 additional procedures on average). This also suggests a reallocation of procedures toward the outpatient setting. For example, physicians on average operate on 3 patients in an outpatient setting to every 1 patient in the inpatient setting (for the same hospital). When a physician practice is acquired by a hospital, however, the additional procedures going to the acquiring hospital are disproportionately performed in an outpatient setting (10 additional outpatient procedures for each inpatient procedure).

Finally, columns 6 and 7 of Table 9 show the estimated effects on the severity of patients treated by a given physician-hospital pair. Drawing from Dranove *et al.* (2003), we measure patient severity as the patient's total claims (column 6) and total Medicare expenditures (column 7) in the year prior to a given inpatient stay. This analysis therefore focuses on patients ultimately admitted to the hospital in a given year. We then calculate the average severity per patient (for each physician-hospital pair) and take this as our dependent variable of interest. In terms of

Medicare expenditures, the sign of the estimates is consistent with decreasing severity of patients for integrated physician-hospital pairs; however, the effects are imprecisely estimated and relatively small in magnitude. We therefore do not find significant evidence that physicians and hospitals are able to meaningfully adjust the severity of their patients upon becoming vertically integrated.

7 Discussion

By vertically integrating with physician practices, hospitals and physicians become more financially integrated and effectively share in the profits from inpatient and outpatient procedures. Compared to an independent or group practice not otherwise owned by a hospital system, vertical integration introduces potential pressure from the hospital system for a physician to change their treatment patterns in some way. Some of these pressures may be purely cost reducing, such as adopting a standard medical device across physicians for given procedures (Craig *et al.*, 2018); however, other pressures may increase treatment intensity or reallocate care to different settings. The net effect is therefore an empirical question.

In this paper, we use the population of Medicare FFS inpatient and institutional outpatient claims to form a comprehensive panel of physician-hospital pairs from 2008 through 2015, and we exploit within-physician variation across hospitals (both cross-sectionally and over time) to quantify hospital influence on physician behaviors. We focus in particular on vertical integration between physicians and hospitals, as this is a natural mechanism by which hospitals may gain some influence on a physician practice.

We estimate relatively large and significant positive effects of vertical integration on physician treatment intensity. Due to heterogeneities in pre-treatment trends for some treatment groups, as well as the introduction of several policy changes toward the end of our time period, we believe that our most compelling estimates are from the 2011 treatment group and subsequent event study in Section 4.2.1, as well as our alternative analysis in Section 4.2.2 that separately identifies effects within the acquiring hospital versus other hospitals for which a physician is not integrated. Each of these alternative analyses suggest an increase of around \$200 in Medicare payments per patient per year for vertically integrated physician-hospitals. Combined with our initial estimates, we find that between 4% and 10% of total estimated within-physician variation in Medicare payments can be explained by the physician's relationship with a hospital. Extrapolating our results to all patients in our final data, we estimate a total increase in hospital costs of between \$95mm and \$255mm per year and an increase in Medicare payments of between \$55mm and \$146mm per year. With a variety of additional outcomes and different patient populations, we find that these effects are almost entirely driven by changes in treatment intensity rather than reallocation across hospitals.

Looking directly at short-term mortality outcomes, we find no evidence of an improvement in quality of care. More generally, we argue that it is unlikely that the increased flow of elective services was a sufficient benefit to Medicare patients in order to justify the additional expenditures. Recall, prior to a hospital's acquisition of a practice, any additional physician fees from increased treatment intensity would go directly to the physician or their practice as additional revenue (i.e., physician fees and facility fees are paid separately for each service). Our findings therefore demonstrate that when the physician becomes the agent of the hospital system, their clinical decision-making becomes *less* conservative relative to treatment decisions made under their own private incentives (before aligning with a hospital). In this way, vertical integration appears to further distort physician treatment decisions. Our findings, alongside existing evidence on changes in treatment location and coding, therefore underscore the need for greater scrutiny of hospital-physician integration by federal regulators.

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Tables and Figures

Figure 1: Adjusted Total Medicare Expenditures between VI and non-VI Pairs

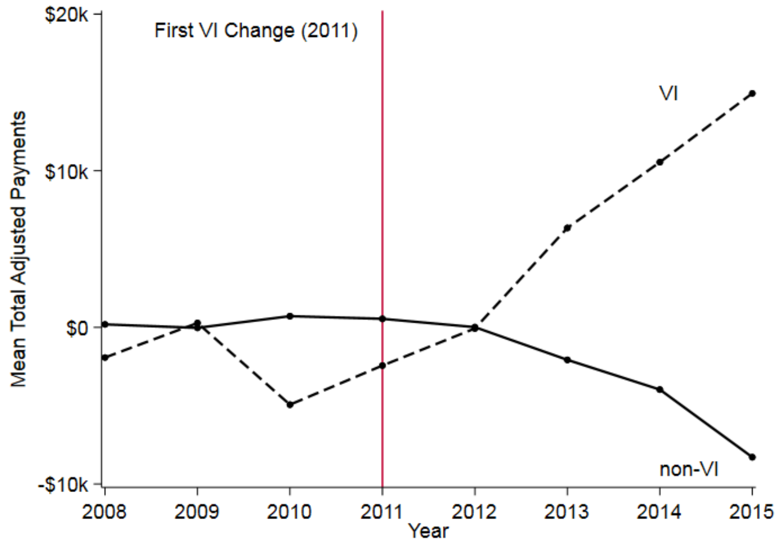

Figure 2: Total Potential Savings from Within-physician Variation

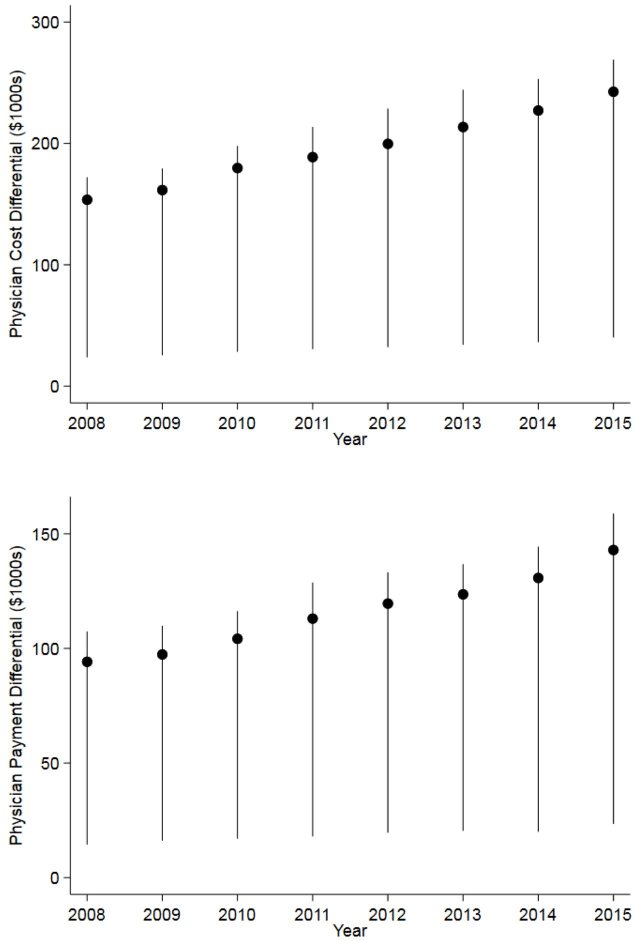

Figure 3: Event Study for Total Medicare Payments and Hospital Costs

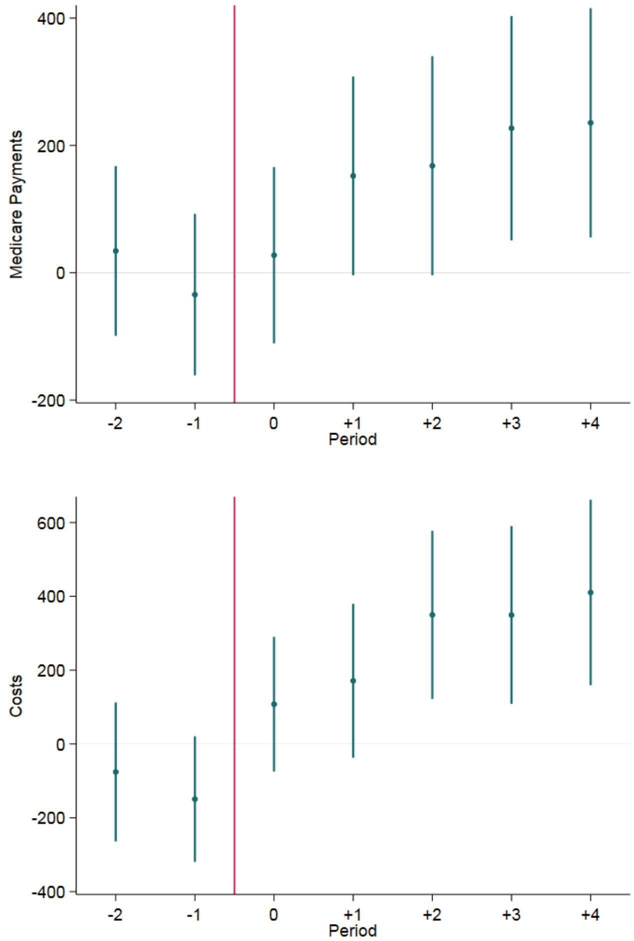

Figure 4: Unconditional Quantile Regression Results

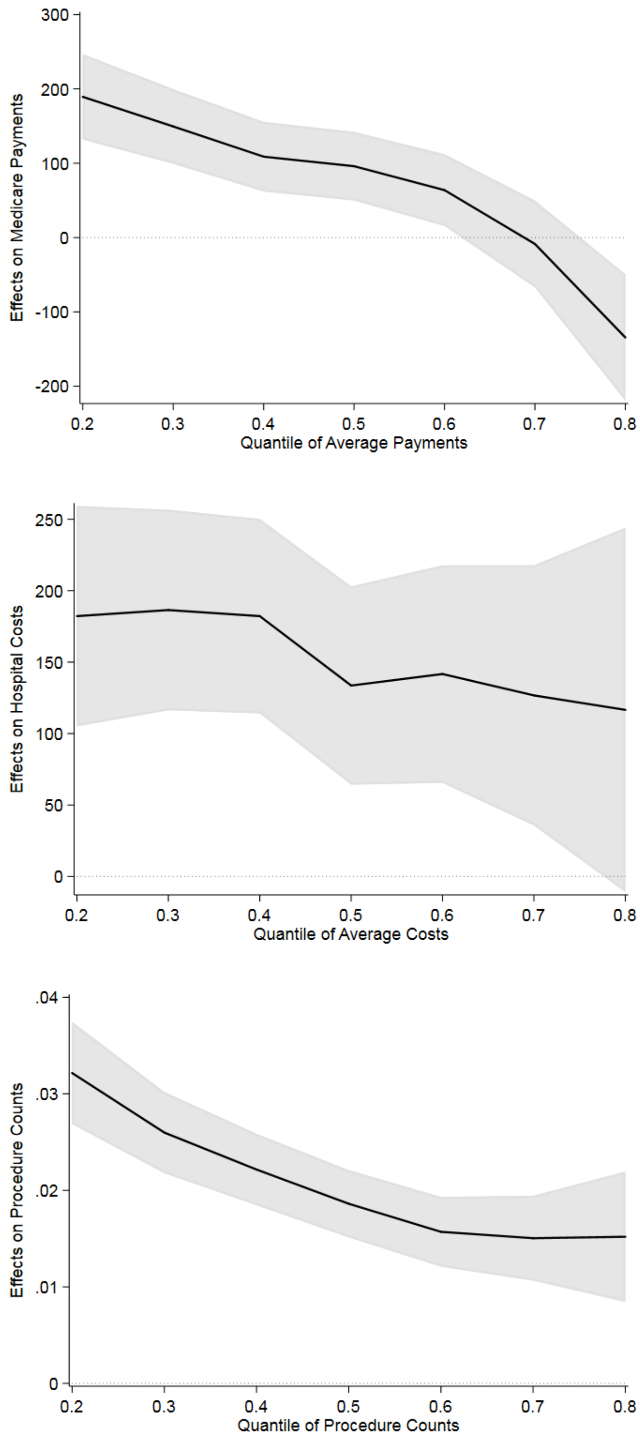

Table 1: **Descriptive Statistics for Physician-Hospital Variables**[a]

	2008	2009	2010	2011	2012	2013	2014	2015	Total
IP Share	0.690	0.704	0.707	0.712	0.716	0.723	0.730	0.737	0.713
	(0.364)	(0.361)	(0.359)	(0.357)	(0.356)	(0.354)	(0.351)	(0.350)	(0.357)
OP Share	0.732	0.740	0.742	0.745	0.747	0.752	0.758	0.766	0.747
	(0.352)	(0.349)	(0.348)	(0.347)	(0.347)	(0.345)	(0.342)	(0.338)	(0.347)
IP Procedures	15.56	15.25	14.99	14.92	14.97	15.37	15.57	16.35	15.34
	(22.87)	(22.55)	(22.61)	(22.42)	(22.81)	(23.81)	(24.33)	(25.63)	(23.30)
OP Procedures	49.33	50.17	51.92	53.02	54.25	55.90	56.05	58.31	53.35
	(102.7)	(104.1)	(106.5)	(110.1)	(114.0)	(116.5)	(112.8)	(119.6)	(110.5)
90-day Mortality	0.0644	0.0609	0.0636	0.0636	0.0623	0.0603	0.0593	0.0569	0.0617
	(0.149)	(0.144)	(0.149)	(0.149)	(0.147)	(0.145)	(0.143)	(0.145)	(0.147)
60-day Mortality	0.0528	0.0496	0.0517	0.0519	0.0505	0.0493	0.0483	0.0461	0.0502
	(0.134)	(0.129)	(0.134)	(0.134)	(0.132)	(0.131)	(0.129)	(0.131)	(0.132)
30-day Mortality	0.0377	0.0348	0.0364	0.0365	0.0356	0.0351	0.0342	0.0318	0.0354
	(0.113)	(0.107)	(0.112)	(0.112)	(0.110)	(0.110)	(0.107)	(0.108)	(0.110)
Total Payments[b]	6,367.7	6,790.5	6,928.1	7,113.1	7,301.9	7,644.3	8,021.9	8,234.8	7,238.4
	(5,454.5)	(5,812.8)	(5,956.2)	(6,111.3)	(6,385.4)	(6,562.7)	(6,658.9)	(6,822.7)	(6,219.2)
Total Costs[c]	8,384.5	8,863.6	9,340.2	9,779.2	10,168.8	10,600.5	11,029.3	11,466.5	9,851.9
	(6,822.1)	(7,220.4)	(7,614.9)	(7,868.5)	(8,165.1)	(8,410.1)	(8,754.5)	(8,935.2)	(7,994.5)
IP Costs[d]	13,655.2	14,502.8	15,389.1	16,193.0	16,958.0	17,711.2	18,366.9	19,100.8	16,306.4
	(7,751.8)	(8,241.9)	(8,821.9)	(9,066.0)	(9,407.1)	(9,612.3)	(9,997.2)	(10,321.2)	(9,276.8)
IP Length of Stay[e]	5.132	5.079	5.058	5.100	5.305	5.330	5.491	5.474	5.229
	(2.464)	(2.409)	(2.402)	(2.379)	(2.530)	(2.535)	(2.553)	(2.583)	(2.481)
OP Costs[f]	3002.0	3305.9	3501.9	3,662.0	3,801.0	4,012.9	4,185.8	4,362.5	3,690.6
	(2,140.3)	(2,395.7)	(2,605.2)	(2,704.0)	(2,791.8)	(2,939.1)	(3,107.5)	(3,230.5)	(2,762.1)
Vertical Integration	0.129	0.137	0.145	0.189	0.205	0.232	0.254	0.327	0.196
	(0.336)	(0.343)	(0.352)	(0.392)	(0.404)	(0.422)	(0.435)	(0.469)	(0.397)
N	73,985	72,363	73,030	70,041	67,187	62,079	57,526	53,918	530,129

[a]Standard deviations in parenthesis.

[b]Calculated as the average Medicare payments per-patient across physician-hospital pairs.

[c]Calculated as the average inpatient and outpatient costs per-patient across physician-hospital pairs.

[d]Calculated as the average inpatient costs per-patient across physician-hospital pairs. Patients without an inpatient stay are excluded.

[e]Calculated as the average inpatient length-of-stay per-patient across physician-hospital pairs.

[f]Calculated as the average outpatient costs per-patient across physician-hospital pairs. Patients without an outpatient stay are excluded.

Table 2: **Descriptive Statistics for Physicians**[a]

	2008	2009	2010	2011	2012	2013	2014	2015	Total
Patients	66.15	65.02	65.42	66.25	67.08	68.36	68.10	69.80	66.89
	(71.69)	(69.34)	(70.17)	(71.99)	(73.67)	(75.47)	(72.44)	(74.39)	(72.31)
IP Procedures	22.49	21.59	21.14	20.88	20.83	21.20	21.24	22.09	21.43
	(27.38)	(26.82)	(26.91)	(26.62)	(27.14)	(28.26)	(28.72)	(30.11)	(27.68)
OP Procedures	65.21	65.61	67.77	69.22	70.74	72.44	71.94	74.16	69.39
	(119.0)	(119.5)	(122.0)	(125.7)	(130.0)	(132.3)	(127.5)	(134.4)	(126.1)
Total Payments	329,723	345,838	354,637	365,641	378,018	404,385	424,874	447,088	377,925
	(398,832)	(414,645)	(427,755)	(433,679)	(451,874)	(483,031)	(501,015)	(526,734)	(454,375)
Practice Size	13.81	14.30	15.18	16.04	17.39	17.40	17.96	18.65	16.21
	(32.27)	(30.82)	(30.36)	(29.82)	(30.83)	(29.42)	(28.68)	(28.43)	(30.24)
Experience	22.55	22.45	22.29	23.32	23.00	23.93	23.65	24.76	23.16
	(6.498)	(6.469)	(6.490)	(6.743)	(6.704)	(6.953)	(6.901)	(6.999)	(6.748)
% Female	0.115	0.113	0.119	0.121	0.121	0.120	0.118	0.121	0.118
	(0.208)	(0.207)	(0.212)	(0.213)	(0.209)	(0.205)	(0.199)	(0.199)	(0.207)
% with PCP	0.0412	0.0388	0.0401	0.0409	0.0371	0.0315	0.0288	0.0273	0.0363
% Multi-specialty	0.249	0.252	0.259	0.235	0.248	0.266	0.284	0.344	0.264
% Surgery Center	0.452	0.464	0.458	0.497	0.500	0.506	0.507	0.452	0.479
% Independent	0.484	0.482	0.476	0.464	0.450	0.439	0.411	0.331	0.447
% Integrated	0.153	0.160	0.170	0.221	0.237	0.269	0.295	0.375	0.229
N	50,375	50,178	50,801	49,070	47,383	44,156	41,347	39,184	372,494

[a]Standard deviations in parenthesis.

Table 3: **Descriptive Statistics for Hospitals**[a]

	2008	2009	2010	2011	2012	2013	2014	2015	Total
IP Procedures	293.9	286.0	281.6	271.8	260.3	248.3	238.0	237.3	265.0
	(444.4)	(433.3)	(426.6)	(410.7)	(394.4)	(376.9)	(365.4)	(368.8)	(404.5)
OP Procedures	852.3	869.3	902.6	901.1	884.2	848.4	805.9	796.6	858.0
	(1545.0)	(1655.2)	(1706.6)	(1698.1)	(1684.9)	(1652.8)	(1576.2)	(1587.8)	(1639.8)
Physician FTE	24.26	24.76	26.00	27.94	28.53	30.99	31.65	32.80	28.33
	(99.19)	(103.4)	(104.3)	(107.8)	(109.6)	(120.1)	(119.7)	(118.9)	(110.6)
Resident FTE	25.70	25.85	26.01	27.73	28.38	29.11	30.57	30.75	27.99
	(108.1)	(109.8)	(111.9)	(115.0)	(120.3)	(121.4)	(125.6)	(127.3)	(117.5)
Nurse FTE	341.1	348.3	350.5	356.8	365.0	367.5	383.9	400.1	363.9
	(447.3)	(457.7)	(460.1)	(472.9)	(487.4)	(493.9)	(519.5)	(550.2)	(487.1)
Other FTE	751.2	747.1	741.4	755.3	761.5	758.2	774.4	801.1	761.0
	(978.4)	(973.0)	(964.8)	(1007.0)	(1031.7)	(1073.9)	(1100.8)	(1155.5)	(1036.9)
Beds	1.979	1.974	1.960	1.969	1.963	1.950	1.977	1.995	1.971
	(2.160)	(2.139)	(2.130)	(2.115)	(2.141)	(2.135)	(2.177)	(2.231)	(2.153)
% For-profit	0.186	0.196	0.201	0.205	0.210	0.211	0.213	0.215	0.205
% System	0.577	0.595	0.603	0.617	0.633	0.645	0.668	0.684	0.627
% Major Teaching	0.0758	0.0779	0.0755	0.0772	0.0707	0.0703	0.0675	0.0710	0.0733
% Integrated	0.389	0.391	0.407	0.447	0.463	0.486	0.533	0.625	0.467
N	3,854	3,787	3,814	3,769	3,791	3,770	3,691	3,648	30,124

[a] Standard deviations in parenthesis

Table 4: **Estimated Effects on Match Values**[a]

	Medicare Payments	Hospital Costs	IP & OP Stays
Integrated	76.176**	133.063***	0.014***
	(30.911)	(42.099)	(0.004)
Practice Characteristics			
Practice Size	-0.819	1.471*	0.000
	(0.584)	(0.777)	(0.000)
Average Experience	-6.412**	-5.972	-0.000
	(2.727)	(3.951)	(0.000)
% Female	-50.230	-133.946	0.011
	(91.770)	(131.180)	(0.014)
Adult PCP	104.173	171.541	-0.029
	(100.065)	(139.857)	(0.021)
Multi-specialty	12.173	-8.283	-0.031***
	(55.865)	(70.731)	(0.008)
Surgery Center	45.621	-31.319	-0.029***
	(62.936)	(80.304)	(0.008)
Independent	-1.575	29.879	0.007*
	(29.129)	(40.953)	(0.004)
Hospital Characteristics			
Physician FTE	0.119	0.017	-0.000***
	(0.086)	(0.099)	(0.000)
Resident FTE	-0.059	-0.373**	0.000
	(0.120)	(0.147)	(0.000)
Nurse FTE	0.008	0.030	-0.000
	(0.048)	(0.061)	(0.000)
Other FTE	0.043***	0.023	0.000
	(0.014)	(0.017)	(0.000)
N		477,423	

[a]Results from generalized within-estimator including physician, hospital, and year fixed effects. Standard errors are in parenthesis, clustered by physician. All regressions include county demographic variables (total population, age distribution, income distribution, and education) as well as dummies for whether the county hospital market is a monopoly, duopoly, or triopoly. We also include hospital bed size and indicators for whether the hospital is for-profit, part of a larger system, or a major teaching hospital. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Table 5: **Effects on Match Values with Multi-hospital Physicians**[a]

	Medicare Payments	Hospital Costs	IP & OP Stays
Integrated with Hospital k	185.041**	32.362	0.023**
	(79.809)	(109.502)	(0.010)
Integrated with Any Hospital	-18.611	390.161***	-0.014
	(103.835)	(147.166)	(0.011)
Practice Characteristics			
Practice Size	-0.842	0.536	-0.000
	(0.850)	(1.152)	(0.000)
Average Experience	-6.221*	-3.637	-0.000
	(3.308)	(4.858)	(0.001)
% Female	16.786	-81.493	0.013
	(110.575)	(160.154)	(0.018)
Adult PCP	172.496	174.617	-0.028
	(118.002)	(158.388)	(0.023)
Multi-specialty	102.354	25.258	-0.027***
	(72.026)	(92.810)	(0.010)
Surgery Center	162.277**	-11.145	-0.023**
	(80.137)	(102.588)	(0.010)
Independent	-15.542	58.144	0.002
	(35.993)	(53.413)	(0.004)
Hospital Characteristics			
Physician FTE	-0.170	-0.323*	-0.000***
	(0.149)	(0.181)	(0.000)
Resident FTE	-0.315*	-0.724***	0.000
	(0.176)	(0.217)	(0.000)
Nurse FTE	-0.074	-0.068	-0.000
	(0.061)	(0.079)	(0.000)
Other FTE	0.074***	0.055**	0.000
	(0.020)	(0.025)	(0.000)
N		353,283	

[a]Results from generalized within-estimator including physician, hospital, and year fixed effects. Standard errors are in parenthesis, clustered by physician. All regressions include county demographic variables (total population, age distribution, income distribution, and education) as well as dummies for whether the county hospital market is a monopoly, duopoly, or triopoly. We also include hospital bed size and indicators for whether the hospital is for-profit, part of a larger system, or a major teaching hospital. Sample is restricted to physicians that operate in a hospital for which they are integrated and a hospital for which they are not integrated in the same year at some point in the panel. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Table 6: **Effects on Match Values with Instrumental Variables Estimator**[a]

	Medicare Payments	Hospital Costs	IP & OP Stays
Integrated	946.458**	3,210.752***	0.327***
	(467.677)	(637.294)	(0.056)
Practice Characteristics			
Practice Size	-1.759	-3.501*	-0.000*
	(1.376)	(1.824)	(0.000)
Average Experience	-6.786*	-5.757	-0.000
	(3.892)	(5.806)	(0.000)
% Female	-32.459	-296.468	0.002
	(127.840)	(188.100)	(0.018)
Adult PCP	89.404	105.193	-0.029
	(168.209)	(218.125)	(0.028)
Multi-specialty	44.422	-168.410	-0.036***
	(88.483)	(108.469)	(0.011)
Surgery Center	52.320	-249.926**	-0.030***
	(96.547)	(118.421)	(0.011)
Independent	317.875	1298.059***	0.140***
	(199.343)	(272.204)	(0.024)
Hospital Characteristics			
Physician FTE	0.221*	-0.149	-0.000***
	(0.135)	(0.146)	(0.000)
Resident FTE	-0.163	-0.692***	-0.000
	(0.160)	(0.209)	(0.000)
Nurse FTE	0.021	-0.139	-0.000
	(0.066)	(0.089)	(0.000)
Other FTE	0.003	0.009	0.000*
	(0.020)	(0.025)	(0.000)
N		257,905	

[a]Results from generalized within-estimator including physician, hospital, and year fixed effects. Standard errors are in parenthesis, clustered by physician. We instrument for the vertical integration indicator as discussed in Section 4.2.4 in the main text. All regressions include county demographic variables (total population, age distribution, income distribution, and education) as well as dummies for whether the county hospital market is a monopoly, duopoly, or triopoly. We also include hospital bed size and indicators for whether the hospital is for-profit, part of a larger system, or a major teaching hospital. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Table 7: **Effects on Match Values without Reallocation**[a]

	Medicare Payments	Hospital Costs	IP & OP Stays
Integrated	64.134**	122.894***	0.013***
	(30.858)	(42.130)	(0.004)
Practice Characteristics			
Practice Size	-0.778	1.686**	0.000
	(0.589)	(0.782)	(0.000)
Average Experience	-6.744**	-6.406	-0.000
	(2.726)	(3.938)	(0.000)
% Female	-73.623	-161.566	0.011
	(92.070)	(132.201)	(0.014)
Adult PCP	114.817	163.075	-0.029
	(102.667)	(138.978)	(0.021)
Multi-specialty	13.693	-1.912	-0.029***
	(55.998)	(70.727)	(0.008)
Surgery Center	46.775	-30.957	-0.028***
	(63.068)	(80.188)	(0.008)
Independent	-10.790	21.291	0.006*
	(29.089)	(41.067)	(0.004)
Hospital Characteristics			
Physician FTE	0.111	0.022	-0.000***
	(0.085)	(0.100)	(0.000)
Resident FTE	-0.045	-0.395***	0.000
	(0.122)	(0.147)	(0.000)
Nurse FTE	0.002	0.032	-0.000
	(0.048)	(0.061)	(0.000)
Other FTE	0.042***	0.023	0.000
	(0.014)	(0.017)	(0.000)
N	475,778		

[a]Results from generalized within-estimator including physician, hospital, and year fixed effects. Standard errors are in parenthesis, clustered by physician. All regressions include county demographic variables (total population, age distribution, income distribution, and education) as well as dummies for whether the county hospital market is a monopoly, duopoly, or triopoly. We also include hospital bed size and indicators for whether the hospital is for-profit, part of a larger system, or a major teaching hospital. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Table 8: **Effects on Components of Inpatient Stay**[a]

	Inpatient Hospital Costs	Medical Supplies	Operating Room Costs	Anesthesia Costs	Lab Costs	Radiology Costs	MRI Costs	Length of Stay	No. ICU Days	Procedure Count
Integrated	180.997***	40.564	-11.029	5.278	9.286	-5.943	-0.514	-0.007	0.021	0.030***
	(49.711)	(30.024)	(22.928)	(4.999)	(8.826)	(6.058)	(1.359)	(0.014)	(0.013)	(0.009)
Practice Characteristics										
Practice Size	4.290***	1.719***	1.351**	0.084	0.525***	0.268***	0.058**	0.001***	-0.000	0.000**
	(0.962)	(0.592)	(0.528)	(0.136)	(0.176)	(0.103)	(0.026)	(0.000)	(0.000)	(0.000)
Average Experience	-3.850	5.052*	1.711	-0.367	0.102	0.984*	-0.019	0.003**	0.003**	-0.001
	(4.640)	(2.922)	(2.173)	(0.432)	(0.777)	(0.529)	(0.121)	(0.001)	(0.001)	(0.001)
% Female	-144.543	-73.065	61.577	-8.904	-29.822	-4.796	0.994	-0.024	-0.077*	-0.016
	(171.032)	(86.397)	(77.613)	(15.286)	(29.591)	(18.336)	(3.757)	(0.049)	(0.046)	(0.029)
Adult PCP	185.862	219.584***	115.577*	40.090***	-36.705	-4.892	-2.602	0.010	0.007	0.001
	(222.617)	(84.584)	(60.774)	(13.645)	(34.603)	(26.604)	(8.163)	(0.071)	(0.056)	(0.038)
Multi-specialty	93.700	131.142**	0.021	3.266	-12.379	-37.609***	-2.003	0.040	0.031	0.002
	(104.200)	(60.243)	(44.354)	(7.704)	(18.574)	(13.488)	(2.992)	(0.028)	(0.029)	(0.020)
Surgery Center	-14.680	21.711	-34.327	-1.382	-20.663	-32.339**	-0.464	0.042	0.048	-0.039*
	(109.481)	(65.355)	(47.972)	(8.670)	(19.474)	(13.538)	(2.971)	(0.030)	(0.030)	(0.021)
Independent	-19.361	58.773**	-74.605***	-6.783	9.866	-8.539	0.201	0.004	0.026**	0.016*
	(48.619)	(29.976)	(21.647)	(4.582)	(8.495)	(5.536)	(1.218)	(0.015)	(0.013)	(0.009)
Hospital Characteristics										
Physician FTE	-0.378***	-0.103	-0.126***	-0.017*	0.019	-0.004	-0.004	0.000**	0.000	-0.000
	(0.120)	(0.074)	(0.043)	(0.009)	(0.024)	(0.014)	(0.004)	(0.000)	(0.000)	(0.000)
Resident FTE	-0.361*	-0.131	-0.267***	0.036**	-0.072	-0.074***	-0.006	0.000	-0.000**	0.000
	(0.202)	(0.106)	(0.082)	(0.016)	(0.053)	(0.028)	(0.007)	(0.000)	(0.000)	(0.000)
Nurse FTE	0.351***	0.031	0.046	0.001	0.027	-0.005	0.000	0.000***	0.000***	0.000***
	(0.074)	(0.049)	(0.030)	(0.006)	(0.016)	(0.009)	(0.002)	(0.000)	(0.000)	(0.000)
Other FTE	0.079***	0.020*	0.043***	-0.006***	-0.024***	0.001	-0.001	-0.000***	-0.000	0.000
	(0.022)	(0.012)	(0.008)	(0.001)	(0.005)	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)
N	402,568	389,255	389,255	389,255	389,255	389,255	389,255	425,003	404,428	404,428

[a]Results from generalized within-estimator including physician, hospital, and year fixed effects. Standard errors are in parenthesis, clustered by physician. All regressions include county demographic variables (total population, age distribution, income distribution, and education) as well as dummies for whether the county hospital market is a monopoly, duopoly, or triopoly. We also include hospital bed size and indicators for whether the hospital is for-profit, part of a larger system, or a major teaching hospital. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Table 9: **Effects on Aggregate Physician-hospital Variables**[a]

	Share to Hospital		IP Stays & OP Visits			Patient Risk[b]	
	Inpatient	Outpatient	Total	Inpatient	Outpatient	Claims	Payments
Integrated	0.083***	0.063***	7.304***	1.124***	10.375***	0.013	-156.713
	(0.003)	(0.003)	(0.500)	(0.161)	(1.001)	(0.058)	(136.992)
Practice Characteristics							
Practice Size	0.000**	0.000***	0.029***	0.011***	0.045***	0.002**	-2.947
	(0.000)	(0.000)	(0.007)	(0.003)	(0.014)	(0.001)	(2.731)
Average Experience	0.000	0.000	-0.161***	-0.063***	-0.167**	0.004	-11.935
	(0.000)	(0.000)	(0.039)	(0.015)	(0.081)	(0.005)	(13.159)
% Female	0.005	0.016**	-1.400	-1.014**	-0.482	0.221	-77.180
	(0.007)	(0.008)	(1.443)	(0.405)	(3.258)	(0.196)	(475.582)
Adult PCP	0.003	-0.002	2.740	0.118	1.622	-0.470	-815.193
	(0.009)	(0.009)	(1.876)	(0.505)	(3.924)	(0.354)	(762.967)
Multi-specialty	-0.004	-0.006	-0.194	-0.424*	-1.940	0.079	-223.012
	(0.004)	(0.004)	(0.823)	(0.226)	(1.747)	(0.125)	(304.708)
Surgery Center	-0.006	-0.007	-0.175	-0.687***	-1.820	0.079	-276.562
	(0.004)	(0.004)	(0.876)	(0.264)	(1.934)	(0.125)	(307.095)
Independent	0.038***	0.027***	2.886***	0.467***	4.079***	-0.049	-255.532*
	(0.002)	(0.003)	(0.459)	(0.151)	(0.935)	(0.059)	(139.278)
Hospital Characteristics							
Physician FTE	0.000***	0.000	-0.003***	-0.000	-0.007***	0.000*	0.171
	(0.000)	(0.000)	(0.001)	(0.000)	(0.002)	(0.000)	(0.328)
Resident FTE	-0.000**	-0.000*	-0.001	-0.001*	0.004	-0.000*	-0.768
	(0.000)	(0.000)	(0.001)	(0.000)	(0.003)	(0.000)	(0.628)
Nurse FTE	-0.000	-0.000	0.001	0.000	-0.000	0.000***	0.002
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.238)
Other FTE	0.000	0.000***	0.001***	0.000	0.002***	0.000	0.114*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.066)
N	491,401	456,449	501,013	491,401	456,449	368,689	368,689

[a]Results from generalized within-estimator including physician, hospital, and year fixed effects. Standard errors are in parenthesis, clustered by physician. All regressions include county demographic variables (total population, age distribution, income distribution, and education) as well as dummies for whether the county hospital market is a monopoly, duopoly, or triopoly. We also include hospital bed size and indicators for whether the hospital is for-profit, part of a larger system, or a major teaching hospital. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

[b]Following Dranove *et al.* (2003), each patient's risk profile is quantified as the total number of claims or Medicare payments for a given patient in the year prior to the current inpatient stay.