PHYSICIAN COMPETITION AND THE PROVISION OF CARE

Evidence from Heart Attacks

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ABSTRACT
We study the impact of competition among physicians on service provision and patients' health outcomes for the US commercial market. We focus on cardiologists treating patients with a first-time heart attack treated in the emergency room. Physician concentration has a small but statistically significant effect on service utilization. Cardiologists in more concentrated markets perform more intensive procedures, particularly diagnostic procedures—services in which the procedure choice is more discretionary. Higher concentration leads to fewer readmissions but has no effect on mortality. These findings suggest that changes in organizational structure, such as a merger of physician groups, influence not only the negotiated prices of services, but also service provision.

KEYWORDS: competition, quality, utilization, physician markets
JEL CLASSIFICATION: I11, L11, L40

I. Introduction

Health care is a unique industry in terms of how consumers and firms interact. Consumers of health care (i.e., patients) do not observe the prices paid to physicians but rely on physicians to make consumption (i.e., diagnostic and treatment) decisions. Physicians not only provide care and make decisions for their patients but also negotiate with insurance firms over payment contracts. Evidence suggests a link between health-care provision and the financial incentives of physicians.[1] These financial incentives are driven by the fee-for-service contracts that are typical in the United States; these contracts pay physicians based on the quantity of services provided. In the commercial sector, where prices are shaped by competitive market forces, the same financial incentives are likely to influence diagnostic and treatment decisions. However, there is currently no documented evidence about how competition among physicians affects service use.[2] Determining the interplay between

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1 See Hemenway et al. (1990), Hillman, Pauly, and Kerstein (1989), Gruber and Owings (1996), Li et al. (2014), Clemens and Gottlieb (2014), Coey (2015), and Johnson and Rehavi (2015).

2 A recent study, Godager, Iversen, and Ma (2015), assesses the impact of competition on physician referrals.

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market forces and health-care provision is therefore an important part of understanding how the health-care industry functions.

In a previous study, we showed that higher market concentration is associated with higher negotiated service prices for physicians in the commercial sector (Dunn and Shapiro 2014).[3] This paper extends our analysis by examining how concentration impacts health services. Specifically, we assess how the competitive environment of physician firms affects both the quantity and the type of health services provided to the patient. We also examine how it ultimately affects the health of the patient. Our estimation relies on a measure of physician market concentration called the fixed-travel-time Herfindahl-Hirschman index (FTHHI). This measure was used in Dunn and Shapiro (2014) to assess the relationship between physician concentration and service prices. Similar to the measure of hospital competition used by Kessler and McClellan (2000), the FTHHI is based on theoretically predicted market shares. Thus, unlike typical concentration measures based on actual market shares, the measure of physician concentration used in this study implies no mechanical relationship with health-care demand.

To analyze the effect of competition on service provision, we focus on how competition among cardiologists impacts the quantity and type of services given to patients with first-time acute myocardial infarction (AMI)—commonly referred to as a heart attack—taken to the emergency room. Focusing on heart attacks has a number of advantages for analyzing physician behavior. One advantage is that it is a severe condition in which patients are likely to be inelastic to out-of-pocket payments.[4] This allows us to focus primarily on the decisions and the incentives of the physician. Although physicians may locate based on the expected number of heart attacks in a given area, the severity of heart attacks is difficult to predict ex ante. In the words of Cutler, McClellan, and Newhouse (2000, 527), "Who is to know whether, if he or she suffers a heart attack, it will lead to major impairment or death?" Importantly, the unobserved determinants of average severity across regions are plausibly not related to the consolidation decisions of cardiologists.

The estimates show that cardiologists who reside in more concentrated markets provide more services in terms of the intensity of services for patients with identical observable levels of severity. Overall, an increase in the FTHHI of one standard deviation leads to about a 5 percent increase in an intensity-weighted number of cardiologist services. The effect of market concentration on service utilization appears to be stronger for more discretionary services. Primarily, we find that market concentration increases the use of cardiac catheterization, but decreases the probability of a less invasive diagnostic test, such as a cardiovascular stress test or myocardial perfusion imaging test, being performed. However, we find no evidence that market concentration has an effect on angioplasty or bypass surgery—intensive treatments performed after diagnostic tests are performed. In terms of

3 Similar findings showing that less physician competition leads to higher payments has been shown in Gravelle et al. (2016), Baker et al. (2014), Austin and Baker (2015), and Kleiner, White, and Lyons (2015).

4 The RAND health study found lower elasticities for hospital services, suggesting patients are less price sensitive for more severe conditions (Manning et al. 1987; Aron-Dine, Einav, and Finkelstein 2013). Duarte (2012) examines this more directly and finds elasticities near zero for some specific acute conditions, such as appendicitis.

health outcomes, higher cardiologist concentration leads to fewer readmissions, but has no impact on mortality.

Given the extensive amount of evidence showing that physicians' financial incentives affect treatment choice,[5] a plausible mechanism that translates market concentration to service provision is the payment size. The fee-for-service payment system pays physicians for each additional unit of service provided, which provides incentives to supply more services. We explicitly test the assumption that market concentration affects service utilization through price by applying a difference-in-differences specification with capitated episodes—episodes that are not fee-for-service.[6] We find the effect of market concentration on service utilization exists only for fee-for-service episodes, which lends support to the financial incentive mechanism. Similarly, we find no evidence of an effect of concentration on services looking at a sample of only capitated patients. To further explore this mechanism, we estimate the physician's treatment response to changes in service price. To isolate the physician's financial incentive response, we exploit the relationship between concentration and price using the FTHHI as an instrument. We find the price elasticity of supply ranges between 1.2 and 1.6 in terms of the number of intensity-weighted cardiologist services, which is similar to that found by Clemens and Gottlieb (2014).

While our overall results are intuitive and consistent with previous results, we also acknowledge and discuss potential endogeneity biases. The potential for endogeneity bias is a limitation of this study, but the likely causes of potential biases would tend to diminish our main result. That is, the estimation strategy employed in this study may be an underestimate of the true impact of concentration on utilization. Overall, the data show evidence of a link between competition, financial incentives, and service utilization. These findings have implications for antitrust analysis and suggest that changes in organizational structure in a market, such as a merger of physician groups, influences not only the negotiated prices of services, but also the utilization of medical treatments.

The paper is organized as follows: Section II provides an overview of the market for physician services and describes how physician concentration could affect service provision. Section III reviews the data sources, which are taken from MarketScan and SK&A. In Section IV, we discuss potential endogeneity issues. In Section V we go over our estimation strategy, in Section VI we discuss the results, and in Section VII we conclude.

II. Physician Concentration, Service Prices, and Service Utilization

Our analysis focuses on three main variables: (1) physician concentration, also referred to as physician "market concentration," or a proxy for "market power," (2) physician

5 Clemens and Gottlieb (2014) examine how physicians responded to a Medicare reimbursement change that occurred in 1997. The authors found that, on average, a 2 percent increase in service prices caused a 3 percent increase in service utilization—a price elasticity of supply of 1.5. Baker (2010) found that orthopedists who began billing for MRIs increased their use of MRIs by 38 percent. Also see Gruber, Kim, and Mayzlin (1999), Spetz, Smith, and Ennis (2001), Grant (2009), and Decker (2009).

6 MarketScan provides an explicit capitation field.

service prices, also referred to as "fees," "payments," or "reimbursements," and (3) service utilization, also referred to as "service provision" and "service use." Service utilization is a measure of the quantity of services provided to the patient. An important part of our study is that these three variables adjust at different frequencies, implying a distinct time horizon governing the determination of each variable.

A. TIMING

Those variables that adjust frequently can be thought of as being determined in the short run, while those variables that adjust only infrequently can be thought of as being determined in the long run. In particular, the three main variables assessed in this study—concentration, prices, and utilization—can be placed in the following three categories:

- **long run:** physician concentration
- **medium run:** service price
- **short run:** service utilization

Market concentration is determined by physicians deciding where and with whom to practice, which the data suggest changes sluggishly. As shown in Dunn and Shapiro (2014), physician market concentration was quite steady over the 2005 to 2008 sample period. Generally, areas that were highly concentrated in 2005 remained highly concentrated in 2008. This sticky behavior of physician concentration is likely due to the large sunk costs involved in physician movement. Physicians build large networks of patients that are costly to forfeit.

Physician reimbursements also change slowly, albeit at a somewhat faster pace than concentration. Specifically, physician reimbursement contracts adjust anywhere from once per year to once every five years. Once the reimbursements are set, they are locked in place for the contract period. This sticky behavior of physician service prices is apparent in the data. For instance, Clemens, Gottlieb, and Shapiro (2014) note that jumps in the Bureau of Labor Statistics' (BLS) physician producer price index (PPI) occur regularly in January (beginning of the year), July (middle of the year), and October (beginning of the fiscal year). Likewise, Dunn and Shapiro (2015) note jumps in physician service prices in January.

The decision about how to treat the patient takes place after a health shock occurs. For instance, the physician may decide whether to perform a certain diagnostic test. All three of these variables are unequivocally chosen in an equilibrium setting. However, when a service use decision is made by a physician, it is necessarily made conditional on market concentration and service prices that are already set in place. By contrast, market concentration and price can only be adjusted based on *expectations* of service utilization decisions.

B. PHYSICIAN CONCENTRATION

During the latter half of the 20th century, more and more physicians decided to practice in groups as opposed to solo practices. Whereas in the 1960s 90 percent had solo practices

(Smart 2006), by the late 1980s this number was down to about half. By 2001, only a third of physicians operated as a solo practice (Rebitzer and Votruba 2011).

As physician groups formed, they emerged and evolved into different organizational structures. Physicians grouped together by specialty or with many specialties (that is, a multispecialty practice). They became associated with health systems or sometimes hospitals (that is, a physician-hospital organization (PHO)). More complex organizational structures evolved where group practices clustered with one another for bargaining purposes.[7]

In this study, we focus on those types of physician organizations where physicians with the same type of specialization are part of the same group or system. Specifically, we focus on consolidation among cardiologists. This type of "horizontal" consolidation has clear implications in terms of its impact on leverage with insurers. An insurer must have enough cardiologists in its network to attract and adequately treat enrollees. Cardiologists with fewer competitors have more leverage with insurers because their exclusion from an insurance carrier's network can cause greater harm to the insurer's profitability. Generally, the fewer competitors the cardiologist firm has, the higher the fees it can extract from the insurer. Indeed it has been empirically shown that cardiologists have higher reimbursements in more concentrated physician markets (Dunn and Shapiro 2014).

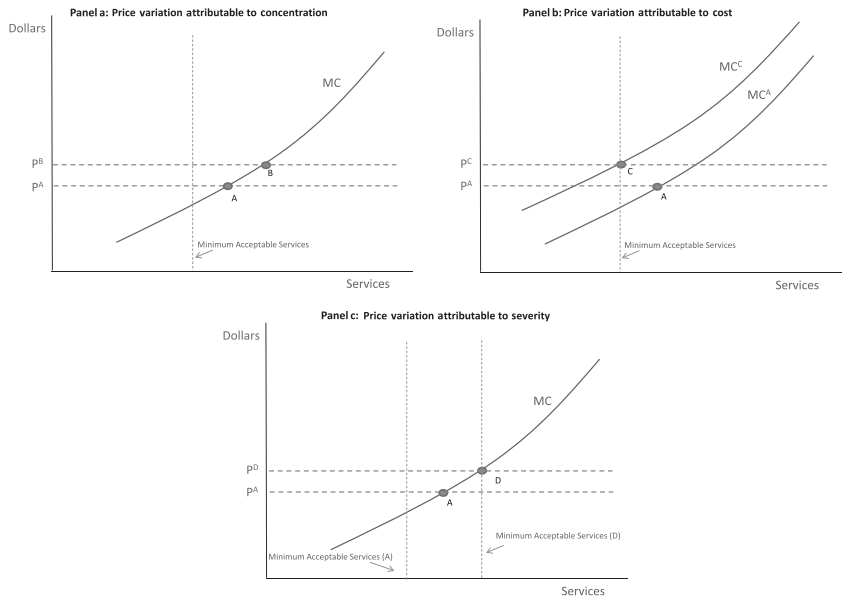
C. PHYSICIAN CONCENTRATION AND SERVICE UTILIZATION

Physician concentration could impact service utilization directly or indirectly via the physician's financial incentives. A more competitive physician market can directly affect utilization if physicians compete via effort or quality of care (Ma and McGuire 1997). The indirect mechanism is whether physicians compete via price, which alters the physicians' financial incentives. That is, higher competition reduces service prices, altering the physicians' financial incentives to provide services.

The indirect mechanism by which service prices could affect service utilization is fairly straightforward. Similar to most firms, a physician firm's marginal cost curve is likely to be upward sloping. A physician's capacity is constrained in the short run and thus each additional service provided to the patient cuts into the physician's leisure time. In the longer run, the physician can expand the quantity of services through other means, such as physical or human capital investment. The physician's marginal cost curve is upward sloping when both of these responses become increasingly more costly with service provision—for instance, through diminishing marginal utility of leisure or convex capital adjustment costs.

7 For example, two physician groups may have distinct offices and administrative services, but may contract with insurance carriers for legal bargaining purposes as an independent practice association (IPA). In most states, IPAs represent physicians who only compete for *capitated* HMO contracts. For noncapitated contracts, the physicians must negotiate individually unless the Federal Trade Commission rules that they are "clinically integrated" for efficiency reasons (Berenson, Ginsburg, and Kemper 2010). In another example, two physician groups may join forces to share administrative services (e.g., a group practice without walls (GPWW)) as well as contracting.

FIGURE 1. Price variation attributable to physician cost and patient severity



Notes: Panel a depicts an example where Physicians A and B share the same marginal cost curve, but Physician B has negotiated a higher payment rate than Physician A. Panel b depicts an example where Physician C (who faces higher costs than Physicians A or B) negotiates a higher service price than Physician A to ensure that the minimum amount of services is provided. Panel c depicts an example where Physician D (who expects to treat sicker patients) negotiates a higher service price than Physician A to ensure that the minimum amount of expected services is provided.

Panel a of Figure 1 depicts the marginal cost curve of two physicians who have identical costs, Physician A and Physician B.[8] Physician A has negotiated a price of P^A while Physician B has more market power and has negotiated a higher price P^B. Since the marginal cost curve is upward sloping, the higher service price leads Physician B to provide more services. For instance, the higher service price may encourage Physician B to perform more time-intensive procedures. Over the long run, a higher service price may encourage Physician B to invest in new technologies because it raises the expected profitability (Chandra and Skinner 2012). Such types of "practice-style" responses to payment increases were found for physicians by Clemens and Gottlieb (2014) and for hospitals in Finkelstein (2007) and Acemoglu and Finkelstein (2008).[9] Historically, since physician consolidation

8 This example hinges on the payment difference being exogenous. We expound on endogeneity concerns in Section IV. We assume that the patient is not sensitive to the service price, which is reasonable if the patient's out-of-pocket expenses are only a fraction of actual payments.

9 There is variation in terms of heart attack treatment capabilities across the United States. For instance, according to a 2004 study (Keeley and Grines), fewer than one in five facilities in the United States even have cardiac catheterization capabilities, and even fewer have the capability to perform angioplasty. There is

typically occurs over a long horizon, our analysis may be capturing both short-run and long-run incentives of physicians.[10]

In our empirical analysis, we estimate two specifications. One specification estimates the reduced-form effect of concentration on utilization and health outcomes. This approach assesses the total effect of concentration, which includes both direct effects and indirect effects stemming from financial incentives. The other specification estimates the effect of concentration on utilization as occurring indirectly through price. This latter approach has the advantage that it implies a specific price elasticity of supply that can be compared to previous studies. In particular, a supply elasticity that lies in a similar range to that found by Clemens and Gottlieb (2014) would lend support to financial incentives playing an important role in how competition affects utilization.

Most models of physician treatment decisions also include the physician's concern for the patient's welfare (e.g., McGuire and Pauly 1991). That is, the patient's utility directly enters the physician's utility function. In this case, the physician may not always respond to price. Rather the physician is more likely to respond to price in cases where the patient is less likely to be harmed or where there is more discretion in the choice of treatment. This type of varying response of price to utilization as a function of discretion was found in Clemens and Gottlieb (2014). Overall, the supply response to price, discussed above, is likely to be dampened when there is more certainty surrounding the treatment choice.

D. TREATMENT FOR HEART ATTACK PATIENTS

This study focuses on the treatment for acute myocardial infarction (AMI), commonly referred to as a heart attack. An AMI occurs when blood cannot flow properly to the heart (i.e., ischemia) because of a blocked coronary artery. When the heart tissue is deprived of oxygenated blood it begins to damage the heart muscle, referred to as an infarction. In most cases, during the onset of an AMI, the person experiences chest pain that usually occurs gradually over several hours. Many patients who experience a heart attack have a history of treated cardiovascular conditions; however, it is common to have had no treated cardiovascular conditions before the AMI occurs—what we label in this study as an "unexpected AMI." For example, 75 percent of patients hospitalized with an AMI

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also medical evidence showing that the capabilities of the facility impact how the patient is treated. A study by Popescu, Vaughan-Sarrazin, and Rosenthal (2007) found that by 30 days after the acute myocardial infarction, 49.1 percent of AMI patients initially admitted to a facility that had revascularization capabilities received coronary revascularization, while this rate was 25.4 percent for patients initially admitted to a facility without revascularization capabilities. The study used data collected between 2000 and 2005. Of those AMI patients admitted to hospitals without revascularization capabilities, 30.6 percent were transferred to a second hospital; 98.2 percent of those transfers were to a hospital with revascularization capabilities.

10 Simply put, there is very little time series movement in physician concentration over the sample period studied. Areas that were relatively concentrated in the beginning of our sample, 2005, were also relatively concentrated towards the end of our sample in 2008. We show that instrumenting using a lagged value of concentration implies similar results.

have cholesterol levels below what national guidelines classify as high risk (Sachdeva et al. 2009).[11]

Medications, such as aspirin or beta blockers, may be given immediately to reduce the patient's heart rate and blood pressure. However, before restoring blood flow to the heart, cardiologists must evaluate the severity via diagnostic procedures. The cardiologist has some discretion in choosing a diagnostic procedure. She can choose less invasive or expensive diagnostic procedures such as blood tests, stress tests, echocardiograms, and myocardial perfusion imaging tests.[12] She can also choose to perform a more invasive diagnostic procedure called a cardiac catheterization. This involves passing a flexible tube into the heart and injecting a radiopaque dye that allows the cardiologist to check blood flow in the coronary arteries and chambers inside the heart to determine the amount of blockage.

Once the severity of the heart attack is determined, a treatment option is chosen. Treating the heart attack entails returning blood flow to the heart in order to mitigate further damage. More intensive procedures include coronary artery bypass grafting (CABG; i.e., bypass surgery) and angioplasty, while less intensive treatments include blood thinners, anticoagulants, thrombolytic therapy, and heart monitoring. CABG, which is performed by a cardiovascular surgeon, involves major open-heart surgery where blood flow is restored through grafts to the coronary arteries. Angioplasty, which is usually performed by a cardiologist, involves threading a catheter with a balloon at its tip to the affected artery. The balloon is then inflated to compress the plaque inside the artery, which allows blood to flow to the heart. A stent may then be placed in the artery to keep the blood vessel open.[13] Once treated, the patient will see the cardiologist for office-visit checkups that may involve further diagnostic testing and heart monitoring.

III. Data

This study has two primary data sets. We use the MarketScan Commercial Claims and Encounters Database, which tracks claims from providers through a nationwide convenience sample of patients. We also use the SK&A physician database, which includes information on location, specialty, unique physician identifiers, medical practice group, and health system of physicians in the United States. In addition to these two data sets, we use data from three other sources to construct control variables. These data come from HealthLeaders-Interstudy, the Area Resource Files (ARF) produced by the US Department of Health and

11 About 25 percent of heart attacks occur without warning signs, and sometimes occur without any symptoms—commonly called a "silent heart attack" (see http://www.webmd.com/heart-disease/understanding-heart-attack-basics).

12 Myocardial perfusion imaging tests, often called nuclear stress tests, are noninvasive imaging tests showing blood movement through the heart muscle. A cardiovascular stress test is where the cardiologist monitors the patient's heart while the patient is on a treadmill or stationary bicycle.

13 Not all cardiologists are trained to perform a catheterization or an angioplasty. Indeed, bypass surgery is generally performed by a cardiovascular surgeon as opposed to a cardiologist. However, all cardiologists are trained to determine how and when certain diagnostic tests and medical treatments are needed.

Human Services, and the Behavioral Risk Factor Surveillance System (BRFSS) produced by the Centers for Disease Control and Prevention.

A. MARKETSCAN DATA

The MarketScan database tracks health-care claims spanning 2004 through 2009, although as we explain below our analysis is run on AMIs that occurred between 2005 and 2008. The data include health claims from employers and insurance carriers throughout the United States that have been paid and adjudicated. Geographic information is provided about the provider's county of practice. Information is also provided about the type of provider, which allows us to separate payments made to cardiologists from those paid to other providers such as hospitals, pharmacies, and other types of physicians. We use the MarketScan's "payment" variable, often referred to as the "allowed amount," which is the amount of dollars eligible for payment after applying pricing guidelines such as fee schedules and discounts, and before applying deductibles and co-payments. MarketScan also indicates the type of plan under which the claim was made, which allows us to isolate episodes in which a capitation payment was made.[14]

A.1. MEDICAL-CARE SPENDING PER EPISODE. This paper analyzes commercially insured patients between ages 19 and 63. We are restricted to examining patients below the age of 63 because our data exclude retirees and Medicare beneficiaries. We focus on those with first-time heart attack (ICD-9-CM 410) treated in the emergency room and then track services given for 90 days afterward—what we define as an "episode of care." A 90-day window is common in the literature and encompasses virtually all of the intensive care provided to heart attack patients.[15] We remove individuals age 64 and older because these people may be enrolled in Medicare during part of the episode. We also removed individuals who were never admitted to the hospital. We isolate first-time AMI episodes by keeping only those episodes where the patient (1) had no previous AMI diagnosis in the entire MarketScan sample and (2) was in MarketScan's enrollee file the year before the AMI.[16] Our analysis assesses first-time AMIs that occurred between 2005 and 2008, but we use extra years of data, 2004 and 2009 MarketScan data, to help create this sample. Specifically, we use the 2004 MarketScan to identify whether the enrollee had an AMI diagnosis in the year before the beginning of our sample period and use the 2009 sample to assess spending for episodes that began in November and December of 2008.

We also create a second sample labeled "unexpected first-time AMIs." This subsample of the full sample isolates those first-time AMI patients who were not treated for any cardiovascular-related conditions before the AMI. These patients possibly had less knowledge of their general cardiovascular condition before the AMI occurred. As we will discuss

14 Approximately 4 percent of our sample are capitated episodes. Although our main analysis excludes capitated episodes, we include them in a difference-in-differences specification (Table 5) and subsample analysis.

15 See Altman, Cutler, and Zeckhauser (2003), and Cutler, McClellan, and Newhouse (1998a, 1998b, 2000).

16 The enrollee file is a separate data file from the insurance claims and tracks whether an individual was enrolled in a health plan, regardless of whether she received care.

later in more depth, the severity of these types of heart attacks is plausibly more random ex ante, which helps with identification in our empirical analysis. Please see the Online Appendix (http://www.mitpressjournals.org/doi/suppl/10.1162/ajhe_a_00099) for a comprehensive overview of the data construction.

Total spending for the episode of care is simply the sum of all dollars paid to health-care providers during the 90-day period after the heart attack. This spending can be divided into two mutually exclusive provider categories: cardiologist and noncardiologist spending. The latter includes spending by facilities, laboratories, and other types of physicians, for example, radiologists and anesthesiologists. We removed providers making treatments that likely were not related to the AMI, for example, orthopedists.[17] Table 1 summarizes spending by category. Total reimbursements paid to the cardiologist, our primary focus of this study, includes the payment for any service line provided by what MarketScan identifies as a cardiologist. We removed episodes where a cardiologist payment was not present, as these are episodes where MarketScan could not identify the type of provider.[18] Spending by a noncardiologist is analogous and includes payments to any provider who is not labeled a cardiologist, but treats the patient within 90 days after the AMI. We provide details on how we cleaned the data in the Online Appendix.

The top portion of Table 1 shows summary statistics on spending in the MarketScan data. The average spending for an AMI is $33,908 in terms of total reimbursements to providers. The number is roughly equivalent in the sample of unexpected AMIs. Although a small portion of overall spending is paid to the cardiologist, she still receives a large absolute amount of reimbursements per AMI ($2,243). Moreover, as the primary decision maker in terms of treatment, it is possible that procedures provided by other provider types are affected by the cardiologist's incentives.[19] We explicitly test this assumption in our empirical analysis.

A.2. CARDIOLOGIST SERVICE PRICES AND UTILIZATION. A major advantage of examining physician services is that reimbursements paid to physicians are based on well-defined procedures categorized by Current Procedural Terminology (CPT) codes.[20] By contrast, reimbursements for inpatient hospital stays are priced in more complex fashion where the pricing methodology changes depending on the specific contract between each insurer and provider (see Reinhardt 2006).[21] The relatively straightforward manner in which physician reimbursements are set allows us to decompose

17 A cardiologist is defined in MarketScan by provider type (that is, "STDPROV" equal to 250). To match the definition in SK&A, we do not include cardiovascular surgeons, cardiothoracic surgeons, or pediatric cardiologists.

18 We kept only those episodes with at least two procedures performed by a cardiologist.

19 The reverse may also be true where physicians respond to the financial incentives of other providers or the hospital; see Foo, Lee, and Fong (2017).

20 Since there are thousands of different CPT codes, physicians usually negotiate the prices of all CPT codes at once based on a fee schedule—for example, all prices set relative to Medicare prices (see Clemens and Gottlieb 2017).

21 For example, inpatient hospital contracts may be based on a discount off of charges, a per diem rate, or price based on the diagnosis code (i.e., DRG code) of the patient.

TABLE 1. MarketScan summary statistics

	All First-time AMI			Unexpected First-time AMI		
Variable	Mean	S.D.	(Min, Max)	Mean	S.D.	(Min, Max)
Expenditures per episode						
Total spending ($)	33,908	22,361	(4,375, 136,222)	33,813	21,808	(4,375, 136,098)
Cardiologist spending ($)	2,243	1,458	(24, 15,721)	2,305	1,447	(24, 15,234)
Noncardiologist spending ($)	31,664	21,965	(537, 134,654)	31,507	21,411	(537, 134,654)
Cardiologist service utilization and service price						
Cardiologist intensity units (IUs)	2,635	1,520	(49, 7,814)	2,706	1,522	(49, 7,814)
Number of procedures performed by cardiologist	14.9	7.3	(2, 68)	15.0	7.2	(2, 68)
Cardiology service price ($ per IU)	0.88	0.29	(0.33, 2.53)	0.88	0.29	(0.33, 2.53)
Cardiologist relative value units (RVUs)	74.6	35.7	(0.5, 256.5)	76.2	35.6	(0.5, 256.5)
Utilization of specific procedures						
Any echocardiogram	0.61	0.49	(0, 1)	0.61	0.49	(0, 1)
Any cardiovascular stress test	0.29	0.45	(0, 1)	0.30	0.46	(0, 1)
Any myocardial perfusion imaging test	0.19	0.39	(0, 1)	0.18	0.39	(0, 1)
Any cardiac catheterization	0.90	0.30	(0, 1)	0.91	0.28	(0, 1)
Any angioplasty	0.64	0.48	(0, 1)	0.67	0.46	(0, 1)
Any CABG	0.10	0.30	(0, 1)	0.10	0.30	(0, 1)
Health outcome						
In-Hospital Death	0.017	0.13	(0, 1)	0.014	0.12	(0, 1)
Readmission for Any Cardiovascular Condition, 90-365 days	0.089	0.29	(0, 1)	0.077	0.27	(0, 1)
Readmission for AMI, 90-365 days	0.007	0.09	(0, 1)	0.006	0.07	(0, 1)

TABLE 1. *Continued*

Variable	All First-time AMI			Unexpected First-time AMI		
	Mean	S.D.	(Min, Max)	Mean	S.D.	(Min, Max)
Patient demographics and health status						
Age	53.2	7.5	(19, 63)	52.2	7.8	(19, 63)
Male	0.74	0.43	(0, 1)	0.76	0.42	(0, 1)
Charlson Comorbidity Index (within 365 days before AMI)	0.49	1.08	(0, 13)	0.26	0.75	(0, 9)
Inpatient admission within 365 days before AMI	0.025	0.154	(0, 1)	0.009	0.092	(0, 1)
Diagnosis code (ICD-9)						
410.0 (Anterolateral wall)	0.04	0.20	(0, 1)	0.04	0.20	(0, 1)
410.1 (Other anterior wall)	0.13	0.33	(0, 1)	0.14	0.35	(0, 1)
410.2 (Inferolateral wall)	0.04	0.19	(0, 1)	0.04	0.20	(0, 1)
410.3 (Inferoposterior wall)	0.02	0.15	(0, 1)	0.03	0.16	(0, 1)
410.4 (Other inferior wall)	0.20	0.40	(0, 1)	0.22	0.41	(0, 1)
410.5 (Other lateral wall)	0.02	0.13	(0, 1)	0.02	0.13	(0, 1)
410.6 (True posterial wall)	0.01	0.07	(0, 1)	0.01	0.07	(0, 1)
410.7 (Subendocardial)	0.42	0.49	(0, 1)	0.40	0.49	(0, 1)
410.8 (Other specified site)	0.01	0.12	(0, 1)	0.01	0.11	(0, 1)
410.9 (Unspecified site)	0.13	0.34	(0, 1)	0.12	0.33	(0, 1)
	$N = 12{,}020$			$N = 6{,}952$		

cardiologist expenditures into a service price and service utilization component in a feasible manner.

Our calculation of the cardiologist's service price is based on the methodology by Dunn, Shapiro, and Liebman (2013) and is calculated using all procedures provided by the cardiologist to the patient over the course of the 90-day episode. There is a three-step process to obtain a measure of service prices. First, we obtain the physician expenditure for a particular episode of care. Second, we quantify the amount of services performed by the physician during the episode of care. Finally, we calculate the service price as defined as the expenditure divided by the quantity of services. First note that the total expenditures made to the cardiologist for treating episode n is

$$TE_n = \sum_{j \in \Gamma_n} p_{jn} \quad (1),$$

where p_{jn} is the full payment (including the patient's out-of-pocket costs) to the cardiologist for procedure j in episode n. The variable Γ_n is the set of all procedures provided to the patient by the cardiologist within 90 days of the AMI. Pricing information for a specific procedure is the payment attached to the specific health claim line in the MarketScan data. We identify procedures j at the most granular level possible, based on a specific CPT code including its modifier. Note that each episode uniquely identifies an individual patient, treated by a cardiology firm that resides in a specific county that begins in a specific year.[22]

Next, we calculate the quantity of services per episode of care, which we refer to as "service utilization." We measure this variable by the following:

$$Q_n = \sum_{j \in \Gamma_n} r_j \quad (2),$$

where, as in Dunn, Shapiro, and Liebman (2013), r_j is proxied by the average price of procedure j in the entire MarketScan sample. That is, r_j serves as a proxy for the intensity of services rendered for a given procedure. We refer to r_j as "intensity units" (IU), which are somewhat comparable to a procedure's relative value units assigned by Medicare. The IU measure is more appropriate for our purposes than RVUs because it is fixed for a given procedure across places of service.[23] Any variation in the utilization component between two episodes of care will be attributable only to differences in the number and intensity of services (IUs) provided, as opposed to differences in the prices charged for the same

22 We removed those episodes where there was more than one county associated with the cardiologist. In our analysis, we cannot be sure that there was only one cardiology firm treating the patient. Although MarketScan does provide physician IDs, they are available for only about half of the available MarketScan data. Given the limited size of the sample of AMI patients we decided to ignore this variable.

23 Medicare's relative value unit (RVU) scale is designed to capture the cost of providing a given service, as opposed to the intensity, per se. Whereas RVUs (for a given procedure) will vary by place of service, our measure (IU) is fixed across this dimension. For robustness purposes, we also measure utilization with RVUs.

service. For instance, an episode that includes two 30-minute visits will count as a larger number of IUs than an episode with one 30-minute and one 15-minute office visit. In our analysis that follows, we will refer to service utilization, Q_n, as the quantity of IUs per episode.

The remaining component of the cardiologist's expenditure of an episode of care is the service price:

$$P_n = \frac{TE_n}{Q_n} \quad (3),$$

which is the price of the episode of care in terms of its average price per service. The cardiologist's service price is simply the amount of dollars paid per IU. Note that there is a simple relationship between total expenditures and service price and utilization:

$$\ln(TE_n) = \ln(P_n) + \ln(Q_n) \quad (4).$$

Table 1 shows summary statistics[24] for cardiologist service price and utilization, as well as additional variables that will be analyzed in this study, such as the use of specific procedures and health outcomes. Note that the average service price will lie close to one by construction—IUs are constructed as the average price of the CPT code based on the entire MarketScan sample. The mortality measure analyzed in this paper is inpatient mortality within the first 90 days after admission. Similar to Gowrisankaran and Town (2003) and Kolstad (2013), this includes only inpatient mortality and does not include mortality that occurs outside of the hospital.[25]

Around 90 percent of heart attack patients received a cardiac catheterization. A smaller fraction received less expensive diagnostic procedures—approximately 60 percent received an echocardiogram, 30 percent received a stress test, and 20 percent received myocardial perfusion imaging (MPI). Approximately 70 percent (not shown in Table 1) of patients received a less invasive type of diagnostic test: either an echocardiogram, stress test, or myocardial perfusion imaging (MPI).[26] In terms of the IU metric employed in this study, a catheterization is much more intensive than any of these less invasive diagnostic tests. For instance, the most common type of catheterization (CPT code 93510) amounts to 1,244 IUs, while the most common type of MPI test (CPT code 78465), echocardiogram (CPT code 93307), and stress test (CPT code 93015) amount to 587, 236, and 143

24 As part of cleaning the data, we removed outliers we believe are attributable to clerical data input error by discarding episodes in the bottom 1st percentile and top 99th percentile based on price and utilization.

25 The mortality rate is 1.6 percent for those age 60 and under and is 3.1 percent for those age 60–64. We have information only on the discharge status of the individual. We have no information on whether the individual died before or after being treated. The inpatient mortality data in MarketScan appears reasonable when compared with external inpatient data sources on AMIs. Specifically, using inpatient discharge data for AMI commercially insured patients under 65 from the Pennsylvania Health Care Cost Containment Council for the years 2002–08, we find a mortality rate of 2.9 percent.

26 Of the 1,128 AMI patients who did not receive a catheterization, 912 received either an echocardiogram, stress test, or MPI.

IUs, respectively. The Online Appendix shows how we mapped CPT codes into procedure types.

We can also control for the primary diagnosis (ICD-9) code reported during the episode of care. Specifically, this variable indicates the type of heart attack that occurred during the episode as diagnosed by the cardiologist.[27] Approximately 2 percent of episodes indicated more than one primary diagnosis code. A large proportion of AMIs in the sample (40 percent) are subendocardial infarctions, which is a heart attack that involves the innermost layer of the myocardium.

Table 1 also reports measures of the patient's health status before the AMI occurred. One measure is the Charlson comorbidity index (CCI), which is calculated by assessing the diagnosis codes of the patient in the 365 days leading up to the heart attack.[28] Another measure is an indicator of whether the patient was ever admitted to a hospital in the 365 days before the AMI occurred. By construction, patients with an unexpected AMI (i.e., those without any cardiovascular preconditions) are more likely to have lower values of these health indicator variables, on average. However, besides these differences in patients' health status before the heart attack occurs, there are no large apparent differences in spending or service use between the full sample and the sample of patients with unexpected AMIs. Patients who suffer an unexpected AMI are a year younger, on average, and also have a slightly lower probability of dying in the hospital within 90 days of the AMI. These small differences are to be expected, since the discovery of cardiovascular conditions are likely to increase with age, along with the conditional probability of dying of a heart attack. It is important to note that the bulk of dollars are paid to the facility for services, such as imaging, room and board, and laboratory services.

B. SK&A DATA

The measure of cardiologist market concentration used in our analysis is taken from Dunn and Shapiro (2014) and is labeled the fixed-travel-time HHI (FTHHI). The FTHHI is constructed from the SK&A database of physicians and includes information on physician location (geocode), specialty, name, medical practice group, and health system. The database is updated every six months (half-year), spans 2005 to 2008, and claims to include 95 percent of office-based physicians practicing in the United States.[29]

27 We dropped episodes where the only ICD-9 reported during the episode had a fifth digit of the ICD-9 equal to 2 (e.g., 410.12 and 410.22), which indicates a subsequent AMI.

28 The CCI assigns scores as follows: 1 each for AMI, congestive heart failure, peripheral disease, cerebrovascular disease, dementia, chronic pulmonary disease, peptic ulcer disease, mild liver disease, diabetes without end-organ damage; 2 each for hemiplegia, moderate or severe renal disease, diabetes with end-organ damage, tumor with metastasis, leukemia, lymphoma; 3 for moderate or severe liver disease; 6 for metastatic solid tumor and AIDS.

29 SK&A has a research center that verifies every field of every record in its database. The data also include the names of doctors of osteopathic medicine, nurse practitioners, physician assistants, and office managers. The SK&A data do not state whether physicians in the data are part of a larger system that also owns hospitals or ambulatory care facilities. An important benefit of the SK&A data relative to other data sources is that they provide information about physician medical practice groups (i.e., firms). Another advantage is that each physician is verified over the telephone, which increases the accuracy of its physician location

The FTHHI is based on the assumption of a market boundary defined by a fixed driving time between the patient and the physician firm. There is a four-step process in creating the FTHHI. First, a geographic market boundary is defined. Second, the probability that a person located within the market boundary will visit a physician firm is constructed. Third, using the probabilities of seeing each physician calculated in step two, an expected market share is calculated. Fourth, using the expected market shares and physician group information, a concentration measure (the FTHHI) is created that is specific to a county and time period. See Dunn and Shapiro (2014) for details on how the FTHHI is constructed.

The FTHHI is constructed using predicted market shares, rather than actual market shares based on patient counts. Using actual market shares would likely be biased by the quality of the physicians. For instance, higher-quality physician offices would tend to have proportionately higher market shares and higher prices. Based on the results of Dunn and Shapiro (2014), we choose to use the FTHHI measure with a market boundary set to 80 minutes. All of the estimates in this study are robust to changes in the radius to 30, 60, and 100 minutes.

The final sample includes the concentration level of 665 unique counties that represent approximately 75 percent of the US population.[30] The counties in our sample tend to be more urban and more densely populated with lower median incomes than those counties left out. The mean FTHHI in the sample is 0.16, but varies across markets with several known factors. Within our sample, concentration tends to be higher in areas that are less densely populated, lower-income and lower-rent areas with fewer cardiologists per capita, and smaller group sizes. We condition on these known factors that affect concentration, implying that identification relies on more idiosyncratic factors affecting concentration across markets.

IV. Identification

The ideal experiment to assess how market structure impacts service provision would involve randomly assigning physicians to markets with different degrees of concentration. Our study is obviously limited in this regard as we can only assess observed geographic differences in market concentration. Since observed differences in physician market structure are determined endogenously by physicians' consolidation decisions, it is important to discuss how this might confound the results in our study.

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and group size information. The six-month frequency of their telephone survey may be important, since SK&A reports that on average, 14.2 percent of physicians move each year. Although all the information in the survey is telephone verified, they gather information for physicians through a variety of sources. This includes company and corporate directories, websites, state licensing information, mergers and acquisitions announcements, trade publications, white and yellow pages directories, professional associations, and government agencies.

30 To match MarketScan, the final sample used in estimation is not balanced, which is why we include state-year fixed effects in our final estimates. The final sample includes 413, 426, 495, and 504 unique counties in years 2005, 2006, 2007, and 2008, respectively. Results did not change when using the balanced panel of counties, or when we dropped counties in the sample for only one year.

The main identification assumption in our empirical analysis is that concentration is not correlated with *unobserved* factors influencing cardiologist service utilization for a heart attack event. That is, we are concerned about factors we do not observe as econometricians, that may be correlated with both concentration and service utilization. In this section, we highlight three key categories of such variables: (1) the patient's out-of-pocket price sensitivity, (2) the physician's unobservable cost, and (3) the patient's unobserved health severity. We also discuss issues of physician concentration measurement and its potential impact on our estimates.

In discussing the link between concentration and utilization, it is important to discuss the role of price. Given previous research documenting that physicians' supply decisions are price sensitive (e.g., Clemens and Gottlieb 2014), the mechanism by which concentration affects service utilization is plausibly through its effect on service price. The increased price obtained from negotiating clout in more concentrated markets increases the marginal profitability of additional services. This mechanism may be formally tested by using physician concentration as an instrument for the service price, when analyzing the impact of service price on utilization. This instrumental variable (IV) analysis not only bolsters our identification argument, it also allows for direct measurement of physician price sensitivity. Given that the three variables, concentration, price, and utilization, are central to our analysis, the following subsection discusses the relationship among these variables.

A. CONSUMER PRICE SENSITIVITY

If concentration impacts prices, this could have an impact on utilization through the patient's response to out-of-pocket price through coinsurance rates (Chandra, Gruber, and McKnight 2010). We argue that our analysis is isolating the decision of the physician and not the patient for two reasons. First, this paper focuses on the intensive margin of service use (i.e., the quantity of services given a heart attack), which is arguably more influenced by the physician, in general, than the extensive margin (i.e., the choice to seek treatment), which is more influenced by the patient (Keeler and Rolph 1988). Second, and perhaps more importantly, one advantage of focusing on a heart attack event is that it is a severe condition in which patients are likely to be inelastic to out-of-pocket payments, which allows us to isolate the procedure decisions and the incentives of the physician. To the extent that patient price sensitivity has any effect, it will lead us to underestimate the effects of concentration on utilization.

B. UNOBSERVED COST

A significant portion of a physician's cost may be unobserved to the econometrician. For instance, some physicians may place differing values on their leisure time. Figure 1 shows a depiction of a stylized model intended to show how unobserved variation in marginal cost could interfere with identifying the physician's response to marginal changes in price. We then discuss how this identification issue relates to measuring the effect of physician concentration on utilization.

Figure 1 is split into three panels. In panel a, Physicians A and B share the same marginal cost curve, but Physician B has negotiated a higher payment rate than Physician

A. There is also the addition of a vertical line marking the minimum acceptable level of services that the physician must provide the patient. This assumption is equivalent to consumers purchasing health insurance knowing that, should a heart attack occur, some minimum threshold of care would be provided.

Panel b includes a third physician, Physician C, who has a higher marginal cost curve than Physicians A and B, but has a negotiated price identical to Physician B. Physician C's marginal cost curve reflects that she might place a larger value on her leisure time than Physicians A and B. In either case, it costs Physician C more at the margin than Physicians A and B to supply the same amount of care to the patient. The important point is that it is conceivable that each physician's *expected* cost is known by the physician when prices are set, or perhaps when consolidation considerations are made.

In panel b, Physician C negotiates a higher service price than Physician A to ensure that the minimum amount of services is provided. In this case, a higher price is associated with *fewer* services.[31] The key difference between panels a and b is that a price increase from greater bargaining leverage unambiguously increases the physician's per-service profit margin, while a price increase attributable to cost does not. This example demonstrates one potential way that unobserved variation in physician cost could cause service price and utilization to be negatively correlated.[32]

A key assumption in our empirical analysis is that market concentration varies independently from costs that are unobservable to the econometrician. Since consolidation is a long-run decision, the assumption is tantamount to assuming that physicians do not make consolidation decisions based on *expected* unobserved costs. One way to test this assumption is to compare an OLS estimate of service price on service utilization directly with that of an IV estimation using concentration as an instrument for price. If physicians are price sensitive and concentration is uncorrelated with unobserved costs, then we would expect the IV estimate of the supply elasticity to be larger (i.e., more positive) than the OLS coefficient.

If there is an unobserved cost factor related to concentration and service price, panel b of Figure 1 shows that this bias would lead to an underestimate of the effects of concentration on utilization. When physicians expect costs to be high, the physicians may have an incentive to consolidate or simply leave the market. Physicians leaving or consolidating would lead to greater physician leverage in the market and higher reimbursements, overcoming the high costs. This would cause concentration and prices to be high when costs are also high. However, note that panel b of Figure 1 implies that, all else equal, high costs are associated with lower service utilization. Thus, this type of physician

31 As an alternative to including a line for the minimum amount of services, the higher cost of Physician C could also be associated with her ability to negotiate a higher price than Physician A. The higher marginal cost for Physician C raises her threat point, relative to Physician A, and may be a key determinant in negotiating a higher service price than Physician A. That is, a higher marginal cost will likely be associated with a higher negotiated service price.

32 As an alternative but related example, it may be that Physician C is of higher quality, so the marginal costs of her treatments are greater, but the amount of services necessary to treat the patient are actually less (e.g., requires fewer diagnostic tests for the same treatment).

movement would cause us to underestimate the true effect of concentration on service utilization.

C. UNOBSERVED HEALTH SEVERITY OF FIRST-TIME AMI PATIENTS

As argued previously, the severity of heart attacks is unpredictable, making it unlikely that the *unobserved* component of heart attack severity would be correlated with the consolidation of physicians in an area. However, it is important to discuss how omitted variable bias due to unobserved (to the econometrician) health severity would affect our results. Panel c of Figure 1 shows where a fourth physician, Physician D, treats patients who, on average, have more severe health shocks. For instance, this could be the leading specialist in the area, who only sees the most severe patients. Since these are patients who need more health services, the minimum acceptable services is shifted to the right.

Physician D expects that she is likely to treat severe health conditions, meaning the average minimal amount of acceptable services is quite high. Similar to the case with marginal cost variation, Physician D then negotiates a higher service price simply to ensure that the minimum amount of services is provided. Figure 1 demonstrates that unobserved variation in health severity could cause upward bias on OLS regression of service price on service utilization.

The key assumption concerning health severity in our main analysis is that it varies independently from concentration. To be clear, physicians likely choose to locate in areas where they expect a large *number* of heart attacks to occur. For instance, physicians may choose to locate in an area with more smokers (or consolidate in an area with fewer smokers). In this case, more competitive markets may be associated with unhealthy geographic areas or an older population. However, conditional on a heart attack occurring, physicians are plausibly less able to predict which areas have more severe heart attacks. This identification assumption is similar to Cutler, McClellan, and Newhouse (2000). Coey (2015), who also examined MarketScan data, found this to be true for patients, finding no evidence that patients with less severe heart attacks selected into more restrictive plans.

Our subsample analysis on unexpected AMI patients further helps mitigate this type of potential omitted variable bias. Furthermore, in our empirical analysis we include variables that control for observable severity such as the patient's age, gender, CCI,[33] and a dummy variable indicating the specific diagnosis code of the AMI (ICD-9 code).[34] Importantly, our results barely change regardless of whether we control for these factors, implying that severity is not mutually correlated with both concentration and service use.

Similar to our discussion with marginal cost variation, it is helpful to sign the bias if this type of omitted variable bias were to occur. Specifically, if bias were to occur, it would be because physician firms are more likely to enter the markets where they expect severity to be high. In other words, one would expect more entry where demand for health services is high. This implies that, similar to unobserved cost, any correlation between concentration

33 Specifically, we include a third-order polynomial of the CCI to account for possible nonlinear effects of the patient's health condition going into the AMI.

34 This includes ten ICD-9 categories—nine dummy variables plus one omitted dummy. See Table 1.

and unobserved severity would cause us to underestimate the effect of concentration on service utilization. To test this assumption, we ran our main regressions using the CCI as the dependent variable and found that the CCI was negatively correlated with the FTHHI, implying that more competitive areas are indeed less healthy.

Finally, one might be concerned that differences in exposure period may affect our result. For example, if mortality and concentration are correlated, then days in the hospital or the total time period getting care may be affected. However, as we will show in the last section of the paper, we find no evidence that concentration is correlated with mortality. Furthermore, we include two measures of utilization—cardiologist IUs per procedure, and inpatient cardiologist IUs per admitted day—which account for exposure time.

D. PHYSICIAN CONCENTRATION MEASURE

Finally, the measure of physician concentration used in this study is based solely on the distance between physician firms and the relative number of physicians in the firm.[35] Thus, we do not have to be concerned about the concentration measure mechanically changing because patients choose certain doctors after the health shock occurs. For instance, patients who realize they are very sick may select a higher-quality physician, raising that physician's market share.[36] While our measure does not contain this type of bias, there is a potential for measurement error in the physician concentration measure, as discussed in Dunn and Shapiro (2014), which would lead to an attenuation bias and underestimation of the impact of concentration on utilization.

The SK&A database does not provide reliable information on whether the physician firm is vertically integrated with a facility—that is, whether the physician firm is owned by a hospital or the physician firm owns the facility.[37] For this reason, the FTHHI incorporates variation due to vertical integration to the extent that the two may be correlated. That is, we cannot rule out the possibility that utilization differences attributable to the FTHHI are stemming from differences in vertical integration.[38] Thus, concentration may have an impact on utilization for reasons over and above just its impact on the size of the physician's payment.

V. Estimation Strategy

The analysis in this paper takes two alternative approaches to identify the effect of concentration on price. One of the approaches estimates this effect as occurring through the financial incentives of physicians. This analysis takes two steps. The first-stage regression

35 In all specifications, we include a control for the average size of the cardiology firm in the market.

36 If our concentration measure were based on the physician's actual market share, which is not used in this study, physician selection would cause us to mistake unhealthy geographic areas as highly concentrated markets.

37 See Iglehart (2005) and Robinson and Miller (2014).

38 As a robustness exercise, we included a hospital FTHHI as an additional control, which captures variation in hospital concentration (see the Online Appendix). The FTHHI was constructed in analogous fashion to the physician FTHHI with an 80-minute boundary, but based on number of beds.

entails estimating the effect of cardiologist concentration (FTHHI) on cardiologist service prices—similar to that studied in Dunn and Shapiro (2014). This establishes the expected positive effect of concentration on price for heart attack services, indicating higher profit margins for physicians in more concentrated markets, all else equal. The second-stage consists of estimating the impact of cardiology service prices on cardiology service utilization, using the FTHHI as an instrument for service price. As an alternative approach to explore this relationship, we also estimate a reduced-form regression of the FTHHI on cardiology service utilization.

A. FIRST STAGE

The first-stage estimation of the cardiologist's service price, P_n, takes the following form:

$$\ln(P_n) = \beta \ln(FTHHI_{ct}) + \delta' X + \zeta_{st} + \varepsilon_n \quad (5),$$

where each 90-day episode of care after the heart attack (n) has a unique year (t) the episode began, as well as county (c) and state (s) where the cardiologist providing care resides. Since the specification includes state-year fixed effects (ζ_{st}), it isolates cross-sectional variation in the FTHHI between counties within a state.[39] The vector X includes a multitude of covariates that control for demographics of the patient undergoing care, such as age and gender, as well as county-level information that is likely jointly related to the cardiologist's costs and her consolidation decisions. As discussed earlier, the FTHHI is not constructed from actual market shares, but rather the relative distance between physicians and the size of the physician firms. Thus, unlike a standard HHI measure, there is no mechanical relationship between the number of patients getting treated by the cardiologist and the FTHHI that would likely bias our estimates.

We include age dummies specific to the exact age for those individuals above 60, but five-year age bin dummies for ages below 60. We also interact a gender dummy with the age dummies. Additional patient-specific variables from MarketScan include the patient's type of insurance carrier (e.g., HMO, PPO) as well as a dummy variable indicating whether the data source was from an employer. To better control for the patient's health, we include a dummy variable indicating whether the patient was ever admitted to an inpatient hospital before the heart attack occurred, the patient's CCI,[40] as well as dummy variables indicating the specific type (ICD-9) of heart attack that did occur. Our results barely changed regardless of whether we control for these factors, implying that severity is not mutually correlated with both concentration and service use.

Our county-level variables are aimed to control for the cardiologist's costs (and capacity), as well as factors that may jointly affect the size of the health shock and the FTHHI. They are specific to the year and the cardiologist's county. Our cost controls include the

39 We also ran our regression using metropolitan statistical area (MSA)-time fixed effects and got very similar results.

40 We include a third-order polynomial of the CCI to control for possible nonlinear effects of health severity.

number of cardiologists per capita, the number of cardiologists per firm,[41] the number of hospitals per capita, the number of university hospitals per capita, the population density, hospital costs per employee, median house value, and median house rental. We also include the median income of the patient's county of residence. To control for factors that may jointly affect the size of health shocks, we include information obtained from the Center for Disease Control and Prevention's Behavioral Risk Factor Surveillance System (BRFSS) as well as the entire MarketScan database. From BRFSS we calculate a prediction of the fraction of individuals in the county who are heavy smokers and the fraction of individuals who are obese. From the entire MarketScan database we generate utilization and prevalence information taken from Dunn, Shapiro, and Liebman (2013), which includes the number of non-cardiovascular-related treated conditions per capita, as well as the amount of non-cardiovascular-related services per episode of care (i.e., a county-level service utilization index). These latter variables are included to capture the possibility that certain counties may have a relatively large number of unhealthy individuals. The vector X also includes the concentration of the insurance market—the same measure constructed in Dunn and Shapiro (2014).[42]

B. SECOND STAGE

The second-stage estimation measures the impact of a change in the cardiologist's service price on the amount of services provided to the patient, IU_n:

$$\ln(IU_n) = \gamma \widehat{\ln(P_n)} + \delta' X + \zeta_{st} + \nu_n \quad (6),$$

where we measure the amount of services as the logarithm of cardiologist intensity units (IUs), $\ln(IU_n)$. The controls are the same as that in the first-stage estimation. The hat over the service price indicates that we are instrumenting the cardiologist's service price with the cardiology FTHHI. The coefficient γ measures the cardiologist's price elasticity of service supply to the extent that it measures the change in services she provides to the patient due to a change in her margin.

The residual, ν_n, represents any unobservable (to the econometrician) factor that affects the amount of services provided to the patient. As discussed in Section IV, ν_n likely represents the physician's unobservable cost and/or the patient's unobservable heart attack severity. As we delineated in Figure 1 of Section IV, there will be downward omitted variable bias on γ under OLS if ν_n represents the physician's unobservable marginal cost. Recall that in this case variations in ν_n are positively related to price but negatively related to Y_n. Under IV estimation, however, omitted variable bias on γ arises only if the FTHHI

41 Firm is defined as the cardiology firm in the SK&A. Our results did not change when we removed cardiologists per capita or cardiologists per firm as a control.

42 Insurance markets are plausibly much larger than physician markets, usually covering a multitude of counties. Our results did not change when we excluded this control from our regression analysis or when we included smaller geographic fixed effects such as MSA-time fixed effects. As a robustness exercise, we include a hospital FTHHI (based on number of beds) with an 80-minute boundary as an additional control, which captures variation in hospital concentration. Point estimates are similar (see the Online Appendix), however, less precise likely because the two concentration measures are highly collinear (R^2 of 0.66).

(or past levels of the FTHHI in some specifications) is correlated with ν_n. Thus, we have to address the concern that the FTHHI could be correlated with either the physician's unobservable marginal cost or unobservable severity of the health shock.

B.1. SIGNING THE POTENTIAL OMITTED VARIABLE BIAS. As highlighted in our previous discussion, any remaining omitted variable bias under IV is likely to be downward, causing us to underestimate γ. Suppose that ν_n represents unobservable (to the econometrician) cost. In this case, ν_n is negatively correlated with Y_n—for a given price, a higher cost translates to a lower margin, and hence less service provided. However, correlation between ν_n and *FTHHI*, if it arises, is likely to be positive—physicians are prone to consolidate when they expect unobservable costs to be high in order to raise their prices. Since ν_n is positively correlated with *FTHHI*, but negatively correlated with Y_n, any omitted variable bias on γ related to unobservable cost is likely to be downward.

Now suppose that ν_n represents unobservable (to the econometrician) heart attack severity. In this case, ν_n is positively correlated with Y_n—for a given price, a more severe heart attack likely requires more services to be provided. However, correlation between ν_n and *FTHHI*, if it arises, is likely to be negative—if physicians expect that an area is prone to very severe heart attacks, more cardiologists are likely to enter the market to meet demand, effectively lowering the FTHHI. Since ν_n is negatively correlated with *FTHHI*, but positively correlated with Y_n, any omitted variable bias on γ, related to unobservable heart attack severity, is likely to be downward. Recall that our focus on AMI patients likely mitigates this type of potential omitted variable bias since it is plausibly difficult to predict heart attack severity a priori.

The key takeaway is that omitted variable bias is theoretically more likely to cause downward bias on γ. Thus, the estimate in this paper is more likely a lower bound on the true supply elasticity. This implies that omitted variable bias would not cause any change to our qualitative findings if we find a positive estimate of γ.

C. REDUCED-FORM ESTIMATION

For completeness, as well as serving as our main estimate, we directly estimate the effect of the FTHHI on service utilization:

$$Y_n = \theta \ln(FTHHI_{ct}) + \delta' X + \zeta_{st} + \omega_n \tag{7},$$

where Y_n represents either the logarithm of a continuous variable (e.g., IUs) or a binary variable (e.g., any echocardiogram). Here, $\theta \approx \beta \cdot \gamma$. Specifically, θ represents the impact of the physician's market power on the amount of services provided to the patient. Similar to equation 6, the residual, ω_n, represents any unobserved cost or unobserved health shock. Thus, the same identifying assumptions apply concerning the correlation between the FTHHI and ω_n as they do between the FTHHI and ν_n.

For the same reasons described above, our estimate of θ is likely a lower bound on the true effect of the impact of concentration on service utilization. For instance, suppose ω represents unobserved cost. This implies a negative correlation between ω_n and Y_n but a positive correlation between ω_n and $FTHHI_{ct}$. Similarly, if ω represents unobserved health

TABLE 2. Effect of cardiologist service price change on cardiologist intensity units (IUs)

	(1)	(2)	(3)
	Log cardiologist intensity units (IUs)		
Outcome:	OLS	IV	IV
Log cardiology service price	−0.462[a]	1.302[a]	1.158[b]
	(0.050)	(0.458)	(0.519)
	First stage: Log cardiology service price		
Log FTHHI		0.038[a]	0.041[a]
		(0.009)	(0.010)
Removed patients with any cardiovascular treatment before AMI			X
Observations	12,020	12,020	6,952
Cragg-Donald Wald F-statistic		94.4	58.8

Notes: The dependent variable in the first stage is the logarithm of cardiologist service price. The dependent variable in the second stage is the logarithm of cardiologist IUs over the 90 days following an AMI. All regressions include state-year fixed effects and controls specified in equation 6. Standard errors clustered by county are in parentheses. The critical value for maximum acceptable bias at 10% is a Cragg-Donald Wald F-statistic of 16.4. [a] $p < 0.01$, [b] $p < 0.05$, [c] $p < 0.10$.

severity, this implies a positive correlation between ω_n and Y_n but a negative correlation between ω_n and $FTHHI_{ct}$.

VI. Empirical Results

A. EFFECT OF CARDIOLOGIST SERVICE PRICE ON CARDIOLOGIST SERVICE UTILIZATION

We display results of the first-stage estimation, equation 5, in the bottom portion of Table 2. The second column reports the estimate of β under the entire sample while the third column reports estimates under the sample of unexpected AMIs, defined as those episodes where the individual had no treated cardiological conditions and who received emergency room care on the day of the AMI.

Estimates of β, the coefficient on the FTHHI, range between 0.038 and 0.041, both statistically significant at the 1 percent level. This implies that a one standard deviation increase in the FTHHI causes about a 4 percentage point increase in service prices.[43]

The upper portion of Table 2 depicts the estimates from the second-stage regression, where we regress the cardiologist's service price on the logarithm of the number of IUs.

43 The mean FTHHI is 0.16 and the standard deviation is 0.21. Thus a one standard deviation increase in the FTHHI implies a price increase of $\exp(\beta \times \ln(0.16 + 0.21) - \beta \times \ln(0.16)) - 1$.

The coefficient on the logarithm of the cardiologist's service price, γ, is negative and statistically significant under OLS, but turns positive and significant using the FTHHI as an instrumental variable. The negative coefficient under OLS is likely stemming from omitted variable bias due to unobservable cost—unobservable marginal cost is positively correlated with price but negatively correlated with utilization. The price elasticity of supply, in terms of IUs, ranges from 1.1 to 1.3 and is statistically significant. These estimates are in the range of those found by Clemens and Gottlieb (2014), who found a price elasticity of supply of 1.5 for all physicians. However, this estimate is slightly larger than theirs obtained for cardiac patients.

B. EFFECT OF CARDIOLOGIST CONCENTRATION ON UTILIZATION

Table 3 shows estimates of the direct effect of physician concentration on cardiologist service utilization—specification 7. The first two columns report estimates where we proxy utilization with IUs, while columns 3 and 4 show estimates where we use a simple procedure count. Columns 5 and 6 depict results where the dependent variable is the amount of cardiologist IUs per procedure—a measure of the average intensity of the procedure used. Columns 7 and 8 report estimates where the dependent variable is the amount of inpatient cardiologist IUs per day admitted—another measure of intensity. Finally, columns 9 and 10 report estimates where we proxy utilization with RVUs.

Under the full sample, a one standard deviation increase in the FTHHI causes about a 5 percent increase in IUs. The estimates are equivalent using the sample of unexpected AMIs and using RVUs. The estimates using the number of procedures and the average intensity of the procedure as the dependent variable paint a more vivid picture. Specifically, there is no strong effect of concentration on the number of procedures but there is a strong statistically significant effect on the average intensity of the procedure as well as the average intensity of an admitted day in the hospital. Thus, an increase in concentration causes the cardiologists to perform more services in terms of the intensity of the procedure, rather than the number of procedures.[44]

Table 4 shows estimates where the dependent variable is the use of a specific procedure or drug: any type of echocardiogram, MPI test, cardiovascular stress test, cardiac catheterization, angioplasty, or CABG. Here we run a linear probability model where the left-hand-side variable is a dummy variable indicating whether the patient received the type of procedure within 90 days of the heart attack.[45] Recall that a catheterization is an intensive procedure performed by the cardiologist to obtain information about the severity of the heart attack, while echocardiograms, MPI tests, and cardiovascular stress tests are less intensive diagnostic procedures. After the results of the diagnostic procedures are revealed, an angioplasty or CABG may or may not be performed to treat the patient.

44 Note that these estimates also correspond to supply elasticity estimates. Specifically, they are approximately equal to the estimates found in Table 5, β, multiplied by the supply elasticities, γ, found in Table 6. For instance, a 10 percent increase in concentration causes about a 0.4 percent increase in price, which translates to about a 0.5 percent increase in IU supply under a price elasticity of supply of 1.25.

45 Estimates using either a logit or probit model are similar.

TABLE 3. Effect of cardiologist concentration on cardiologist service utilization

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Outcome:	Log cardiologist IUs		Log cardiologist procedures		Log cardiologist IUs per procedure		Log inpatient cardiologist IUs per inpatient day		Log cardiologist RVUs	
Log FTHHI	0.052[a]	0.049[b]	0.014	0.010	0.038[b]	0.038[b]	0.113[a]	0.112[a]	0.042[b]	0.045[b]
	(0.017)	(0.020)	(0.011)	(0.012)	(0.015)	(0.016)	(0.023)	(0.027)	(0.018)	(0.022)
Removed patients with any cardiovascular treatment before AMI		X		X		X		X		X
Observations	12,020	6,952	12,020	6,952	12,020	6,952	11,430	6,602	12,020	6,952

Notes: The dependent variable is the logarithm of cardiologist IUs (columns 1 and 2), the logarithm of the number of cardiologist procedures (columns 3 and 4), the logarithm of the number of IUs per procedure over the 90 days following an AMI (columns 5 and 6), and the logarithm of RVUs (columns 7 and 8). All regressions include state-year fixed effects and controls specified in equation 7. Standard errors clustered by county are in parentheses. [a] $p < 0.01$, [b] $p < 0.05$, [c] $p < 0.10$.

TABLE 4. Effect of cardiologist concentration on use of specific procedures

Outcome:	(1) Any echocardiogram	(2) Any MPI test	(3) Any stress test	(4) Any cardiac catheterization	(5) Any angioplasty	(6) Any CABG
Log FTHHI	−0.014	−0.026[a]	−0.033[a]	0.011[b]	0.007	0.001
	(0.013)	(0.008)	(0.009)	(0.005)	(0.007)	(0.005)
Observations	12,020	12,020	12,020	12,020	12,020	12,020

Notes: The dependent variable is a dummy variable representing whether an echocardiogram (column 1), myocardial perfusion imaging test (column 2), stress test (column 3), catheterization (column 4), angioplasty (column 5), or CABG (column 6) was performed over the 90 days following an AMI. All regressions include state-year fixed effects and controls specified in equation 7. Standard errors clustered by county are in parentheses. [a] $p < 0.01$, [b] $p < 0.05$, [c] $p < 0.10$.

There is a positive response of catheterization to an increase in concentration, but a negative response of cardiovascular stress tests, MPI tests, and echocardiograms, albeit the latter is statistically insignificant. This result is consistent with the results in Table 3, where the cardiologist shifts to more intensive services. Here, an intensive diagnostic procedure (catheterization) is chosen instead of, or in addition to, the less intensive diagnostic procedures. Once the diagnostic test is performed, the severity is known, and there is likely less uncertainty as to whether further treatment should be provided. This may explain why there is no response in angioplasty or CABG.

B.1. FALSIFICATION EXERCISE. In Table 5 we perform a type of falsification test in which we include episodes where a capitated payment was made to the cardiologist. Before dropping capitated episodes for our previous analysis, our sample included 513 episodes where a capitated payment was made (4 percent of all episodes). If the effect of concentration on service utilization is stemming from its effect on service prices, we would expect there to be no effect of the FTHHI on service use for episodes where capitated payments are made. In this specification, we include the 513 capitated episodes in our sample, as well as a corresponding dummy variable indicating whether the episode was capitated as well as an interaction with the FTHHI variable. The implied effect of the FTHHI on utilization for capitated episodes is then the sum of the coefficient on the interaction (i.e., Log(FTHHI) × Capitated) and the coefficient on the FTHHI. Table 5 shows that there is no statistically significant effect of the FTHHI on service utilization for capitated episodes.[46] The coefficient on the interaction term is negative, which implies the total effect on capitated episodes is smaller than fee-for-service episodes. As an additional test, we run our main specification on the sample of only capitated episodes. We similarly find an insignificant estimate, although the coefficient is *negative*. Although there is a possibility that the statistically insignificant effect on capitated episodes may in part be due to sample size issues, this exercise gives some credence to the idea that the effect of physician concentration on service provision comes through, at least partially, via service prices.

46 The total amount transacted for episodes involving capitated payments is unknown. Therefore, service prices may not be computed for these episodes.

TABLE 5. Effect of cardiologist concentration on cardiologist service utilization: Difference-in-differences with capitated episodes

	(1)	(2)	(3)
Log FTHHI	0.052[a]	0.050[b]	−0.121
	(0.017)	(0.020)	(0.086)
(Log FTHHI) × Capitated	−0.040	−0.015	
	(0.028)	(0.031)	
Capitated	−0.069	−0.076	
	(0.085)	(0.101)	
Implied Log FTHHI + (Log FTHHI) × Capitated	0.014	0.040	
	(0.030)	(0.034)	
Removed patients with any cardiovascular treatment before AMI		X	
Capitated patients only			X
Observations	12,533	7,225	513

Notes: The dependent variable is the logarithm of cardiologist IUs over the 90 days following an AMI. The first two samples are larger because they include capitated episodes. All regressions include state-year fixed effects and controls specified in equation 7. Standard errors clustered by county are in parentheses. [a] $p < 0.01$, [b] $p < 0.05$.

As a robustness exercise, we reproduced the specification used in Table 3, assessing how cardiologist concentration directly affects cardiologist utilization, including fewer control variables. Specifically, we assessed how the results change when we do not control for observable measures of AMI severity. If the estimates do change, this would lead us to believe that unobserved severity may also be affecting our results. We found only negligible changes in the coefficient when the severity controls are taken away, providing some suggestive evidence that unobserved severity is not important in driving our results.

C. EFFECT OF CARDIOLOGIST CONCENTRATION ON EXPENDITURES

The study thus far has estimated the effect of cardiologist concentration on services specifically provided by the cardiologist. Concentration affects both the service price and the cardiologist's service utilization, the two components of cardiologist expenditures. As shown in Table 1, cardiology services represent only a fraction of total services performed over the 90-day episode of care. However, since the cardiologist is the primary decision maker in terms of types of care, it is possible that a change in the cardiologist's market power might impact the total cost of treating a heart attack more broadly.

To examine the impact on the total cost of treating a heart attack, Table 6 reports estimates of the impact of cardiologist concentration total expenditures, as well as the impact on cardiologist and noncardiologist expenditures. Specifically, total expenditures are simply the sum of payments over the entire 90 days following the AMI. The latter two measures split these payments into two mutually exclusive buckets.

TABLE 6. Effect of cardiologist concentration on expenditures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Outcome:	Log total expenditures		Log cardiologist expenditures		Log noncardiologist expenditures		Share cardiologist expenditures	
Log FTHHI	0.004	0.008	0.091[a]	0.089[a]	0.000	0.003	0.004[c]	0.004[b]
	(0.016)	(0.019)	(0.022)	(0.024)	(0.018)	(0.020)	(0.002)	(0.002)
Removed patients with any cardiovascular treatment before AMI		X		X		X		X
Observations	12,020	6,952	12,020	6,952	12,020	6,952	12,020	6,952

Notes: The dependent variable is the logarithm of total expenditures (columns 1 and 2), the logarithm of cardiologist expenditures (columns 3 and 4), the logarithm of noncardiologist expenditures (columns 5 and 6), and the share of total expenditures paid to the cardiologist (columns 7 and 8) over the 90 days following an AMI. All regressions include state-year fixed effects and controls specified in equation 7. Standard errors clustered by county are in parentheses. [a] $p < 0.01$, [b] $p < 0.05$, [c] $p < 0.10$.

Estimates show that higher cardiologist market concentration has a statistically significant effect on cardiologist expenditures (columns 3 and 4 of Table 6)—a one standard deviation increase in concentration causes about an 8 percent increase in expenditures. This effect is attributable to the 3 percent effect of concentration on prices (Table 2) as well as the 5 percent effect on service utilization (Table 3). Higher cardiologist market concentration has no statistically significant effect on noncardiologist expenditures or total AMI expenditures. This latter result may be because the share of total AMI expenditures going to the cardiologist expenditures is small (9 percent). Overall, higher cardiologist concentration raises the share of total expenditures going to the cardiologist (columns 7 and 8 of Table 6).

D. EFFECT OF CARDIOLOGIST CONCENTRATION ON HEALTH OUTCOMES AND QUALITY METRICS

Our final analysis examines the impact of cardiologist concentration on health outcomes and quality metrics. It is not clear, a priori, whether market power should have any definitive effect on the health of the patient. On one hand, the higher price stemming from market concentration may provide an incentive to the cardiologist to exert more effort or perform necessary tests and procedures. On the other hand, the additional procedures may not be necessary or may be excessive in terms of treating the patient. In addition, less competition between physicians may imply less pressure to compete along the quality dimension. There is mixed evidence in the hospital market. Kessler and McClellan (2000), Kessler and Geppert (2005), Cooper et al. (2011), Gaynor, Moreno-Serra, and Propper (2013), and Bloom et al. (2015) find that more competition between hospitals leads to higher quality and/or better health outcomes. Ho and Hamilton (2000), however, find no measurable impact on mortality, while Propper, Burgess, and Green (2004) and Propper,

TABLE 7. Effect of cardiologist concentration on health outcome and quality metrics

	(1) Death in hospital	(2) Readmission to hospital for AMI	(3) Readmission to hospital for any cardio cond.	(4) Beta blockers within 90 days	(5) Angioplasty within one day
Log FTHHI	−0.002	−0.002[b]	0.001	0.021[a]	0.005
	(0.002)	(0.001)	(0.004)	(0.007)	(0.006)
Observations	11,309	12,020	12,020	10,146	12,020

Notes: The dependent variable is (1) a dummy indicating whether the patient's discharge status indicated death within 90 days of the AMI, (2) a dummy indicating whether the patient was readmitted for an AMI between 90 and 365 days of the AMI, (3) a dummy indicating whether the patient was readmitted for any cardiovascular condition between 90 and 365 days of the AMI, (4) a dummy indicating whether the patient was prescribed beta blockers within 90 days of the AMI, or (5) a dummy indicating whether the patient received an angioplasty the day of the AMI. All regressions include state-year fixed effects and controls specified in equation 7. Standard errors clustered by county are in parentheses. [a] $p < 0.01$, [b] $p < 0.05$, [c] $p < 0.10$.

Burgess, and Gossage (2008) find that competition leads to higher mortality. To examine the impact of concentration on health outcomes, we use two measures of adverse health outcomes: whether the patient died in the hospital, and whether the patient was readmitted with complications.

For a large portion of the MarketScan database there is information about the discharge status of the patient. This means that, for those observations where a discharge status is available, we have information about whether the patient died in the hospital. Using this discharge status variable, we create a dummy variable indicating whether the patient died in the hospital within 90 days of the AMI (see Table 1). As described in Section III, the data show that 1.7 percent of individuals in the full sample and 1.2 percent of individuals in the unexpected AMI sample had a death status at discharge.[47] Readmission is measured as whether the patient returned to the hospital for complications due to an AMI, as well as any cardiovascular condition, between 90 and 365 days after the AMI.

Estimates of specification 7, using a dummy variable indicating death within 90 days of the AMI as the dependent variable, is reported in the first column of Table 7. The results are statistically insignificant, as were results using a logit specification (not depicted). Table 7 also shows the impact on readmission rates, indicating that cardiologist concentration decreases the probability that the patient is readmitted for an AMI. The effect for readmission for any cardiovascular condition is statistically insignificant. Results did not change when we included a control for hospital concentration or when we ran the regression on the sample of unexpected AMIs. Overall, these estimates provide evidence that market

47 Dauda (2016) finds that 60 percent of AMI deaths occur in the hospital. Tu et al. (1999) and Rosenthal et al. (2000) find that in-hospital and the 30-day mortality rate are very highly correlated, and find no evidence that in-hospital mortality rates are biased due to post-discharge mortality or discharge practices.

power does not lead to worse health outcomes. The results on readmissions suggest that higher concentration may lead to improved health outcomes.

A multitude of unobserved factors might affect both mortality and readmissions. An alternative way to evaluate the quality of the physician that is less susceptible to unobservable factors is to examine whether their patients' treatment follows best practices. We assess the impact of concentration on two measures of quality—whether beta blockers were prescribed after the AMI[48] and whether an angioplasty was performed on the same day as the AMI. Both measures are indicators of higher quality and have been shown to have a significant effect on mortality.[49] Approximately 80 percent of the patients in our sample were prescribed beta blockers within 90 days of the AMI and 64 percent of those patients who had any angioplasty had one within one day of the AMI. We also ran a specification conditional on any angioplasty being performed and found similar results. There is a positive effect of concentration on the probability that beta blockers are prescribed; however, this result was not statistically significant in the sample of unexpected AMIs (shown in the Online Appendix). Overall, there is no strong evidence that concentration leads to better or worse quality of care in terms of these metrics.

VII. Conclusion

This study shows that physician market power affects not only payment rates, but also service utilization. We estimate that a one standard deviation increase in cardiologist concentration causes a 3 percent increase in payments, but also a 5 percent increase in service provision by the cardiologist. This results in an expenditure increase of approximately 8 percent. Market power impacts the type of procedure rather than the number of procedures. Specifically, cardiologists in more concentrated markets perform more intensive procedures, particularly diagnostic procedures. Evidence from the difference-in-differences specification using capitated episodes leads us to believe that the impact of physician market power on service utilization is through the effect of market power on the physician's reimbursement rate, similar to other studies finding a link between financial incentives and treatment decisions. We were surprised to find that concentration may lead to lower readmission rates, although the mechanism as to how or why this happens is not clear to us. Focusing on two additional measures of treatment quality based on the specific treatments provided to the patient, we find only a limited correlation between these quality measures and concentration.

A limitation of our study is that we identify variation in treatment decisions across observed geographic differences in concentration, as opposed to random differences. To

48 The measure of quality based on beta blockers prescribed may only be applied to those cases where we observe prescription drug information. Approximately 16 percent of the patients in our sample do not have prescription plan information in the MarketScan. We therefore run our regressions conditional on prescription plan information being available in the data, which removed 1,874 observations from the full sample and 985 patients from the unexpected AMI sample.

49 Receiving angioplasty within the first day is discussed in Chandra and Skinner (2012). Receiving beta blockers post-AMI has been a metric for quality in numerous studies and has been shown to have a significant effect on mortality (Gottlieb, McCarter, and Vogel 1998).

be clear, we cannot entirely be sure that our results are not influenced by omitted variables, unrelated to market structure that are spuriously correlated with both our FTHHI measure and cardiologist service use. However, we show that unobserved cost and health severity variation would likely bias our results against the findings in this study. That is, the main qualitative result in this study is not likely to be impacted by these types of omitted variable biases. This leads us to believe that our estimates may underestimate the true impact of concentration on utilization. An avenue for future research would be to exploit time series variation in physician concentration, although we note that this type of variation is also not immune to similar types of endogeneity concerns.

Overall, our findings are potentially important for antitrust analysis and suggest that changes in organization structure in a market, such as a merger of physician groups, influences not only the negotiated prices of services, but also the utilization of medical treatments. Our main estimates imply that over half of the impact of concentration on expenditures is through quantity as opposed to price.

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DISCLAIMER

The views expressed in the paper are those of the authors and not of the Bureau of Economic Analysis, the Federal Reserve System, or the Federal Reserve Bank of San Francisco.

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