Essays on Competition in Health Care Markets

By

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Abstract

In these essays, I empirically estimate the impact of interactions between primary care physicians (PCPs) and specialists on physician behavior. In the first chapter, I examine the impact that the acquisition of PCPs by firms employing specialists has on patient referral patterns in markets where integration takes place. In the second chapter, I estimate a model of physician entry behavior to understand the extent to which PCPs and specialists consider the number of physicians of the other type in the market when selecting which markets to enter.

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Chapter 1

Can Hospitals Buy Referrals? The Impact of Physician Group Acquisitions on Market-Wide Referral Patterns

Summary

In the United States, hospitals and multispecialty physician practices acquired over 1,100 primary care physician (PCP) practices between 2009 and 2013. These acquisitions increase the incentives acquired PCPs have to refer patients to specialists employed by the acquirer, altering referral flows in markets where physician group acquisitions take place. As a result, the acquisition of PCP practices may lead to an increase in the acquirer's share in the market for specialty physician services. Using Medicare billing data, I construct a novel database of physician mergers, which I link to data on referral relationships for the universe of physicians accepting Medicare. Utilizing an event study framework that takes advantage of the structure of referral linkages to control for merger endogeneity, I find that the average acquired PCP increases referrals to specialists employed by the acquirer by 52 percent after acquisition. This comes at the expense of referrals to specialists employed by competitors rather than from demand inducement. Following integration, referrals from the average acquired PCP to specialists employed by competitors fall by 7 percent. These results suggest that the acquisition of PCP practices by hospitals or multispecialty practices may result in an increase in market share in specialty services for acquirers. However, I also find evidence that competitors recoup some of the lost referrals from other PCPs in the market. Therefore, the typical acquisition of a PCP practice results in the reshuffling of referral relationships in the market rather than only an increase in market share for the acquirer.

1.1 Introduction

Between 2009 and 2013, hospitals and multispecialty physician practices acquired over 1,100 primary care physician (PCP) practices. If the acquirer employs PCPs prior to the acquisition, these mergers may result in standard horizontal anticompetitive effects by increasing concentration in the market for primary care services. To date, acquisitions of PCPs by specialty firms have received less scrutiny from regulatory agencies than have other types of health care mergers, and when they have been scrutinized, the focus has been on horizontal competitive effects, as in St. Alphonsus Medical Center versus St. Luke's Health System (United States Court of Appeals, 2015). However, these mergers also have the potential for vertical anticompetitive effects, and it is necessary to know the magnitude of these effects to understand the full impact of these mergers on competition. In this paper, I evaluate the extent to which the acquisition of PCP practices by hospitals and multispecialty practices lead to the vertical anticompetitive effects of foreclosure and reduced competition by quantifying the impact of these acquisitions on referral patterns.

Acquisitions of PCP practices by specialty firms – either hospitals or multispecialty practices – have the potential for vertical anticompetitive effects because the PCP and specialist markets are linked through patient referrals. A defining feature of the market for physician services is the information asymmetry that exists between patients and physicians. Because patients may be unable to accurately evaluate physician services, they depend on physicians to recommend services they need, and in the case of PCPs, to refer them to specialists. However, when making referrals, physicians may act as imperfect agents for their patients, maximizing their own payoff in addition to patient utility if there is asymmetric information. Being acquired by a firm that employs specialists may make referring to specialists employed by the acquirer more attractive to acquired PCPs. For example, integration may give acquired PCPs a financial stake in the acquiring firm or reduce the cost of referring to specialists employed by the acquirer by streamlining electronic medical records and appointment scheduling. Therefore, mergers between specialty firms and PCP practices may increase the acquirer's market share in specialty markets by changing the flow of referrals.

One difficulty in studying mergers involving physician practices is the limited data available. Since these mergers are typically small, they generally do not meet Hart-Scott-Rodino reporting requirements[1] and may not even be accompanied by a press release from the parties. In order to

[1] Under the Hart-Scott-Rodino Act, companies are required to notify the FTC and Department of Justice about

study the impact of acquisitions of PCP practices on referral patterns, I use Medicare billing data to construct a novel database of mergers involving hospitals and physician practices. I have identified 4,195 mergers involving practices or hospitals employing physicians of any type that took place between 2009 and 2013, and I utilize a subset of 947 acquisitions of PCP practices by firms that employ specialists from 2010 to 2013 in my analysis. I then link this database to 188 million Medicare referrals between 2.5 million physicians pairs that took place between 2009 and 2014. Finally, I utilize the Hospital Compare database from the Centers for Medicare and Medicaid Services (CMS) and data from the American Hospital Association (AHA) to classify firms as hospitals and private practices.

Care should be taken when generalizing the results of this study to privately insured patients. While Medicare insures a large share of the patient population, the Medicare population is not a representative sample. Medicare typically reimburses providers at lower rates and – unlike many private insurance plans – does not restrict which providers patients can see. The Medicare population is also older. Lower Medicare reimbursement rates and an older patient population with more entrenched referral relationships may reduce the effect of integration on referrals for Medicare patients compared to privately insured patients. On the other hand, less restriction on provider choice may lead to a larger integration effect for Medicare patients. Nakamura et al. (2007) found that integration between two hospitals had a larger effect on referrals of privately insured patients than Medicare patients. Predicting which of these effects dominates for integration involving physician practices is an area for future research.

In order to understand the impact that mergers between specialty firms and PCP practices have on referrals, it is necessary to look at several different patient flows. I first estimate the impact of an acquisition on referrals from acquired PCPs to specialists employed by the acquirer. However, this does not fully capture the impact of a merger on the acquirer's specialty services market share. If the supply of referrals is relatively inelastic, an increase in referrals from target PCPs to the acquirer will result in a decrease in referrals to competitors. Hospital markets are typically local and concentrated; therefore, competing hospitals may respond to the loss of referrals by increasing incentives to other PCPs in the market to recoup some of the lost referrals. In addition, acquirers may be capacity

transactions that exceed a certain threshold. The threshold in 2008 – the first year in this study – was \$63.1 million, and as of 2016, had risen to \$78.2 million. Most transactions involving physician practices fall well below this threshold. For example, the 2012 acquisition of Saltzer Medical group – a forty-four physician practice – by St. Luke's Health System was valued at \$9 million.

constrained, leading non-acquired PCPs who previously referred patients to them to refer elsewhere. If either of these effects occur, a merger may result not in an increase in specialty service market share for the acquirer but rather a realignment of referral relationships in the market. In order to examine this possibility, I also measure the impact of a merger on referrals from non-acquired PCPs to competitors.

To estimate these changes to referral patterns, I use a difference-in-difference framework. A valid concern is that mergers between PCP and specialty practices are endogenous. For instance, specialty practices may acquire PCP practices with whom they have weak referral relationships, or specialty practices that acquire PCPs may be growing relative to other firms. In order to address these concerns, the difference-in-difference model controls for time-invariant heterogeneity across physician referral pairs. I also take advantage of the unique structure of referral data to control for unobservable time-varying heterogeneity. Since specialists receive referrals from multiple PCPs, I am able to include specialty firm by year fixed effects to control for trends that are unique to specific firms. Therefore, the results are unbiased under the assumption that referral flows between merging PCPs and specialists, with the exception of specialty firm-specific time trends, would have followed the same time trends, absent the merger, as pairs that did not merge. Because I allow for differing time trends across treated firms, this is weaker than the standard difference-in-difference assumption.

This study makes several contributions to the existing literature. To my knowledge, this is the first paper to study the impact on referral patterns of mergers between physician practices and hospitals using panel data for more than a single market. Previous studies of the effects of mergers on referral patterns have focused on the effects of hospital mergers on hospital admissions (Huckman, 2006; Nakamura et al., 2007; Nakamura, 2010). However, all of these studies lack physician-level panel data and cannot control for unobservable heterogeneity to the degree that I can. Furthermore, the effect of mergers between physician practices and hospitals on admissions may differ from the effect that hospital mergers have on hospital visits. In particular, obtaining referrals may be a more direct aim of physician practice acquisitions. Studies that have looked specifically at the effect of hospital employment on referrals have used either a case study (Carlin et al., 2016) or cross-sectional data (Baker et al., 2015). My analysis uses panel data to control for time-invariant differences between merging and non-merging physicians and exploits multiple referral relationships for a given physician to control for time-varying heterogeneity. Finally, I look at the impact of an acquisition on a number of different referral relationships in the market to obtain a more complete understanding of the effect of mergers on specialty services market shares.

Using the data and methodology described above, I estimate that the average acquired PCP increases referrals to specialists employed by the acquirer by 52 percent after acquisition. This comes at the expense of referrals to specialists employed by competing specialty practices: referrals from the average acquired PCP to specialists employed by competing specialty practices drop by 7 percent. I find that acquisition does not result in an increase in the total number of referrals from acquired PCPs, suggesting that physicians do not induce demand for referrals after integration. These results imply that the acquisition of PCP practices by specialty practices may result in an increase in market share in specialty services for acquirers. However, I also find evidence that competing hospitals recoup some of the lost referrals from other PCPs in the market. Therefore, the typical acquisition of a PCP practice by a specialty firm results in the reshuffling of referral relationships in the market, rather than only an increase in market share for the acquirer.

The rest of the paper is organized as follows. In Section 2, I discuss the market background. Section 3 describes the data. Section 4 presents the empirical framework. Section 5 presents the results, and Section 6 concludes.

1.2 Background

1.2.1 Physician Employment

For the purposes of this paper, I classify physicians as employees of one of two types of firms: hospitals and private practices (or "practices"). Physicians employed by hospitals receive salaries directly from the hospital. While hospital-employed physicians have less autonomy in running their practices, they receive administrative services and support negotiating contracts with insurers. Hospitals employed 21 percent of physicians in 2013, although the share varies across specialties (AHA, 2008-2013; AHRF, 2013).[2] PCPs are more likely than specialists to be employed by hospitals: in 2013, 25 percent of PCPs were hospital employees compared to 20 percent of specialists (AHA, 2008-2013).

I classify all physicians not employed directly by a hospital as private practice employees. A

[2]This number differs across sources: Kane and Emmons (2013) report that 23 percent of respondents to a survey by the American Medical Association in 2012 reported being employed by a practice at least partially owned by a hospital, but only 6 percent reported direct hospital employment. A survey done by the Medical Group Management Association found that 34 percent of physicians were employed by a hospital-owned practice in 2013 (Burns et al., 2013).

private practice is a firm consisting of one or more physicians who share equipment, records, and personnel and distribute income among members according to a prearranged agreement (Burns et al., 2013). Profit sharing agreements are common among partner physicians, but support staff and some physicians may be paid on a salaried or hourly basis. Most private practices are small: the average private practice employs four physicians. By comparison, the average hospital-based practice employs thirty physicians (AHA, 2008-2013; CMS, 2008-2014). The size of private practices can vary greatly: 19 percent of physicians are employed by solo practices, while 38 percent are employed by practices with over 50 physicians. Fifty-three percent of physicians are employed by multispecialty practices, which employ at least two specialties.

While some private practices are independent, there are a number of different types of relationships private practices have with hospitals. Individual physicians may have admitting privileges at one or more hospitals, and private practices may be affiliated with a hospital through a contractual relationship short of employment. Sixty-five percent of hospitals report having an affiliation agreement with physicians (AHA, 2008-2013).[3] Affiliation agreements differ in the degrees of risk sharing, operational integration, exclusivity, and capital investment (Ciliberto and Dranove, 2006; Cuellar and Gertler, 2006). The most common type of affiliation arrangement is the integrated salary model (ISM).[4] In my data, I observe whether hospitals have contractual relationships with physician practices but not which physician practices is involved in the relationship. Therefore, I do not distinguish between practices based on hospital affiliation in my analysis.

Consolidation of Physician Practices and Hospitals

The number of physicians employed by health systems and multispecialty practices has increased in recent years, a fact that has been well documented (Kocher and Sahni, 2011; Burns et al., 2013; Cutler and Morton, 2013; Kane and Emmons, 2013). The share of physicians employed by hospitals rose from 16 to 21 percent between 2010 and 2013, and the share employed by multispecialty practices increased from 42 to 53 percent between 2008 and 2014. PCP employment exhibited similar trends: hospital employment increased from 22 to 25 percent between 2010 and 2013, and multispecialty

[3]The response rate for this question was 77 percent, so the share of hospitals with affiliation agreements may be as low as 50 percent.

[4]There are a number of other types of affiliations. Under Management Service Organizations (MSOs), hospitals buy the physical assets of the physician group and provide administrative services, such as record-keeping and billing. Physician Hospital Organizations (PHOs) are joint ventures in which hospitals provide administrative services and manage facilities; however, physicians maintain independent offices and own their practices. Independent Practice Associations (IPAs), the loosest form of affiliation between hospitals and physician groups, are contractual relationships in which hospitals and physicians jointly hold managed care contracts.

practice employment increased from 50 to 61 percent between 2008 and 2014 (AHA, 2008-2013; CMS, 2008-2014). These increases are attributable both to a propensity for new physicians to choose employment at hospitals and larger private practices (Christianson et al., 2014), as well as to acquisitions of smaller physician practices by hospitals and larger private practices. In this paper, I focus on the latter.

The passage of the Patient Protection and Affordable Care Act (ACA) was one of the primary drivers of this recent wave of consolidation. The ACA has accelerated the move from fee-for-service payment to alternative payment models, such as bundled payments and accountable care organizations (ACOs), which compensate providers based on cost and quality rather than volume.[5] As a result of provisions in the ACA, 30 percent of Medicare claims were billed through alternative payment models in 2015, and CMS expects the share to increase to over 50 percent by the end of 2018 (Obama, 2016). Private insurers are following suit: Aetna and Blue Cross have committed to move 75 percent of their contracts into alternative payment models by 2020.[6]

Physician practices have several motivations for integrating with hospitals and other private practices. First, in order to participate in an ACO, a firm must be able to collect and analyze data on patient health outcomes, which can require large upfront costs. For example, the cost of installing an electronic health record (EHR) system to track these data range from \$32,000 to \$120,000 per physician in the first year of implementation (Christianson et al., 2014; Fleming et al., 2011). Hospitals and larger private practices have easier access to capital and can better take advantage of economies of scale to make these types of investments. Additionally, the increasing cost and complexity of group management has led physicians to pursue integration. Integrating with a health system or other private practice reduces physicians' administrative duties and allows them to spend more time on patient care. Physicians list financial security and fewer administrative responsibilities as the top reasons for choosing hospital employment over private practice. In addition, physicians may integrate with hospitals to take advantage of Medicare reimbursement rates that compensate care provided in hospital outpatient facilities at a higher rate than care provided at private practices' offices (Koch et al., 2016).

The ACA has also made employing physicians more beneficial for hospitals. ACOs may comprise

[5]The fee-for-service model compensates physicians based on the amount of time a service takes. By contrast, providers who participate in ACOs are compensated based on both quality and cost metrics, in addition to volume of care. If the treatment costs of an episode of care are less than targets set by the Centers for Medicare and Medicaid Services (CMS) and certain quality standards are met, the members of an ACO share the savings.

[6]Source: http://hcttf.org/aboutus/

health care providers from multiple firms. By employing the physicians involved in their ACOs, hospitals are better able to monitor and adjust quality and costs for the entire episode of care. This allows hospitals to control costs and meet quality targets under alternative payment models (Christianson et al., 2014). In addition, a reduction in inpatient care has led hospitals to purchase outpatient facilities (Cutler and Morton, 2013). Furthermore, both hospitals and physician practices seek integration as a way to increase their size and negotiating position with insurers (Christianson et al., 2014; Kirchhoff, 2013). Finally, hospitals and multispecialty practices acquire PCPs to control the stream of referrals to physicians they employ, which is the focus of this paper.

Together, these trends point to continued integration of physicians and hospitals in coming years, and these same forces are also driving multispecialty physician practices to acquire PCP practices. A large part of this consolidation comes in the form of mergers and acquisitions, and importantly, these events have the potential for anticompetitive effects in markets for physician services.

1.2.2 Referrals

Referrals are an economically important conduit for medical expenditures. Primary care physicians – which include specialties such as family practitice and internal medicine[7] – are typically patients' first point of contact with the health care system in the United States. PCPs provide routine preventative care, treat common conditions, and refer patients to specialists for more complex treatment or testing. Through referrals, PCPs act as downstream firms selecting upstream specialists as inputs in the bundle of care they provide their patients. In this sense, PCPs serve as gatekeepers for medical services performed by specialists.

A defining feature of the market for physician services is the asymmetry of information between patients and physicians (Arrow, 1963). Health care services can be complicated and difficult to evaluate, and primary care physicians receive at least seven years of specialized training – medical school and residency – that equips them with knowledge about the services a patient seeks. Therefore, physicians may act as agents for their patients, evaluating specialist quality on their behalf. While public insurance programs such as Medicare and Medicaid allow patients to contact specialists directly, some private managed care plans, specifically health maintenance organizations (HMOs), require patients to receive a referral from their PCP before seeing a specialist for most procedures.

[7]Primary care providers may also include non-physician providers, such as nurse practitioners and physician assistants; however, in this paper I focus only on physicians

A PCP acting as a perfect agent will choose a specialist to maximize her patient's utility. However, there is a wide body of evidence suggesting that a PCP makes medical decisions to maximize some combination of her own payoff and the patient's utility. (Pauly, 1980; Nakamura et al., 2007; Ho and Pakes, 2014). The physician's payoff includes both the cost of the referral, such as the time the PCP must spend learning about the quality of the specialist, as well as any benefit she receives. The patient's utility may include the distance he must travel to the specialist, the health he receives from the referral, and other attributes of the specialist, such as bedside manner. The specialist to whom a PCP refers a patient will differ from the specialist that maximizes the patient's utility if the direct payoff to the PCP offsets the reduction in the patient's utility.

1.2.3 Effect of Integration on Referrals

The acquisition of a PCP practice by a firm employing specialists may affect several different referral flows. In addition to affecting referrals from acquired PCPs, integration may affect referrals from other PCPs in the market where the merger takes place. To illustrate these effects, I use a stylized market with two physician practices employing PCPs and two hospitals employing specialists, presented in Figure 1.1. The arrows represent patients referred from a PCP firm to a specialty firm. For example, A1 is the flow of patients referred from Physician Group A to Hospital 1. In this example, Physician Group A is acquired by Hospital 1 and Physician Group B and Hospital 2 are independent.

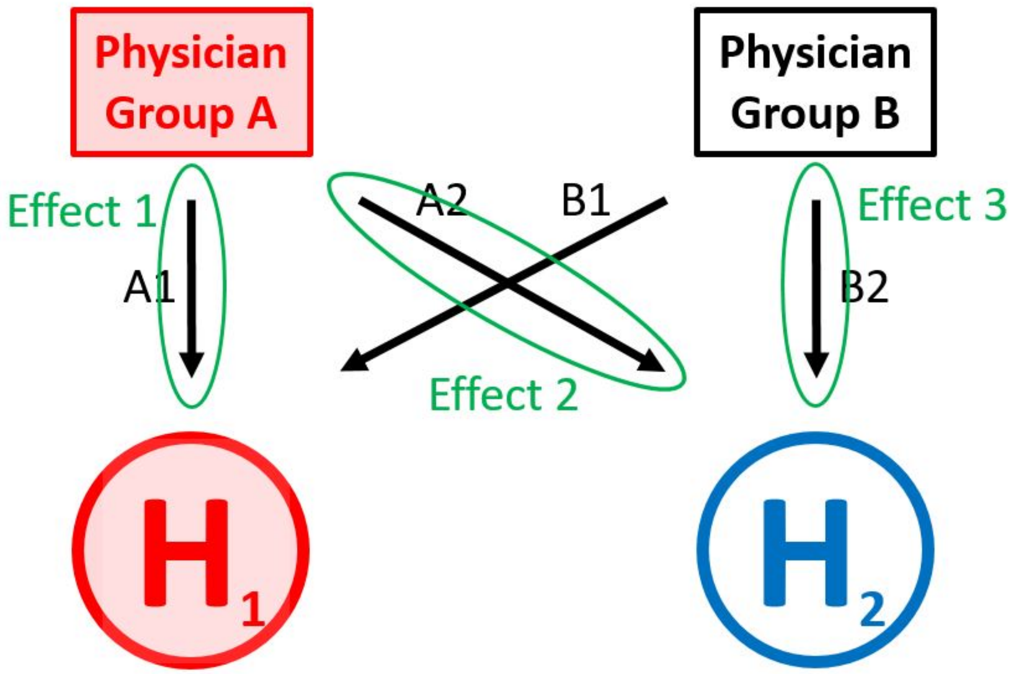


Figure 1.1: *Effect of Integration on Referrals Flows*

Referrals from Acquired PCPs

The primary referral flow that integration affects is the flow of patients from acquired PCPs to specialists employed by the acquirer, which is labeled "Effect 1" in Figure 1.1. In particular, being acquired by a firm that employs specialists may make a PCP more likely to refer patients to specialists employed by the acquirer for several reasons. First, a merger may increase the benefit a PCP receives for making a referral to a specialist employed by the acquirer by increasing the payoff for referring a patient to the acquirer or decreasing the cost of referring to the acquirer relative to other specialists. Second, the relative utility a patient receives for a referral to a specialist employed by the acquirer may increase post-merger.

Acquired PCPs may be more likely to refer patients to specialists at the acquirer post-merger due to increased payoffs. A series of laws, beginning with the 1972 Anti-Kickback Law and followed by the Stark Laws in 1989 and 1995, prohibit payments for referrals; however, financial incentives to refer patients to specialists employed by the same firm still exist. A number of hospitals have been convicted of violating the laws that prohibit payment for referrals in recent years (Schencker, 2015a,b,c, 2016). Even without breaking the law, hospitals are still able to incentivize physicians for referrals. For example, physicians employed by a hospital may have a financial stake in the profitability of specialists employed by the acquiring firm through profit sharing agreements.

Mergers may also lead acquired PCPs to refer more patients to specialists employed by the acquirer by decreasing the cost of referring patients to these specialists relative to other specialists. Acquiring physician practices and hospitals often take steps to make referring to physicians within the firm easier, such as the implementation a system that provides PCPs with information on specialists in the group that have available appointments. Additionally, being employed by the same firm may make it easier for PCPs to learn about specialists. Acquired PCPs may also now be part of a narrow insurance network with the acquiring hospital, therefore seeing patients who need to be referred to the acquiring hospital. While Medicare patients do not have restrictions on provider networks, PCPs may learn more about these providers through their other patients, making them more likely to refer all patients there.

Finally, a PCP may be more likely to refer a patient to a specialist at the acquirer post-merger because patients receive higher utility from seeing a PCP and specialist employed by the same firm. EHR systems facilitate better communication and coordination between physicians, which studies have shown may improve patient outcomes (Liss et al., 2011; O'Malley and Reschovsky, 2011; Peikes et al., 2009). However, only about half of physicians have access to electronic medical records for physicians outside of their practice (QuickStats, 2015). On the other hand, 87 percent of physicians work for a firm with an EHR system, increasing the probability that an acquired PCP will have access to the same EHR system as specialists employed by the acquirer after acquisition. Therefore, acquisition may increase the probability a PCP refers a patient to a specialist at the acquirer.

If referrals from acquired PCPs to specialists employed by the acquirer increase as a result of integration, either total referrals must increase or referrals to competitors must decrease. The effect of integration on referrals from acquired PCPs to competing specialists is represented in Figure 1.1 as "Effect 2". If demand for referrals is inelastic with respect to referral incentives, then referrals to competitors will fall and "Effect 2" will be negative.

Competitors' Responses to Consolidation

Given a shift in referrals made by acquired PCPs to the acquirer away from other specialists in the market, an acquisition may result in an increase in referrals from non-acquired PCPs to the acquirers' competitors (shown as "Effect 3" in Figure 1.1). There are two ways in which this could occur. First, competing hospitals and specialty practices may respond strategically to the loss of referrals from acquired PCPs. The market for physician services is local and concentrated. Gaynor et al. (2013) estimate that the average hospital in California has three competitors. Therefore, a competitor's merger may elicit a response. Specifically, a competitor could increase incentives to non-acquired PCPs in the market in order to make up for referrals lost from the acquired PCPs. Competitors could make themselves more attractive to all physicians in the market by investing in infrastructure and services. They may also target specific PCP practices. For example, hospitals can form joint ventures or contract with physician practices to provide services for the hospitals. In addition, both hospitals and private practices employing specialists may reach out to specific PCPs directly or through a referral consultant to provide PCPs in the market with information about the firm's specialists.

Second, if capacity constraints at the acquirer are binding, non-acquired PCPs in the market may be forced to refer patients elsewhere, so I test for this possibility as well. It is important to distinguish between these effects because they have different implications for competition. If firms respond strategically, the acquisition may result in a realignment of referral relationships in the market, diminishing the initial change in market share to the acquirer. However, if an increase in referrals to competitors is the result of the acquirer's capacity constraint, the increase may be temporary, since the acquirer can expand output in the long run (e.g., by hiring more specialists).

1.3 Data

For a measure of referrals, I use the number of Medicare patients shared between pairs of providers, which is publicly available from CMS for 2009 to 2014 (CMS, 2009-2014b). A visit is counted as a referral from Provider A to Provider B if the patient saw Provider B within 30 days of a visit to Provider A. Visits with at least one claim billed to Medicare Part A (e.g., hospital care) or Part B (e.g., preventative care) are included in the sample, and the data include both inpatient and outpatient claims. As is standard in the literature, I use annual counts of patients referred between pairs of PCPs and specialists, which I call "referrals." While a referral may be thought of as a recommendation of a specialist from a PCP to a patient, which specialist a patient actually sees is the relevant outcome for measuring the effect of integration on market share. Integration may increase the number of recommendations an acquired PCP makes for specialists employed by the acquirer, but only when patients follow these recommendations – which is what patient flows measure – is market share shifted from competitors to the acquirer.

The raw Medicare referral data contain observations only when there are positive referral flows between physicians. However, the absence of referrals between a PCP and specialty firm is itself information. For example, if an acquired PCP refers zero patients to the acquiring firm in the year prior to integration and a positive number of patients post-integration, I want to capture that as an increase in referrals. Therefore, for my analysis, I add zeros for missing PCP and specialist firm pairs for all years in which the PCP and the specialty firm bill claims to Medicare when I observe positive referrals between the PCP and the specialty firm in at least one year in the study period. I also add zeros for target PCP and acquiring specialty firms even if I never observe referrals between the pair in the data because excluding these observations would bias the results upward.[8]

To associate physicians' referrals with firms, I use the Medicare Data on Provider Practice and Specialty (MD-PPAS) file from CMS (CMS, 2008-2014). A physician billing to Medicare must assign to a claim both her physician identification number (the National Provider Identifier), as well as the Tax Identification Number (TIN) for her firm. I assign providers to firms based on the share of Medicare Part B claims they bill under a firm's TIN. The MD-PPAS data contain Medicare claims for the top two TINs under which a physician bills, which represent 99.6 percent of total claims billed. For my analysis, I assign a physician's employer as the TIN under whom they bill the largest number of claims at the annual level. On average, the first TIN captures 95.8 percent of total claims, and 87.3 percent of physicians in my sample bill over 90 percent of claims to one TIN in a given year.

I also use the MD-PPAS file to identify provider specialty. I classify physicians with the following specialties as PCPs: Family Practice, General Practice, and General Internal Medicine. These account for 94.1% of physicians classified as primary care physicians by Medicare. I exclude PCPs who bill over 90 percent of their claims in an inpatient setting for at least one year in the sample, which accounts for 17.7 percent of PCPs. I remove these physicians to limit the number of inpatients in the sample, since inpatients have no choice of firm at which to see a specialist. I also limit specialists to

[8]Due to confidentially restrictions, referrals are not reported for providers who share fewer than eleven patients in a given year. Therefore, as a robustness check, I set missing referrals equal to ten when I observe referrals between a PCP and specialist pair at some point in the sample period. Since my analysis is conducted at the PCP and specialty firm level, I only add a value of ten when I observe referrals from a PCP to the firm that employs the specialist otherwise.

the top seven medical and surgical specialties by number of referrals: Cardiology, Gastroenterology, General Surgery, Nephrology, Ophthalmology, Orthopedic Surgery, and Pulmonary Disease. These specialties account for 53.4 percent of specialists that accept Medicare, and specialists in these fields perform services for which patients commonly receive referrals.

Finally, I use the Physician Compare database from CMS to identify hospitals among employers in the MD-PPAS data (CMS, 2013-2014). I assign TINs to hospitals based on physicians' Medicare billings, hospital name, and state. I am able to match TINs to 2,861 of 4,581 (62.5 percent of) general medical and surgical hospitals in the AHA data.

1.3.1 Merger Identification

I use employer (TIN) changes in the MD-PPAS data set to identify mergers between firms that employ physicians. Firm A is acquired by Firm B in year Y if, beginning in year Y, no provider bills to Firm A and more than fifty percent of providers employed by Firm A in the year prior to the merger are employed by Firm B in year Y.[9] Since my focus is on mergers rather than individual employees switching physician practices, I only consider the acquisition of practices that employ at least two providers who accept Medicare prior to the merger.[10] Such firms employ 85.5 percent of PCPs in the sample.

Using this methodology, I have identified 4,259 mergers involving physician practices and hospitals. There was an increase in mergers in every year between 2009 and 2013, except in 2012 (Table 1.1). The sharpest increase took place between 2009 and 2010, possibly in anticipation of the ACA. The vast majority of mergers in my sample involved the acquisition of private practices; only 1.5 percent of mergers involved the acquisition of hospitals. This suggests that this methodology does not do a good job of identifying the acquisition of hospitals, possibly because these mergers involve a more complicated tax structure. Most mergers involve multiple both PCPs and specialists. Only 21.6 percent of mergers involved only PCPs or only specialists (Table 1.2), while the plurality of mergers involved the acquisition of firms that employed only specialists (44.3 percent). Vertical mergers, the focus of this analysis, accounted for 34.0 percent of all mergers. They accounted for

[9]In some cases, employee count drops off in years prior to falling to zero. In instances where employment falls by more than 60% and does not subsequently increase prior to dropping to zero, I identify acquirers in the drop off year and consider the year with the drop off to be the year in which the merger took place. In instances when the acquirer identified in the drop off year and the merger year disagree, I remove the merger from my sample.

[10]Studying individual physicians switching firms is an interesting question; however, I focus on the acquisition of an entire firm because of the availability of policy remedies to address such transactions through antitrust regulation.

a higher share of acquisitions by hospitals (38.9 percent) than those by physician practices (32.9 percent). Vertical mergers involving the types of PCPs and specialists used in my analysis account for 26.1 percent of total mergers.

In order to study the impact of integration on referrals, I focus on vertical mergers – acquisitions of private practices that employ at least one PCP by hospitals and private practices that employ at least one specialist. Because I only have referral data for 2009 through 2014, I use mergers that took place between 2010 and 2013, which leaves me with 947 acquisitions by 548 firms. I include physicians in the set of acquired PCPs if they were employed by a target firm in the year prior to the merger and the acquiring firm in the year of the merger. I include physicians in the set of acquiring specialists if they were employed by an acquiring firm at any point during the sample period. I classify physicians as targets or acquirers only in years in which they were employed by either the target or acquiring firm.[11]

There are several potential concerns about identifying mergers using this method. First, because the data only include Medicare claims, it is possible that physicians stop billing claims under a TIN, not because the group was acquired, but because the group stopped accepting Medicare. However, in order for a TIN to be identified as an acquired firm (target), over half of providers must subsequently bill the majority of their claims to the same TIN. It is possible that this could occur absent a merger if the new TIN was previously a secondary TIN that now became the primary for members of a group. However, this is not what I observe in the data. Second, using tax information only captures integration when physicians become employees of a different firm. Therefore, this method does not capture looser forms of integration between physician groups and hospitals.

1.3.2 Summary Statistics

Primary Care Physicians

Table 1.3 contains summary statistics for PCPs used in the analysis. The data contain 198,685 PCPs. Ninety-three percent of non-pediatric PCPs accept Medicare (about the same share that accept private insurance), so these represent the vast majority of practicing PCPs (Boccuti et al., 2015). Of the PCPs in the sample, 3,662 PCPs are classified as target PCPs. While this represents only 1.9 percent of the sample, physician markets are very local, so these may represent a large

[11] The exception is target PCPs who were employed by another firm prior to employment by the target firm. I classify these as target PCPs, since they provide information on pre-integration referral flows for these PCPs.

share of a given PCP market. Target PCPs make 6.0 million referrals during the study period, which represents 3.2 percent of total referrals made.

Targets differ from controls on some observable characteristics. Prior to integration, target firms are more likely to be multispecialty firms than are control firms – 45.4 percent of target firms are multispecialty compared to only 19.0 percent of control firms. On average, target firms are slightly larger than control firms, employing 3.8 PCPs compared to 3.3 PCPs on average, and the average target PCP sees more patients. Target PCPs make fewer referrals per patient and bill less per patient than do control PCPs, suggesting that target PCPs may see healthier patients. The average number of referrals per patient is high – about one referral per patient for both target and control PCPs. However, Medicare patients are intensive users of the health care system. Not all PCPs in the billing data appear in the referral data due to the censoring of the data below eleven referrals. Only 68.6 percent of control and 89.9 percent of target PCPs have positive referrals in at least one study year. Importantly for identification, PCPs refer to a large number of specialty firms: The average target PCP refers to specialists employed by 10.4 firms, and the average control PCP refers to specialists at 9.3 firms.

Specialists

Table 1.4 contains summary statistics for specialists used in the analysis. The billing data contain 128,333 physicians from the top seven specialties, 19,749 (15.4 percent) of whom are employed by an acquirer at some point during the study period. The characteristics of acquiring firms differ from those of non-acquirers. On average, acquirers are much larger, employing 33.9 specialists compared to 3.3 specialists employed by non-acquiring firms. In addition, 97.7 percent of acquirers are multispecialty firms prior to integration, compared with 19.0 percent of other firms. The average specialist employed by an acquirer sees fewer patients and bills less per patient. However, the average acquirer-employed specialist receives a similar number of referrals as the average control specialist. A smaller share of acquirer-employed specialists appear in the referral data: 72.5 percent compared to 76.6 percent. However, because acquirers employ more specialists, acquiring firms are more likely to have referrals in the data: 98.7 percent compared with 84.7 percent. Finally, specialists receive referrals from a large number of PCPs. The average acquiring firm receives referrals from 128.4 PCPs at 85.3 firms.

1.4 Estimation

I use an event study, which has several advantages over the difference-in-difference framework, to estimate the effect of integration on referral patterns. First, it is possible that referral patterns do not respond to a merger immediately, and as a result referrals between the merging parties may not shift immediately following integration or may grow over time, both of which an event study can capture.[12] Additionally, an event study allows for the identification of pre-merger trends. Small, insignificant coefficients on pre-integration merger effects support the important identifying assumption that trends in referrals between physician practices and hospitals that merge do not differ from trends in referrals between other firms.

1.4.1 Referrals between Merging Parties

As discussed in Section 2, a merger between PCP and specialty firms may increase incentives for target PCPs to refer patients to specialists employed by the acquirer, resulting in an increase in the number of referrals made by target PCPs to specialists employed by the acquiring firm.[13] To begin, I assume that only referrals from target PCPs to specialists employed by the acquirer respond to the merger. In this base model, I estimate the effect of integration on the number of patients referred, R_{ijt}, from primary care physician i to specialists employed by firm j in year t as

$$R_{ijt} = \phi_{ij} + \lambda_{jt} + \gamma_{it} + \sum_{s \in \mathcal{S}} \alpha_s^m M_{ijt}^s + \epsilon_{ijt}, \tag{1.1}$$

$$\text{where } \mathcal{S} = \{-4, -3, -2, 0, 1, 2, 3, 4\},$$

using OLS. The indicator M_{ijt}^s is equal to one when both the referring PCP and receiving PCP are parties in the same merger s years after t and zero otherwise. Therefore, the effect of being integrated s years after the merger relative to the year prior to the merger is given by the vector of treatment indicators, α_s^m. Unlike a difference-in-difference model, which would give the effect of an event relative to the pre-period, the event study gives the effect relative to a single omitted year, in this case, the year prior to the merger. Thus, α_0^m gives the estimated change in referrals in the year

[12] Hospitals often transition acquired physicians to their compensation formulas over a period of two years (Christianson et al., 2014).

[13] I exclude referrals to specialists employed by the target firm in the main specification.

the merger was consummated, while α^m_{-2} is the effect of the merger two years prior to the merger, both relative to the year prior to the merger. Standard errors are clustered at the referring physician by receiving firm level.

It is possible that mergers are endogenous events. To address this concern, I include fixed effects to control for several types of unobservable heterogeneity that may exist between merging parties and other firms. First, specialty firms may be more likely to acquire PCPs with whom they already have strong referral relationships. To control for time-invariant differences between merging PCP and specialist firm pairs, the model includes referring physician by receiving firm fixed effects, ϕ_{ij}. Second, it is possible that specialty firms that acquire physicians are growing or contracting, which could lead to referral growth or decline relative to their peers, respectively. I exploit the structure of the data to control for time-varying differences between acquirers and other firms. In the sample, 99 percent of acquiring firms to whom target PCPs refer patients also receive referrals from non-target PCPs. Because acquiring specialty firms receive referrals from both target and non-target PCPs, I am able to include λ_{jt}, a matrix of receiving firm by year fixed effects. I also include referring physician by year fixed effects to address similar concerns for target PCPs.[14]

My estimates will be unbiased under the assumption that the differences in the time trends of referrals between merging physicians and those of referrals between other pairs of physicians can be written as a linear combination of PCP and specialty firm time trends. This assumption is weaker than the standard event study assumption that the time trends between treated and untreated observations do not differ. I am unable to control for unobservable time-varying heterogeneity in referrals between specific physician pairs because time-varying physician pair by year fixed effects are collinear with the treatment effect variables. Therefore, the estimates will be unbiased only under the untestable assumption that there is no correlation between time trends in referral patterns and the decision to integrate. However, small and insignificant coefficients on the treatment variables for years prior to the merger provide support for the assumption that time-trends do not differ, leaving only the assumption that there is no contemporaneous shock. Mergers are typically planned at least a year before consummation, making this less likely, since the shock would need to be anticipated prior to the decision to integrate.

[14]98 percent of target PCPs who refer to specialists employed to the acquirer refer patients to other specialists as well.

1.4.2 Referrals from Acquired PCPs to Competitors

In Section 4.1, I assumed that only referrals from target PCPs to acquiring specialists respond to the merger; however, that need not be the case. If this assumption fails to hold, the estimates from the specification in Section 4.1 will not accurately portray the effect of integration on referrals between the merging parties.

If demand for specialty services is inelastic, then an increase in referrals to the acquiring firm will result in a decrease in referrals to other specialists, all else equal. If target PCPs decrease referrals to other specialists post-merger, then the effect estimated in Equation 2 will overstate the true effect of the merger on referrals from target PCPs to acquiring specialists. Therefore, I estimate the model with separate treatments for both the effect of a merger on referrals from target PCPs to acquiring specialists and the effect on referrals from target PCPs to non-acquiring specialists:

$$R_{ijt} = \phi_{ij} + \lambda_{jt} + X_{it}\beta^p + \sum_{s \in \mathcal{S}} \alpha_s^m M_{ijt}^s + \sum_{s \in \mathcal{S}} \alpha_s^o O_{ijt}^s + \epsilon_{ijt}, \tag{1.2}$$

where the indicator O_{ijt}^s is equal to one if the referring PCP was acquired in s years after t and the receiving specialist was is employed by the acquirer. As in Equation 1, α_s^m measures the effect of integration on referrals from target PCPs to acquiring specialists. The model also includes an additional set of treatment effects, α_s^o, which measure the effect of integration on referrals from acquired physicians to specialists who are not employed by the acquiring firm. I am unable to include PCP by year fixed effects in this model, since they are collinear with the treatment effects. To control for differences in the time trends between target PCPs and other PCPs, the model includes X_{it}, a vector of time-varying observable PCP characteristics, which contains amount billed per patient and patient panel size.

1.4.3 Total Target PCP Referrals

I next look at the effect of integration on the total number of referrals from target PCPs. Demand for referrals may not be perfectly inelastic. For some patients, such as those seeking elective procedures or on the margin of benefiting, physicians may make the choice about not just who to refer to but whether to refer at all. If this is the case, a merger may result in a change in the total number of referrals made by target PCPs.

On one hand, a merger may lead to an increase in the total number of referrals. If integration increases incentives to refer patients to acquiring specialists, PCPs may induce demand for additional referrals for marginal patients. Additionally, a merger may lead PCPs to refer out some procedures they previously performed themselves. There are some procedures that can be performed by either a PCP or a specialist. For example, PCPs often perform pap smears and other tests performed by gynecologists. While physicians employed by private practices are often compensated through profit sharing arrangements, hospitals pay physicians on a salaried basis, decreasing the financial incentives target PCPs have to perform procedures themselves after acquisition by a hospital. Alternately, a merger may lead to a decrease in the total number of referrals made by target PCPs. Hospitals cite cost savings as a key reason to integrate. If this is in fact the case, PCPs may perform a larger portion of care themselves or refer fewer marginal patients, resulting in fewer referrals to specialists, which is likely to lead to cost savings.

I estimate the effect of integration on the total number of referrals made by target PCPs as

$$R_{it} = \gamma_i + \tau_t + X_{it}\beta^p + \sum_{s \in \mathcal{S}} \alpha_s^{target} T_{ijt}^s + \epsilon_{ijt}, \tag{1.3}$$

where T_{ijt}^s is equal to one if referring physician i was acquired s years after t and zero otherwise. α_s^{target} measures the effect of being acquired s years after the merger on referrals to all specialists. Significant positive values of α_s^{target} for $s \geq 0$ are consistent with the demand inducement hypothesis, while significant negative values are consistent with the cost savings hypothesis. I run this regression at the PCP by year level. As in Equation 2, PCP by year fixed effects are collinear with the treatment effects. Therefore, I include time-invariant PCP fixed effects, γ_i, and time-varying PCP characteristics, X_{it}, to control for PCP heterogeneity. I also include year fixed effects, τ_t, to control for secular time trends. Standard errors are clustered at the PCP level.

1.4.4 Referrals from Non-Acquired PCPs to Competitors

If target PCPs decrease referrals to specialists not employed by the acquirer following integration, referrals from non-target PCPs to competitors may increase. This could happen in one of two ways. First, it may be optimal for competing firms that lose referrals from target PCPs following a merger to increase referral incentives to non-acquired PCPs in the market in order to recoup some of the lost referrals. Second, acquirers may give preference to referrals from PCPs they employ. Previous work has found that acquired PCPs may refer more profitable patients to the acquirer (Nakamura et al., 2007). If the acquirer is capacity constrained, non-acquired PCPs may be forced to refer patients elsewhere, resulting in an increase in referrals to non-acquiring specialists. If either of these effects occur, integration may result in a realignment of referral relationships in the market where the merger took place, offsetting some or all of the increase in market share to the acquirer due to an increase in referrals from target PCPs. In order to identify a more homogeneous set of competitors, I study only referrals to cardiologists in the analyses discussed in this section.

Competitor Responses

To test whether cardiology firms respond to a merger by a competing cardiology firm, I look at the effect of the acquisition of a PCP firm from which a cardiology firm received referrals prior to the merger on referrals from non-acquired physicians to the specialty firm. If competing specialty firms respond to a merger by increasing incentives, referrals from non-acquired physicians should increase post-merger. One would expect that firms that received a larger share of referrals from target PCPs prior to the merger would have more incentive to respond, since they are at risk of losing more referrals. In order to test this, I estimate several versions of the model with treatments that allow for different levels of affiliation: the specialty firm received more than five, ten, or twenty percent of referrals from target PCPs in the year prior to integration.

One concern is that firms that acquire PCP practices are more likely than non-acquiring firms to be growing aside from the merger. For example, they may be investing in the quality of services they provide, hiring more specialists, or increasing advertising. When estimating the effect of integration on referrals between the merging parties in Equations 1 and 2, I include receiving firm fixed effects to control for these types of expansion. However, I am unable to employ that strategy here because it would result in using target PCPs – who are certainly affected by the merger – as controls. Instead, I include market-level fixed effects, excluding the acquirer. Therefore, referrals from non-acquired PCPs to the acquirers' competitors who did not receive referrals from target PCPs serve as the control group. All specialty firms in the acquirer's market will be exposed to expansion by the acquirer and other market trends, but only firms that lose referrals from target PCPS will have the incentive to increase incentives to other PCPs in the market after the merger in order to recoup to lost referrals.

I use referral relationships to identify each firm's set of competitors in the specialty services market. I first calculate the share of referrals that each specialty firm receives from PCPs at a given firm between 2009 and 2014. I then classify firms as competitors in the specialty services market if they both receive over 25 percent of referrals from the same set of PCP firms. I do not include market-level fixed effects for specialty firms with more than one acquiring competitor, since it is not possible to separate the effects of mergers by multiple competing firms on referrals to a given specialty firms. For this analysis, I limit my data set to referrals from PCPs to cardiologists, to construct a more homogeneous set of competitors.

I estimate the effect of integration on referrals from non-target PCPs to firms that received referrals from target PCPs prior to the merger as follows:

$$R_{ijt} = \phi_{ij} + \rho_{jt} + \gamma_{it} + \sum_{s \in \mathcal{S}} \alpha_s^{comp} C_{ijt}^s + \epsilon_{ijt}, \tag{1.4}$$

where ρ_{jt} denotes time-varying market-level fixed effects for the competitors of each acquirer. The model also includes physician pair fixed effects, ϕ_{ij} and PCP by year fixed effects, γ_{it}. [15] The indicator C_{ijt}^s is equal to one when the referring PCP was not acquired during the sample period and the receiving firm received referrals from a target firm in the year prior to integration and did not acquire a PCP firm during the sample period. I run several versions of the model, letting C_{ijt} vary with the number of referrals the receiving firm received from the target physician practice. In the loosest specification, I include all firms that receive over five percent of referrals from target physician groups, and in the tightest specification I include firms that receive over twenty percent of referrals from target physicians. In some instances, a firm that received referrals from a target PCP firm may also acquire a PCP firm following the initial merger. Because this is a rare occurrence, I remove these firms from my sample of responding competitors. [16]

[15] I do not include the number of cardiologists employed by the receiving firm in each year as a control because this may be affected by the merger. For example, if competitors lose referrals as a result of the merger, they may employ fewer specialists. I run an alternative specification that does include number of cardiologists and find similar results.

[16] While acquiring a PCP firm is a potential response to the acquisition of a PCP firm by a competing cardiology firm, I do not include this in my analysis due to endogeneity concerns. In particular, mergers may be correlated with unobservable market characteristics. It is possible that the same market unobservables that lead to mergers also lead specialty groups to align with PCPs in other ways. However, I argue that while a merger is a binary choice, other types of incentives are continuous. For example, deciding how much money to invest in capital improvements or outreach to physician groups. Therefore, if the latent variable that leads to a merger is continuous and increasing, then these types of incentives should increase over time, which would be picked up in a pre-trend. Of course, this still depends on the assumption that there is not a shock to the market correlated with the initial merger.

Capacity Constraints

I next study whether referrals from non-acquired PCPs to specialists employed by acquirers decrease post-merger as a result of capacity constraints. If acquirers are capacity constrained and receive an increase in referrals from target PCPs following integration, PCPs who referred to an acquirer prior to integration will be forced to shift referrals from acquirers to other firms. As a result, referrals between PCPs who referred to the acquirer prior to integration and non-acquiring specialty firms should increase post-merger. Therefore, to test for the presence of capacity constraints, I analyze the effect of integration on referrals from these PCPs to non-acquiring firms. A positive effect indicates that acquirers are capacity constrained, which may limit their ability to increase market share in the short term.

I estimate this effect as follows:

$$R_{ijt} = \phi_{ij} + \lambda_{jt} + X_{it}\beta^p + \sum_{s \in \mathcal{S}} \alpha_s^{cap} D_{ijt}^s + \epsilon_{ijt}, \tag{1.5}$$

which includes physician-firm pair fixed effects, ϕ_{ij}, specialty firm by year fixed effects, λ_{jt}, and time-varying PCP observables, X_{it}. The coefficients of interest are the vector treatment coefficients α^{cap}. The indicator D_{ijt}^s is equal to one when the referring PCP referred more than twenty percent of patients to an acquiring cardiology firm in the year before the merger. Referrals from target PCPs and referrals to acquiring cardiology firms are non included in the treatment group. Because the model includes specialty firm by year fixed effects, referrals from PCPs who did not refer patients to an acquirer prior to the merger act as controls for specialty firm specific time trends. These PCPs should not be affected by acquirer capacity constraints.[17]

1.5 Results

1.5.1 Referrals between Merging Parties

I begin by estimating the effects of integration on referrals from target PCPs to specialists employed by the acquirer. I present the results for the baseline specification, Equation 1, in the first column of Table 1.5. The estimated coefficients for the treatment effects are presented graphically in Figure

[17] I exclude referrals from PCPs who referred between zero and twenty percent of patients to an acquirer in the year prior to integration since they are affected by the merger. Including them would bias the effect towards zero.

1.2. All of the pre-merger treatment coefficients are insignificant and small, except for the coefficient four years prior to integration, which is significant at the ten percent level. The magnitude of the largest pre-merger coefficient, α^1_{-4}, is less than one fifth that of the largest post-merger coefficient, α^1_4. Small and insignificant coefficients provide support for the exclusion restriction. Acquisition has an immediate impact on referrals to specialists employed by the acquirer. Referrals increase by 8.6 referrals in the merger year. This is lower than the impact of integration on referrals in subsequent years because PCPs are employed by the acquirer for only part of the integration year.

One to four years after integration, referrals from target PCPs to acquiring specialists are between 22.0 and 28.1 referrals higher than referrals in the year prior to integration. In the year prior to integration, target PCPs refer on average 33.6 patients to specialists employed by the acquirer; therefore, this is equivalent to an increase of 65.5 to 83.6 percent for the average target PCP. While there is an increase in referrals between one and four years after integration, the coefficients one and four years post-merger are not significantly different at the ten percent level. Therefore, most of the increase in referrals occurs immediately following integration. This is consistent with financial incentives and administrative changes in how referrals are made, and suggests that learning about specialists employed by the acquirer, which would take place over time, is a less important driver of referral growth.

1.5.2 Total Referrals Made by Target PCPs

I next check to see whether integration affects PCPs' extensive margin when choosing whether to refer a patient at all. The final column for Table 1.5 contains the estimates of the effect of integration on the total number of referrals made by target PCPs as specified in Equation 3, and the treatment coefficients for this model are plotted in Figure 1.4. Again, the coefficients on the pre-merger treatment effects are small and insignificant. The average treatment effect is a reduction of 7.0 referrals in the year following the merger, which grows to a reduction of 19.8 referrals three years after the merger, the latter of which is significant. A decrease in referrals post-merger implies that acquisition does not lead target PCPs to induce demand for specialty services.

There are several possible explanations for a reduction in referrals. One possibility is that acquired PCPs see healthier patients who need fewer referrals following acquisition. I run regressions similar to Equation 3 with total patients in a PCP's panel and the charges billed per PCP as the outcomes and no time-varying PCP controls. I report the coefficients from these regressions in the first two columns of Table 1.6. As shown in the first column, four years after integration, PCPs see 39.3 fewer patients than they do in the year prior to integration, which is equivalent to an 8.9 percent reduction in panel size for the average target PCP. Furthermore, target PCPs bill 28.0 dollars less per patient four years after integration relative to the year prior to the merger. While I control for number of patients and charges billed per physician in Equation 3, it is possible that charges billed is an imperfect control for patient health. Alternatively, a decrease in referrals is consistent with the story that hospitals acquire PCPs in order to reduce costs. PCPs referring a smaller share of patients to specialists could be the result of PCPs reducing unnecessary referrals or performing more services themselves, both of which may help to contain costs. Therefore, despite no evidence of demand inducement, referrals may be somewhat elastic with respect to incentives.

1.5.3 Referrals to Competing Specialists

Since total referrals do not increase following integration, the increase in referrals to specialists employed by the acquirer must result in a decrease in referrals to competing specialists. Therefore, the treatment coefficients estimated in Equation 1 will overstate the true effects. This is due to the inclusion of PCP by year fixed effects, which bias the results upward since referrals to competitors must be decreasing as a result of integration. Thus, I estimate Equation 2 in order to estimate the magnitude of Effect 2, as well as to get a more accurate estimate of Effect 1.

The second and third columns in Table 1.5 contain the estimated coefficients for Equation 2, and Figure 1.3 plots the treatment coefficients for this model. The pre-merger coefficients are small and insignificant for both treatments. The effect on referrals in Column 3 indicates that integration results in an insignificant decrease of 0.3 referrals from target PCPs to non-acquiring specialists in the year of integration. In subsequent years, referrals fall further, by between 1.9 and 3.3 referrals relative to the year before integration. As expected, the treatment effects for the merging parties estimated in Equation 2, which are presented in Column 2, are smaller than those estimated in Equation 1, which includes PCP by year fixed effects. Referrals increase by 7.5 referrals in the year of integration, and in following years, referrals are between 17.5 and 21.1 referrals higher than they were in the year before integration. For the average target PCP, this is equal to an increase of 52.2 to 63.1 percent relative to the year prior to integration.

Integration between PCP and specialty firms may lead to several types of anticompetitive effects. First, acquisition may lead to an increase in market concentration if the acquirer has a large market share in the specialty services market. Because the average target PCP refers 222 patients to specialists employed by the acquirer in the year prior to integration, acquisition results in a target PCP referring an additional 7.9 to 9.5 percent of their patients to specialists employed by the acquirer. Therefore, acquiring ten percent of PCPs in the market will lead the acquirer to gain an additional one percent market share in the specialty service market after four years. Second, integration may lead to a reduction in referral match quality. If patients have heterogeneous preferences, then PCPs who refer to a larger set of specialists may be better able to match patient preferences with specialist characteristics. However, a shift in referrals to specialists employed by the acquirer from other specialists may lead to a narrowing of specialists in the PCP's referral network. Indeed, as shown in Columns 3 and 4 of Table 1.6, target PCPs refer to 0.5 fewer specialists and 0.4 fewer specialty firms in the year after integration.

1.5.4 Competitor Responses

I next test whether competitors are able to recoup some of the referrals they lose from target PCPs after the merger through an increase in referrals from other PCPs in the market. This could occur either because competitors respond to the loss of referrals by increasing incentives for referrals or because the acquirer is capacity constrained and an increase in referrals from target PCPs necessitates other PCPs referring patients elsewhere. If the former occurs, there should be an increase in referrals from all non-target PCPs only to hospitals that previously received referrals from target PCPs. Whereas, if the increase in referrals is due to capacity constraints, only PCPs who referred to the acquirer prior to the merger should increase referrals to competitors.

Competitor Responses

The results of the regressions from Equation 4 are presented in the first three columns of Table 1.7. The first column presents the estimates for when the receiving specialty firm received more than five percent of referrals from a target PCP firm in the year prior to the merger. Figure 1.5 plots the event study coefficients for this treatment. All of the treatment coefficients after the year of integration are positive, and those two and three years after integration are significant at the ten and five percent-level, respectively. There is a negative trend prior to the merger, so the post-merger coefficients may be biased downward. If competitors are respond to a merger by increasing incentives for referrals, those who received the largest share of referrals from target PCPs should have larger responses.

However, competitors who received over ten or twenty percent of their referrals from target PCPs recouped no referrals from other PCPs in the market, and in fact saw their referrals from these PCPs decrease as well. The results for competitors who received over five percent of referrals from target PCPs suggest that competitors with a relationship to target PCPs may be able to recoup some of the lost referrals following integration; however, the other results, which should be larger, contradict this.

Capacity Constraints

The results of the regressions from Equation 5 are presented in the last column of Table 1.7. The coefficients on referrals from capacity constrained PCPs to non-acquiring specialty firms are significant pre-merger; however, the signs are positive. The effects on referrals are positive and significant in every year following integration, suggesting that capacity constraints may limit the extent to which acquirers can translate an increase in referrals from target PCPs into an increase in market share, at least in the short run. While this effect could attenuate an increase in market share for the acquirer, total referrals to the acquirer may increase in the long run as firms are able to adjust capacity.

1.5.5 Robustness Checks

Referrals by Specialty

Integration may have a differential effect on referrals to different specialties. Therefore, I estimate Equation 2 separately for each specialty and present the results in Table 1.8. For Effect 1 – the impact of the merger on referrals from target PCPs to specialists employed by the acquirer – all specialties have at least one positive and significant post-merger coefficient. Therefore, the integration effect is not due only to an increase in referrals to a particular specialty, but rather increases in referrals across specialties. Additionally, all specialties except for opthalmology experience a significant negative decrease in referrals to competitors in at least one year following integration.

Referrals to specialties that receive a higher share of visits that result from referrals may be more responsive to a change in referral incentives. Table 1.9 contains the coefficient estimates for Effect 1 by specialty ranked in descending order by the share of visits to the specialty that result from referrals. As expected, the specialties with the smallest increase in referrals – orthopedic surgeons and ophthalmologists – are those with the smallest share of visits that result from referrals.

Hospital and Private Practice Acquirers

I include all acquirers – both hospitals and private practices – in the main analysis. However, different types of firms may respond differently to integration. Therefore, I also conduct the analysis separately for acquirers that are hospitals and those that are private practices. For these analyses, I limit the sample to referrals to firms of the same type as the acquirer, since these are more similar to the treated referrals and therefore should act as better controls. The estimates for Equation 2 are presented in Table 1.10.

The estimates for Effect 1 – the impact of integration on referrals from target PCPs to specialists employed by the acquirer – are similar in magnitude for both types of acquiring firms. One year after integration, referrals to acquirers are 19.6 and 17.6 referrals higher for hospitals and private practices, respectively. Both types of acquirers achieve similar peak increases as well –24.7 for hospitals and 25.1 for private practices. However, hospitals achieve this two years after integration compared to four years after integration for private practices. This could be due to hospitals implementing more systematic changes, such as having receptionists booking referrals, while private practices either implement these slower or may depend on PCPs learning about specialists employed by the firm over time.

Effect 2 for private practice acquirers is similar to the main results for all acquirers: integration results in a decrease of between 2.2 and 3.7 referrals to each competitor. However, integration leads to no significant decrease in referrals to competing hospitals for hospital acquirers. While the confidence intervals are large, including referrals to private practices produces smaller bands but still no significant effect.

Missing Values

In the main specification, I assume that missing referrals between physician pairs that share patients in at least one year are equal to zero. However, referrals in those years could be anywhere between zero and ten. Therefore, I run alternative specifications of Equations 1 through 3 with missing values equal to ten rather than zero. The estimates for Equation 2 are presented in the first second and third columns of Table 1.11. The results for this specification are qualitatively similar to the results from the main specification but slightly smaller in magnitude. Referrals from the average PCP to each specialists employed by the acquirer increase by 15.8 referrals, compared to 17.9 referrals in the main specification. Relative to the base year, this represents an increase of 37.8 percent, compared to 53.4 percent in the main specification. The effect on referrals to competitors is also similar: a decrease of 2.1 referrals compared with a decrease of 2.3 referrals in the main specification in the year after integration. The impact on total number of referrals, presented in Column 4, is smaller in magnitude and similarly negative.

Referrals to Target Specialists

The prior analyses have looked at effect of integration on referrals to specialists employed by the acquirer who were not employed by an acquired PCP firm prior to integration. I exclude these because integration may not change the incentives that target PCPs have to refer to these specialists. Table 1.12 includes regression results for Equations 1 and 2 including these referrals. Not surprisingly, including referrals to target specialists produces a larger effect on referrals to the acquirer following integration. Because both models include receiving firm fixed effects, this indicates that target PCPs were more likely to refer patients to specialists employed by the same target firm than were other PCPs. Looking at Equation 2 in Columns 2 and 3, integration leads target PCPs to refer an additional 48.9 patients to the acquirer in the year following integration.

1.6 Conclusion

In this paper, I estimate the impact of acquisitions of PCP practices by hospitals and multispecialty practices on referral patterns. I find that the average acquired PCP increases referrals to specialists employed by the acquirer by 52 percent. While the magnitude of the effect is slightly sensitive to assumptions made about missing values, the sign of the effect is robust to alternate specifications. Acquisition also leads to a decrease in referrals from acquired PCPs to specialists employed by competing firms of 7 percent. Again, the sign of this effect is robust to alternate specifications. I find no evidence that acquisition results in inducement of demand for referrals and limited evidence that competitors are able to recoup lost referrals from non-acquired PCPs.

Together, these results imply that the acquisition of a PCP practice may increase the acquirer's market share for specialty services. On average, an acquired PCP refers an additional ten percent of her patients to specialists employed by the acquirer after integration. Therefore, for every ten percent of the PCP market a specialty firm acquires, its market share in the specialty service market increases by one percent. If the acquirer has a large share in the specialty service market prior to integration, the acquisition of PCPs could have anticompetitive consequences for the specialty services market. However, it is important to note that the magnitude of the effect is small. Assuming linearity, acquiring half of the PCP market would only give the acquirer an additional 5 percent share of the specialty service market. Therefore, evaluating vertical effects will be most valuable when a transaction involves a large share of the PCP market or the acquisition of specialists as well as PCPs.

The effect of shifting referrals to specialists employed by the acquirer on patient welfare is ambiguous. If patients were previously being referred to the utility maximizing specialist, a narrowing of specialist networks may reduce patient utility. However, increased communication and coordination between acquired PCPs and specialists employed by the acquirer may improve patient outcomes. Overall, the results of this paper results suggest that there is reason for further scrutiny of these mergers.

Table 1.1: *Mergers over Time*

	Hospital Acquires		Practice Acquires		
Year	Hospital	Practice	Hospital	Practice	All Mergers
2009	0	131	8	458	597
2010	0	171	9	602	782
2011	5	170	5	782	962
2012	0	153	8	772	933
2013	5	160	24	796	985
All Years	**10**	**785**	**54**	**3,410**	**4,259**

NOTE: Mergers are identified using Medicare claims data.

Table 1.2: *Acquisitions of Physician Practices by Specialty*

	Acquirer Firm Type					
	Hospital		Physician Practice		All Acquirers	
Merging Specialties	Count	Share	Count	Share	Count	Share
Specialists Only	21	2.7%	742	21.8%	763	18.2%
PCPs Only	13	1.7	132	3.9	145	3.5
Targets with Only Specialists	446	56.8	1,413	41.4	1,859	44.3
Vertical Mergers	305	38.9	1,123	32.9	1,428	34.0
Mergers Used in Analysis	230	29.3	865	25.4	1,095	26.1
All Specialties	**785**	**100.0%**	**3,410**	**100.0%**	**4,195**	**100.0%**

NOTE: Mergers are identified using Medicare claims data. This table includes acquisitions of physician practices between 2009 and 2013. Vertical mergers include acquisitions of firms that employ PCPs by firms that employ specialists. The set of vertical mergers used in the analysis includes only mergers involving PCPs who do not bill over ninety percent of claims in an inpatient setting in at least one year during the study period and specialists with one of the following specialties: cardiology, gastroenterology, general surgery, nephrology, ophthalmology, orthopedic surgery, and pulmonary disease.

Table 1.3: *PCP Summary Statistics*

	Targets	Controls
Number of PCPs	3,662	195,023
Number of Firms	947	80,734
Number of Referrals (Millions)	6.0	182.4
Multispecialty Firms (%)	45.4	19.0
Average Firm Size	3.8 (9.9)	3.3 (17.8)
Average Patients Seen	377.6 (308.1)	280.3 (286.6)
Average Charges per Patient	278.2 (139.1)	298.9 (280.4)
Average Referrals	361.7 (642.5)	304.5 (590.0)
Share of PCPs with Referrals	89.9	68.6
Share of Firms with Referrals	93.1	75.7
Average Specialists Referred To	21.2 (21.0)	18.0 (21.1)
Average Firms Referred To	10.4 (8.4)	9.3 (10.3)

NOTE: Standard deviations in parentheses. Averages of patients seen, charges per patient, and share of multispecialty firms are calculated for 2009. All other statistics are calculated for 2009 through 2014. Referral statistics include referrals to the following specialties: cardiology, gastroenterology, general surgery, nephrology, ophthalmology, orthopedic surgery, and pulmonary disease.

Table 1.4: *Specialist Summary Statistics*

	Acquirers	Controls
Number of Specialists	19,749	108,584
Number of Firms	548	48,057
Number of Referrals (Millions)	18.9	169.5
Multispecialty Firms (%)	97.7	19.0
Average Firm Size	33.9 (62.4)	3.3 (13.7)
Average Patients Seen	447.1 (594.7)	564.1 (583.6)
Average Charges per Patient	394.2 (223.1)	415.7 (309.8)
Average Referrals	390.7 (606.9)	394.7 (569.1)
Share of Specialists with Referrals	72.6	76.6
Share of Firms with Referrals	98.7	84.7
Average PCPs Received From	128.4 (137.0)	29.6 (40.1)
Average Firms Received From	85.3 (85.4)	24.7 (31.4)

NOTE: Standard deviations are in parentheses. Averages of patients seen, charges per patient, and share of multispecialty firms are calculated for 2009. All other statistics are calculated for 2009 through 2014. Statistics include the following specialties: cardiology, gastroenterology, general surgery, nephrology, ophthalmology, orthopedic surgery, and pulmonary disease.

Table 1.5: *Effect of Integration on Referrals from Acquired PCPs*

	Referrals from Acquired PCPs to			
	Acquirers (Equation 1)	Acquirers (Equation 2)	Others (Equation 2)	All Specialists (Equation 3)
Year Relative to Merger	(1)	(2)	(3)	(4)
Four Years Prior	-5.75*	-3.34	0.04	4.75
	(3.36)	(2.96)	(0.53)	(8.22)
Three Years Prior	-4.12	-1.15	0.62*	3.72
	(2.52)	(2.15)	(0.37)	(4.57)
Two Years Prior	-1.19	0.47	0.07	2.17
	(1.63)	(1.36)	(0.27)	(3.09)
Year of Merger	8.58***	7.50***	-0.28	-6.98
	(1.52)	(1.26)	(0.28)	(2.92)
One Year After	23.42***	17.94***	-2.32***	-17.06**
	(2.39)	(2.00)	(0.31)	(4.38)
Two Years After	25.06***	17.26***	-3.25***	-15.77***
	(3.11)	(2.58)	(0.39)	(5.23)
Three Years After	28.45***	21.02***	-2.96***	-19.84***
	(4.45)	(3.77)	(0.47)	(7.09)
Four Years After	27.74***	21.73***	-1.87***	-15.92*
	(5.31)	(4.72)	(0.65)	(8.55)
PCP by Specialty Firm FE	Y	Y		
Specialty Firm by Year FE	Y	Y		
PCP by Year FE	Y			
PCP FE				Y
Year FE				Y
Observations	5,991,352	6,104,227		724,808
Avg. 1 Year Prior	33.59	33.59	33.74	291.03

Note: The dependent variable in each regression is number of referrals to specialists. Equations 1 and 2 are run at the referring PCP by receiving specialty firm level and Equation 3 at the PCP level. Standard errors for Equations 1 and 2 are clustered at the referring physician-receiving firm pair level, and standard errors for Equation 3 are clustered at the referring physician level. Regressions without PCP by year fixed effects include controls for the number of patients a PCP sees, as well as charges per patient. The omitted category is the year prior to integration, which is normalized to zero. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.6: *Effect of Integration on Target PCP Characteristics*

Year Relative to Merger	Panel Size (1)	Amount Billed per Patient (2)	Number of Receiving Specialists (3)	Number of Receiving Firms (4)
Four Years Prior	-9.74**	-3.69	-0.33	0.04
	(4.83)	(2.68)	(0.25)	(0.11)
Three Years Prior	-6.63**	-2.14	-0.21	-0.07
	(2.98)	(2.04)	(0.16)	(0.07)
Two Years Prior	-2.16	-1.82	-0.04	-0.03
	(2.29)	(1.43)	(0.11)	(0.05)
Year of Merger	2.09	-1.53	0.18	0.04
	(1.75)	(1.48)	(0.11)	(0.04)
One Year After	-11.00***	-12.76***	-0.49***	-0.39***
	(2.48)	(1.76)	(0.15)	(0.06)
Two Years After	-16.97***	-18.38***	-0.73***	-0.39***
	(3.50)	(2.01)	(0.19)	(0.08)
Three Years After	-21.21***	-20.64***	-1.08***	-0.50***
	(5.56)	(321)	(0.28)	(0.11)
Four Years After	-39.27***	-27.97***	-1.42***	-0.75***
	(10.45)	(3.82)	(0.42)	(0.16)
PCP FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	967,455	967,455	614,941	614,941
Avg. 1 Year Prior	351.06	273.43	12.25	5.33

NOTE: Regressions are run at the PCP level. Standard errors are clustered at the referring physician level. The omitted category is the year prior to integration, which is normalized to zero. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.7: *Effect of Integration on Referrals to Competitors*

	Competitor Response (Equation 4)			Capacity (Equation 5)
	> 5%	> 10%	> 20%	> 20%
Year Relative to Merger	(1)	(2)	(3)	(4)
Four Years Prior	4.52	-1.46	-5.56**	2.83***
	(2.84)	(2.61)	(2.60)	(1.01)
Three Years Prior	2.03	2.15	1.80	2.29***
	(1.91)	(1.56)	(1.88)	(0.62)
Two Years Prior	1.16	1.56	0.66	2.06***
	(1.23)	(1.08)	(1.51)	(0.44)
Year of Merger	-0.62	-2.17	-0.32	2.61***
	(1.20)	(0.91)	(1.24)	(0.38)
One Year After	1.51	-1.25	-0.29	3.90***
	(1.53)	(1.37)	(1.66)	(0.46)
Two Years After	4.12***	-3.45**	-6.29**	5.23***
	(1.99)	(2.99)	(2.69)	(0.60)
Three Years After	3.82**	-5.25**	2.71	5.05***
	(1.97)	(2.26)	(3.54)	(0.78)
Four Years After	1.32	-9.91***	-8.53**	2.67**
	(2.43)	(3.43)	(4.10)	(1.06)
PCP by Spec. Firm FE	Y	Y	Y	Y
Spec. Market by Year FE	Y	Y	Y	
PCP by Year FE	Y	Y	Y	
Spec. Firm by Year FE				Y
Observations	1,794,582	1,794,582	1,794,582	1,889,877
Avg. 1 Year Prior	46.17	43.54	48.22	30.79

NOTE: The dependent variable in each regression is number of referrals to specialists. All regressions are run at the referring PCP by receiving specialty firm level. Standard errors are clustered at the referring physician-receiving firm pair level. Regressions without PCP by year fixed effects include controls for the number of patients a PCP sees, as well as charges per patient. The omitted category is the year prior to integration, which is normalized to zero. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.8: *Effect of Integration on Referrals from Acquired PCPs by Specialty*

	Cardiology		General Surgery		Gastroenterology		Nephrology		Ophthalmology		Orthopedic Surgery		Pulmonary Disease	
	Referrals from Acquired PCPs to													
	Acquirers	Others	Acquirers	Others	Acquirers	Others	Acquirers	Others	Acquirers	Others	Acquirers	Others	Acquirers	Others
Year Relative to Merger	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Four Years Prior	0.32	1.43	-0.22	1.72	-3.40***	1.09	-0.87	-1.12	-1.38*	-0.18	-0.70	1.83**	1.83	-1.43
	(2.66)	(1.26)	(1.02)	(1.06)	(1.22)	(0.86)	(1.54)	(2.00)	(0.78)	(0.70)	(0.96)	(0.73)	(1.41)	(1.87)
Three Years Prior	0.39	2.54***	0.12	1.42**	-2.09**	0.11	-0.85	-0.35	-0.89*	-0.33	0.33	-0.06	1.61	0.63
	(2.17)	(0.94)	(0.72)	(0.67)	(0.94)	(0.63)	(0.96)	(1.39)	(0.52)	(0.52)	(0.55)	(0.55)	(1.05)	(1.22)
Two Years Prior	2.52**	0.91	-0.15	0.61	-1.80**	-0.07	-0.67	0.22	-0.38	0.48	0.85**	0.30	-1.31	-1.43
	(1.16)	(0.72)	(0.55)	(0.44)	(0.73)	(0.47)	(0.61)	(0.99)	(0.32)	(0.38)	(0.43)	(0.39)	(1.22)	(0.97)
Year of Merger	3.36***	-0.59	1.93***	0.29	2.24***	-0.13	2.04***	1.66	0.23	0.84**	1.23***	-0.42	3.99***	-1.92
	(1.13)	(0.62)	(0.42)	(0.45)	(0.45)	(0.41)	(0.61)	(1.34)	(0.31)	(0.38)	(0.41)	(0.39)	(1.10)	(1.69)
One Year After	10.37***	-4.01***	4.09***	-0.83*	3.89***	-1.55***	3.54***	-0.24	0.66	-0.33	1.89***	-0.96**	6.36***	-2.62**
	(1.87)	(0.76)	(0.58)	(0.49)	(0.63)	(0.56)	(0.95)	(1.34)	(0.52)	(0.42)	(0.59)	(0.49)	(1.22)	(1.08)
Two Years After	10.07***	-6.11***	5.55***	-1.11*	4.29***	-0.98	3.61***	-3.57**	1.02	-1.22	1.94**	-1.42**	5.06***	-2.45**
	(2.32)	(1.04)	(1.05)	(0.67)	(0.89)	(0.68)	(1.33)	(1.71)	(0.71)	(0.80)	(0.84)	(0.62)	(1.28)	(1.16)
Three Years After	10.67***	-4.98***	8.27***	-0.99	6.24***	-0.79	3.42**	-1.00	2.03**	0.08	3.74***	-0.30	5.75***	-2.76**
	(3.36)	(1.28)	(1.24)	(0.91)	(1.28)	(0.87)	(1.42)	(2.00)	(0.91)	(0.69)	(1.07)	(0.80)	(1.59)	(1.39)
Four Years After	9.62**	-1.10	5.58***	-2.52*	6.43***	-2.69**	4.35**	1.93	-2.15	-1.05	5.93***	-1.86	4.42**	-2.13
	(4.31)	(1.69)	(1.34)	(1.39)	(1.85)	(1.31)	(1.77)	(2.84)	(1.62)	(1.23)	(1.23)	(1.21)	(2.12)	(2.00)
PCP by Specialty Firm FE	Y		Y		Y		Y		Y		Y		Y	
Specialty Firm by Year FE	Y		Y		Y		Y		Y		Y		Y	
Avg. 1 Year Prior	24.79	46.01	8.03	17.37	4.48	22.61	2.58	34.94	1.53	15.67	4.49	18.25	8.92	32.42
Avg. Total 1 Year Prior	151.92		30.65		37.91		47.15		36.98		35.59		54.99	
Observations	2,280,268		722,527		752,705		601,068		1,023,740		737,723		867,638	

NOTE: Standard errors are clustered at the referring physician-receiving firm pair level. Regressions include controls for the number of patients a PCP sees, as well as charges per patient. The omitted category is the year prior to integration, which is normalized to zero. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.9: *Effect of Integration on Referrals by Specialty Type*

Specialty	Visits from Referrals (%)	Referral Share Rank	Acquirer Coefficient (1 Year After)	Total Referral Share
Pulmonary Disease	79.3%	1	55.0	11.6%
Nephrology	72.8	2	3.5	7.5
Cardiology	69.8	3	10.4	6.8
Gastroenterology	48.0	4	3.9	10.3
General Surgery	45.9	5	4.1	13.3
Orthopedic Surgery	30.5	6	1.9	5.3
Ophthalmology	21.7	7	0.7	1.8

NOTE: The acquirer coefficient is the coefficient on the effect of integration on referrals from target PCPs to specialists employed by the acquirer. These coefficients are estimated using Equation 2, which includes treatment coefficients for referrals to non-acquiring specialists, as well as PCP by specialty firm and specialty firm by year fixed effects. Standard errors are clustered at the referring physician-receiving firm pair level.

Table 1.10: *Effect of Integration on Referrals from Acquired PCPs by Acquirer Type*

	Hospitals		Private Practices	
	Referrals from Acquired PCPs to			
	Acquirers	Non-Acquirers	Acquirers	Non-Acquirers
Year Relative to Merger	(1)	(2)	(3)	(4)
Four Years Prior	13.48***	9.87	-7.13**	-0.84
	(3.86)	(11.73)	(3.53)	(0.57)
Three Years Prior	4.00	9.31**	-2.47	0.18
	(4.46)	(4.47)	(2.43)	(0.42)
Two Years Prior	5.49**	3.34	-0.75	-0.22
	(2.27)	(3.58)	(1.59)	(0.31)
Year of Merger	8.98***	1.18	7.07***	-0.42
	(1.99)	(4.11)	(1.49)	(0.31)
One Year After	19.62***	-1.98	17.61***	-2.62***
	(3.16)	(4.98)	(2.35)	(0.35)
Two Years After	24.68***	-9.10	15.66***	-3.63***
	(4.16)	(6.48)	(3.04)	(0.43)
Three Years After	21.44***	-5.56	21.13***	-2.94***
	(7.43)	(7.65)	(4.28)	(0.52)
Four Years After	9.41	-8.20	25.09***	-2.06***
	(10.00)	(10.45)	(5.29)	(0.72)
PCP by Specialty Firm FE	Y		Y	
Specialty Firm by Year FE	Y		Y	
Observations	6,104,227		5,790,303	
Avg. 1 Year Prior	34.15	35.26	33.46	33.68

NOTE: Regressions are estimated using Equation 2. The dependent variable in each regression is number of referrals to specialists, and regressions are run at the referring PCP by receiving specialty firm level. Standard errors are clustered at the referring physician-receiving firm pair level. Regressions include controls for the number of patients a PCP sees, as well as charges per patient. The omitted category is the year prior to integration, which is normalized to zero. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.11: *Effect of Integration on Referrals from Acquired PCPs (Missing Values Set to 10)*

	Referrals from Acquired PCPs to			
	Acquirers (Equation 1)	Acquirers (Equation 2)	Non-Acquirers (Equation 2)	All Specialists (Equation 3)
Year Relative to Merger	(1)	(2)	(3)	(4)
Four Years Prior	-4.91	-2.27	0.27	3.89
	(3.23)	(2.92)	(0.50)	(7.71)
Three Years Prior	-2.29	-0.72	0.59*	3.21
	(2.44)	(2.11)	(0.35)	(4.02)
Two Years Prior	-1.01	0.92	0.09	1.78
	(1.58)	(1.34)	(0.26)	(2.75)
Year of Merger	7.92***	6.78***	-0.57***	-7.74***
	(1.40)	(1.16)	(0.26)	(2.46)
One Year After	20.68***	15.82***	-2.07***	-15.00***
	(2.25)	(1.88)	(0.28)	(3.78)
Two Years After	22.36***	15.59***	-2.87***	-12.92***
	(2.93)	(2.44)	(0.35)	(4.43)
Three Year After	26.22***	19.81***	-2.37***	-14.49**
	(3.93)	(3.63)	(0.43)	(5.97)
Four Years After	24.75***	19.68***	-1.20***	-11.20
	(4.26)	(4.65)	(0.57)	(7.36)
PCP by Specialty Firm FE	Y	Y		
Specialty Firm by Year FE	Y	Y		
PCP by Year FE	Y			
PCP FE				Y
Year FE				Y
Observations	5,991,352	6,104,227		724,808
Avg. 1 Year Prior	41.86	41.86	41.14	374.96

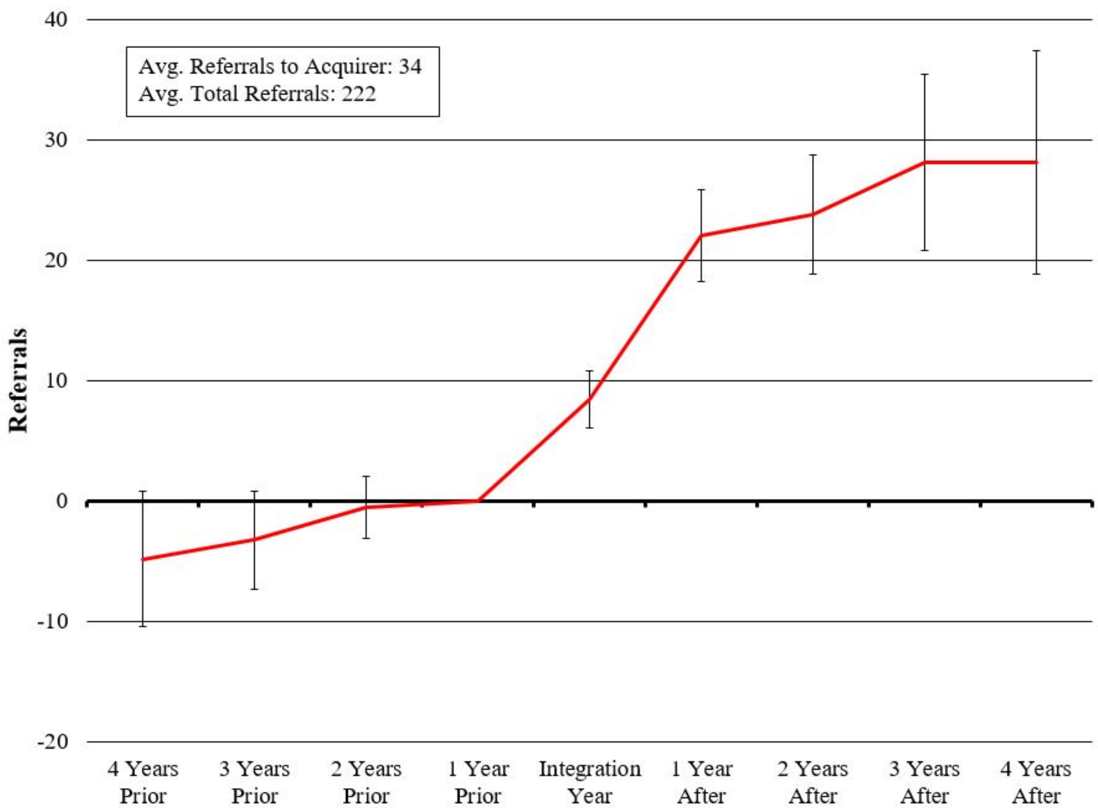
NOTE: Standard errors are clustered at the referring physician-receiving firm pair level. Regressions without PCP by year fixed effects include controls for the number of patients a PCP sees, as well as charges per patient. The omitted category is the year prior to integration, which is normalized to zero. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.12: *Effect of Integration on Referrals from Acquired PCPs (Including Target Specialists)*

	Referrals from Acquired PCPs to		
	Acquirers (Equation 1)	Acquirers	Non-Acquirers (Equation 2)
Year Relative to Merger	(1)	(2)	(3)
Four Years Prior	-5.84	-5.16	-0.33
	(3.64)	(3.94)	(0.67)
Three Years Prior	-3.30	-1.68	0.32
	(2.64)	(2.41)	(0.40)
Two Years Prior	-2.00	-0.73	-0.28
	(1.91)	(1.71)	(0.29)
Year of Merger	8.79***	7.73***	-0.19***
	(1.39)	(1.24)	(0.28)
One Year After	58.67***	48.90***	-2.37***
	(4.41)	(3.80)	(0.31)
Two Years After	52.47***	41.48***	-3.35***
	(3.98)	(3.51)	(0.39)
Three Years After	54.10***	42.13***	-3.02***
	(5.26)	(4.66)	(0.47)
Four Years After	51.46***	40.84***	-1.78***
	(6.13)	(5.51)	(0.65)
PCP by Specialty Firm FE	Y	Y	
Specialty Firm by Year FE	Y	Y	
PCP by Year FE	Y		
Observations	6,129,137	6,129,929	
Avg. 1 Year Prior	33.98	37.93	

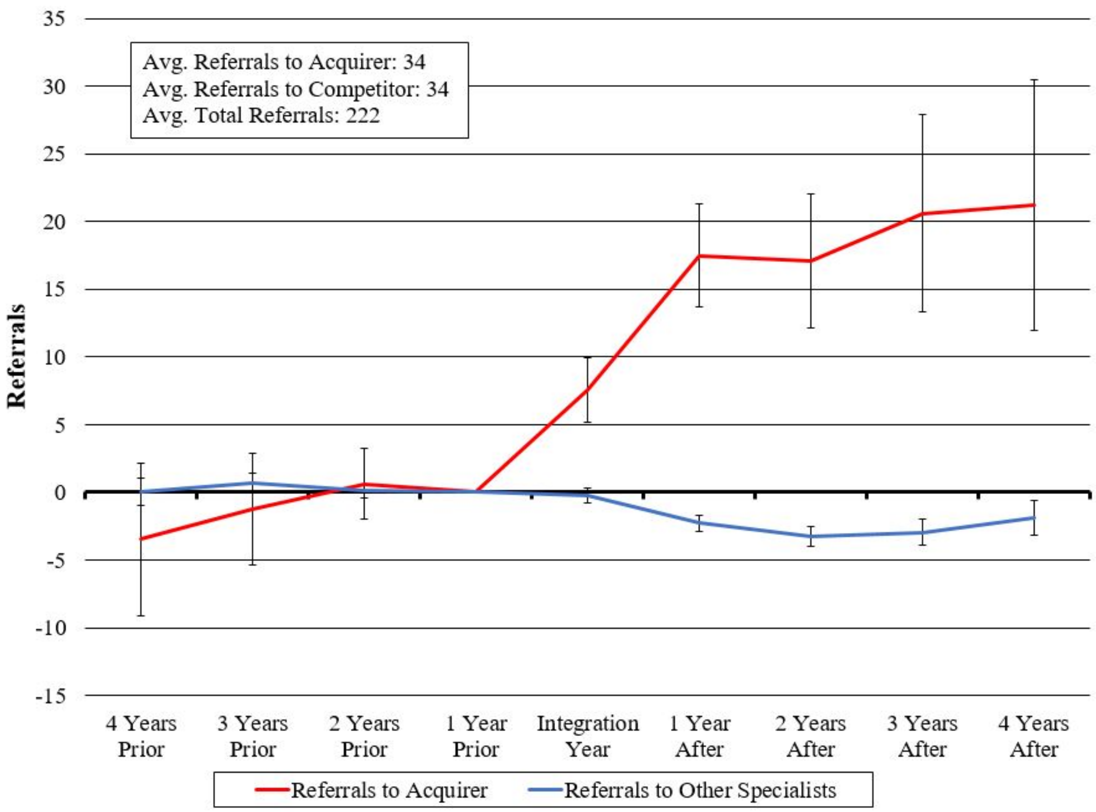
NOTE: Standard errors are clustered at the referring physician-receiving firm pair level. Regressions without PCP by year fixed effects include controls for the number of patients a PCP sees, as well as charges per patient. The omitted category is the year prior to integration, which is normalized to zero. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 1.2: *Effect of Integration on Referrals from Target PCPs to Acquiring Specialists*



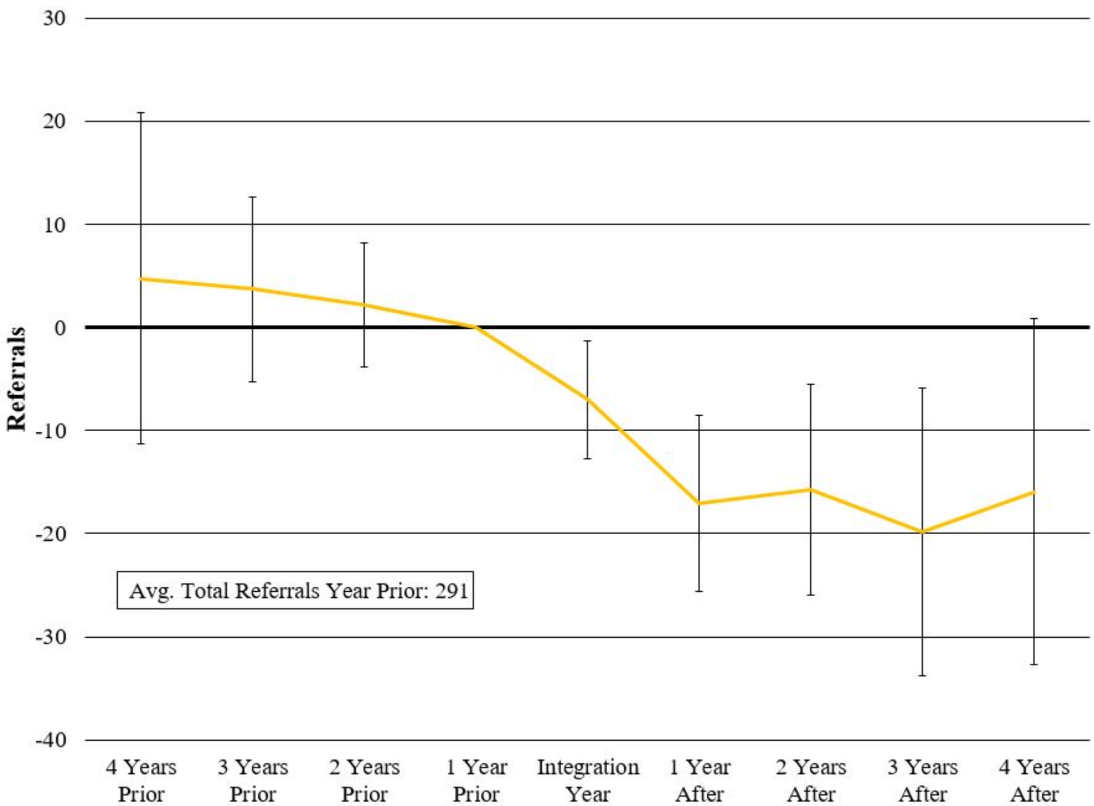
Note: The figure plots coefficients on the indicator for referrals from target PCPs to specialists employed by the acquirer. The omitted category is the year prior to integration, which is normalized to zero. Standard errors are clustered at the referring physician, receiving firm level and 95% confidence intervals are shown. The regression includes referring physician and receiving firm pair fixed effects, as well as referring physician by year and receiving firm by year fixed effects.

Figure 1.3: *Effect of Integration on Referrals from Target PCPs to Acquirers and Competitors*



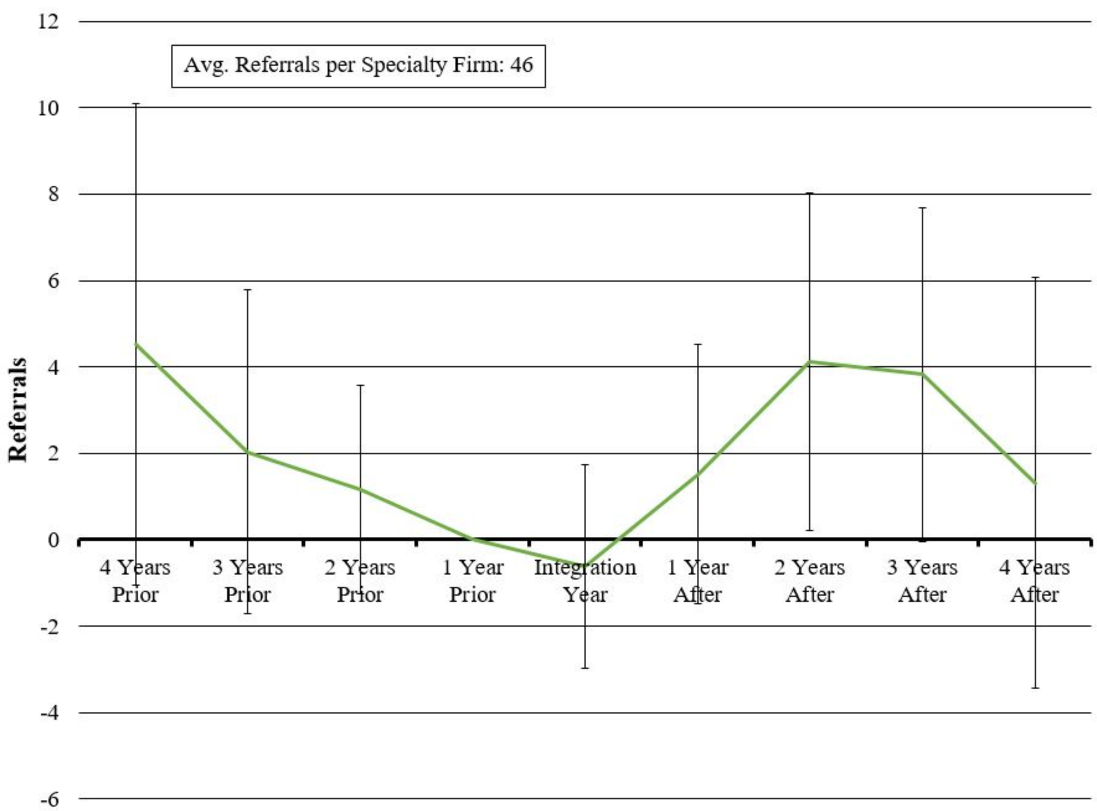
Note: The figure plots coefficients on the indicator for referrals from target PCPs to specialists employed by the acquirer (Effect 1), as well as referrals from target PCPs to specialists not employed by the acquirer (Effect 2). The omitted category is the year prior to integration, which is normalized to zero. Standard errors are clustered at the referring physician, receiving firm level and 95% confidence intervals are shown. The regression includes referring physician and receiving firm pair fixed effects and receiving firm by year fixed effects, as well as controls for observable characteristics, including the number of patients seen and charges billed per patient.

Figure 1.4: *Effect of Integration on Referrals from Target PCPs to All Specialists*



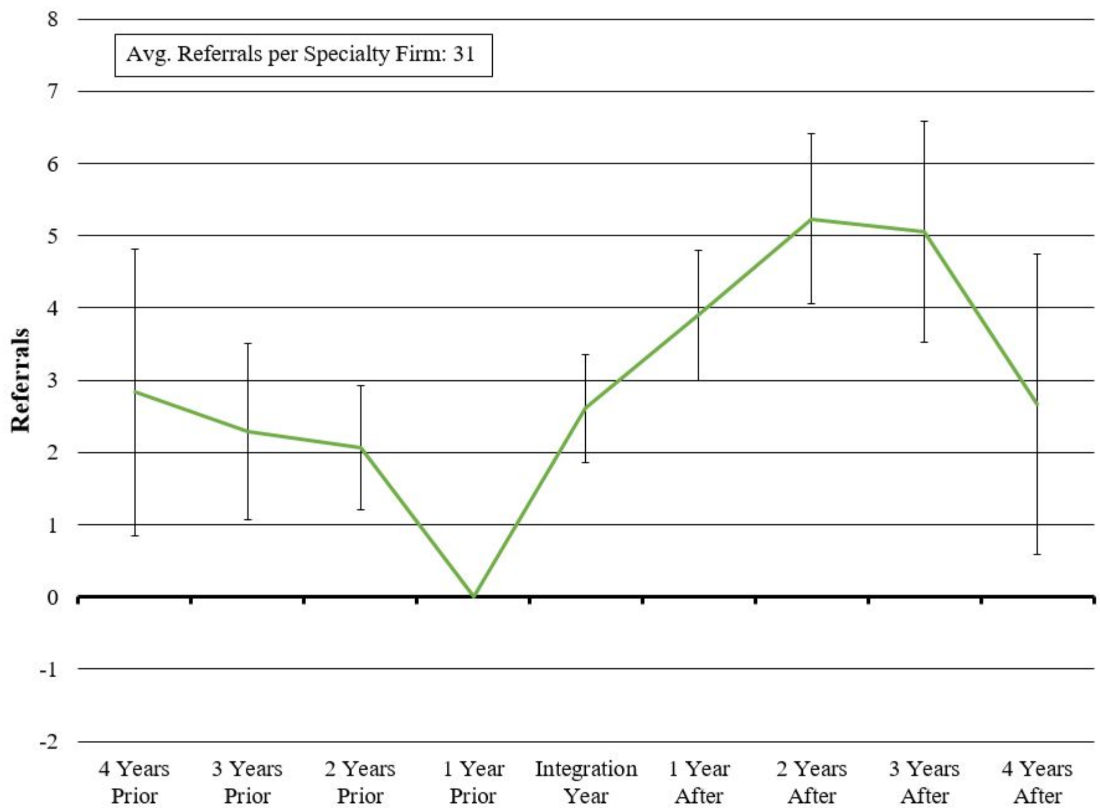
Note: The figure plots coefficients on the indicator for referrals from target PCPs. The omitted category is the year prior to integration, which is normalized to zero. Standard errors are clustered at the referring physician level and 95% confidence intervals are shown. The regression includes referring PCP and year fixed effects.

Figure 1.5: *Effect of Integration on Referrals to Competitors*



Note: The figure plots coefficients on the indicator for referrals from non-acquired PCPs to non-acquiring specialty firms that received referrals from target PCPs prior to integration. The omitted category is the year prior to integration, which is normalized to zero. Standard errors are clustered at the referring physician, receiving firm level and 95% confidence intervals are shown. The regression includes referring physician and receiving firm pair fixed effects, as well as receiving firm by year and specialty market by year fixed effects.

Figure 1.6: *Effect of Integration on Referrals Due to Capacity Constraints*



NOTE: The figure plots coefficients on the indicator for referrals to non-acquiring specialty firms from non-acquired PCPs who referred patients to an acquirer prior to integration. The omitted category is the year prior to integration, which is normalized to zero. Standard errors are clustered at the referring physician, receiving firm level and 95% confidence intervals are shown. The regression includes referring physician and receiving firm pair fixed effects, as well as and referring physician by year fixed effects and controls for observable characteristics, including the number of patients seen and charges billed per patient.

Chapter 2

Strategic Complementarity in Physician Entry

Summary

Empirical evidence suggests that the ratio of physicians to patients in a market influences the quality of health care patients receive. Therefore, it is important to understand the factors that determine in which markets physicians choose to locate. Past research on physician entry has treated doctors as homogeneous agents whose entry decisions are strategic substitutes. However, the effect that a physician's entry has on another physician's entry decision is likely to depend on each physician's specialty. For example, while two cardiologists may be strategic substitutes, the profits of a cardiologist and a urologist are likely to be independent. Further, specialists and primary care physicians (PCPs) may be strategic complements due to mutually beneficial referral relationships. Therefore, I estimate a two-sided entry model that allows the strategic relationship of physicians' entry decisions to vary by specialty type. I find evidence that the entry decisions of physicians within a specialty are strategic substitutes, while PCPs' and some specialists' entry decisions are strategic complements.

2.1 Introduction

The U.S. Department of Health and Human Services estimates that there are currently 6,100 Health Professional Shortage Areas (HPSAs), which may consist of anywhere from parts of cities to multiple counties, in the United States. Newhouse et al. (1982) and Rosenthal et al. (2005) find that rural areas have lower physician-to-population ratios and that specialists disproportionately locate in cities. Numerous policies exist that attempt to address physician shortages. Loan forgiveness programs and reimbursement bonuses exist to compensate physicians who locate in a HPSA, and specialists are sometimes paid compensating differentials to locate in less desirable locations. Additionally, 17 states have passed legislation to allow nurse practitioners to practice independently of doctors in order to alleviate shortages of primary care physicians (PCPs).

Physician shortages may have negative effects on patient outcomes. A number of studies (Farmer et al., 1991; Macinko et al., 2007; Shi et al., 2004; Starfield et al., 2005) find that the ratio of PCPs to patients has a negative association with mortality rates, particularly in rural areas. Shi (1992) finds evidence that PCP to population ratios are positively correlated with lifespan and birth-weight ratios. Higher PCP ratios are also associated with better preventative care. For example, increased PCP supply may increase the probability of early breast cancer detection (Ferrante et al., 2000).

This paper seeks to further our understanding of the influence that other physicians' entry decisions have on a physician's decision to locate in a specific market. Most physician entry models (Bresnahan and Reiss, 1991; Schaumans and Verboven, 2008) consider physicians to be homogeneous agents. I propose a model that allows strategic interactions to vary by physician specialty. Specifically, I adopt an entry model with strategic complementarity between firms presented in Schaumans and Verboven (2008) to model the strategic complementarity of PCPs' and specialists' entry decisions.

To my knowledge, the only other research that allows for these types of interactions between primary care physicians and specialists is an unpublished paper by Schaumans (2008), which studies the Belgium health care market. My model differs from hers in several significant ways. First, her model assumes linearity in number of entrants. This functional form has equilibrium implications because it rules out multiplicity of equilibria, which may bias estimates. Second, her model assumes that error terms are uncorrelated. Under the assumption of independence of error terms across physician types, the model may confuse unobserved market characteristics that enter both types' payoff functions with strategic interaction effects. Finally, while her work restricts primary care physicians to move before specialists, I allow for simultaneous moves by primary care providers and specialists.

The paper is organized as follows: Section 2 provides background on the markets for PCPs and specialists. Section 3 describes the data I use for my analysis. Section 4 describes the model I use, and Section 5 describes the estimation procedure and results. Finally, Section 6 summarizes the findings of the paper and discusses the next steps in my research.

2.2 Market Background

After completing four years of generalized training in medical school, doctors receive three to seven years of additional training in a specific specialty. Since specialty selection occurs at least three years before entering the market as a practicing doctor, I treat specialty as fixed when the decision to enter a market is made. Specialists and PCPs provide services that are generally complementary. PCPs possess broad knowledge that they can use to treat simple cases, whereas specialists possess specialized knowledge that can be used to treat more complex cases. However, in some instances, their services may be substitutes. For example, a PCP may perform gynaecological exams that may also be performed by a gynaecologist. This section provides an overview of the types of interactions that may occur between specialists and primary care physicians. It also includes a description of the market for doctors' services.

2.2.1 Complementarity of PCPs' and Specialists' Entry Decisions

A PCP visit is often a requisite for a specialist visit due to insurer restrictions and information asymmetry. Some insurance plans require that PCPs act as gatekeepers for specialty services. For example, patients enrolled in health maintenance organization (HMO) plans, which accounted for 36 percent of the United States population in 2016,[1] must receive a referral from their PCP before visiting a specialist. Even when insurance plans do not require a referral, information asymmetry in physician service markets may lead patients to solicit recommendations for specialists from their PCPs. Specialists perform services that are complicated and difficult for patients to evaluate, and PCPs undergo at least seven years of specialized, post-collegiate training that equips them to evaluate

[1] Kaiser Family Foundation, "State HMO Penetration Rate."

medical services. Thus, PCPs may act as agents for their patients and evaluate specialty services on their behalf. Therefore, specialists' profits should be increasing in the number of PCPs in a market, since more PCPs increase the number of opportunities for patients to receive referrals.

PCPs' profits may also increase with the number specialists. First, PCPs may benefit from referrals from specialists. Shea et al. (1999) find that 4 percent of referrals are from specialists to PCPs. In addition, PCPs may be able to provide higher quality care to their patients when the market contains a larger set of specialists to whom to refer patients. Through referrals, PCPs act as downstream firms that select upstream specialists as inputs in the bundle of care they provide their patients.

Finally, higher numbers of specialists and PCPs may also benefit the other through increased specialization. While specialist and PCPs have different skill sets, there is also overlap between sets of services they can perform. For example, a PCP may perform some services traditionally performed by gynecologists, such as Pap smears, while a cardiologist may provide routine preventative care for her patients. Having specialists located in close proximity allows PCPs to refer complex cases to specialists that they would otherwise be required to treat.

2.2.2 Market Definition

Markets for physician services are local. In their analyses of hospital markets, Kessler and McClellan (2000) and Ho and Pakes (2013) include general hospitals within 35 miles and teaching hospitals within 100 miles in a patient's choice sets. Bresnahan and Reiss (1991) define a physician market to be a town and limit their analysis to small, isolated markets. In my analysis, I define a market to be a county. Many towns and even counties lack a given type of specialist. For example, 563 out of 919 counties used in my analysis have no general surgeons. Therefore, it makes sense to define a market for my analysis as a larger geographic area. However, my data set does not allow me to identify distances between patients and physicians.

A market may be larger than a county though, so I include only counties that are relatively remote. In order to avoid problems with markets for large metropolitan areas that include multiple counties, I eliminate counties that are located in a metropolitan statistical area (MSA), as well as counties adjacent to MSAs. MSAs include counties with an urban core of at least 50,000 people. A county is considered adjacent to an MSA if it shares any part of a border with a county located in an MSA. For example, Dane County is excluded because it is located within the Madison, WI, MSA, and Sauk County is excluded because it shares a border with Dane County. I also eliminate an additional 67 markets with more than 34 primary care physicians for computational reasons. Because there is a large right tail in the distribution of the number of firms, estimating the model for these markets, which constitute 7 percent of non-adjacent markets, would require over twice as many parameters. After these restrictions, I am left with 919 markets that I use in the analysis.

2.3 Data

The data set I use comes from the Area Health Resource File (AHRF), which contains information on 3,148 counties in the United States. I use the most recent data available in the AHRF data set. Unless otherwise noted, the variables used are for 2011.

Table 2.1 summarizes the variables used in the analysis across markets. The AHRF data set contains the number of physicians practicing in each market by specialty, as well as demographic characteristics for each market. Table 2.2 provides counts of the number of physicians by market for PCPs and seven specialties to which PCPs commonly refer patients. My analysis focuses on these specialties, which include cardiology, gastroenterology (GI), general surgery, neurology, obstetrics and gynaecology (OB-GYN), orthopedics, and ontolaryngology (ENT).

Table 2.3 presents counts of observed market configurations of general surgeons and PCPs after standardizing by market size. For example, there are 127 markets with fewer than two general surgeons and five PCPs per 100,000 residents. Counties with a high number of PCPs and general surgeons per capita include Norton City, VA, Adams, NC, and Grafton, NH. It is important for identification of the model that there is variation in market outcomes that cannot be entirely explained by variation in population. As Table 3 shows, there is indeed variation in market outcomes in the data independent of population. The correlation between general surgeons per capita and PCPs per capita is 0.43. This correlation may be due to unobserved market characteristics; however, it is also possible that this correlation exists due to strategic complementarities between primary care physicians and specialists as discussed in Section 2. In my econometric analysis, I control for observed market characteristics and allow for unobserved market characteristics in order to identify what impact, if any, strategic complementarities have on this correlation.

2.4 Model

I use an entry model that incorporates characteristics of the markets for specialists and PCPs described in Section 2. First, I define markets at the county level and eliminate markets where overlap with other markets is likely. Second, physicians of the same specialty provide substitute services, while specialists and PCPs provide complementary services. Specialists' entry decisions are independent of the number of specialists of other types in the market.

My model is an extension of the Bresnahan and Reiss (1991) entry model, and is based on the Schaumans and Verboven (2008) model of entry with strategic complementarity between firms' entry decisions. Schaumans and Verboven (2008)distinguish between two types of firms – physicians and pharmacies – where firms of the same type are strategic substitutes and firms of different types are strategic complements. In both papers, all physicians are modeled as strategic substitutes. I extend this literature by allowing physicians to be either strategic substitutes or strategic complements. In my model, physicians of the same specialty are strategic substitutes, but I allow specialists and PCPs to be strategic complements.

2.4.1 Payoffs

There are two types of firms, $i = s, p$, where firms of type s are a specific type of specialist and firms of type p are PCPs. For expository purposes, consider firms of type s to be general surgeons. The number of firms of type i observed in market m is denoted by n_i^m. Firms' payoff functions vary by type but are identical across firms of the same type. If a firm i enters market m, its payoff is given by

$$\pi_i^*(n_s^m, n_p^m, X^m) = \pi_i(n_s^m, n_p^m, X^m) - \varepsilon_i^m, \tag{2.1}$$

where $\pi_i(n_s^m, n_p^m, X^m)$ is the deterministic component of payoffs, which dependson the number of firms of the same type and other type, as well as observable market characteristics, and ε_i^m is a random error term. Payoffs are normalized to zero when no firm of type i enters. For simplicity, the market superscript and vector of observable market characteristics have been omitted from subsequent representations.

Based on the market characteristics described in Section 2, the model incorporates the following assumptions about form of the profit function:

1. Entry decisions by firms of the same type are strategic substitutes. This means that, all else equal, increasing the number of own-type firms in the market reduces a firm's payoffs:

$$\pi_s(n_s+1, n_p) < \pi_s(n_s, n_p)$$
$$\pi_p(n_s, n_p+1) < \pi_p(n_s, n_p)$$

2. Entry decisions by firms of the other type are strategic complements or independent. Therefore, all else equal, increasing the number of the other type of firms in the market either does not affect profits or increases profits:

$$\pi_s(n_s, n_p) \leq \pi_s(n_s, n_p+1)$$
$$\pi_p(n_s, n_p) \leq \pi_p(n_s+1, n_p)$$

3. The effect of strategic substitutability between firms of the same type is greater than the effect of strategic complementarity between firms of different types. Therefore, the positive effect of increasing the number of own-type firms by one will be greater than the negative effect of increasing the number of other-type firms by one, resulting in a decrease in profits, all else equal:

$$\pi_s(n_s+1, n_p+1) < \pi_s(n_s, n_p)$$
$$\pi_p(n_s+1, n_p+1) < \pi_s(n_s, n_p)$$

The equilibrium is derived in the following section using these assumptions, which are verified in the empirical analysis.

2.4.2 Equilibrium

Each firm decides whether to enter a market given the set of firms already in the market. A unique pure-strategy Nash equilibria does not exist in this game. This problem is solved as in Bresnahan and Reiss (1990) and Mazzeo (2002). First, the prediction is made about the total number of firms of each type in the market, rather than the entry decisions of specific firms. Second, I assume that firms move sequentially. I discuss both of these in detail below.

The market configuration (n_s, n_p) is a Nash equilibrium if and only if

$$\pi_s^*(n_s, n_p) \geq 0 > \pi_s^*(n_s + 1, n_p)$$
$$\pi_p^*(n_s, n_p) \geq 0 > \pi_p^*(n_s, n_p + 1).$$

When these conditions are satisfied, n_s general surgeons and n_p primary care physicians have non-negative profits and therefore decide to enter, but an additional firm of either type will not find it profitable to enter. This condition can be rewritten in terms of observable profits, $\pi_i(n_s, n_p)$, and the random component, $(\varepsilon_s, \varepsilon_p)$:

$$\pi_s(n_s, n_p) \geq \varepsilon_s > \pi_s(n_s + 1, n_p) \tag{2.2}$$
$$\pi_p(n_s, n_p) \geq \varepsilon_p > \pi_p(n_s, n_p + 1). \tag{2.3}$$

One-Sided Complementarity

In the baseline case, I assume that primary care physicians' entry decisions are strategic complements for specialists' entry but primary care physicians' entry decisions are independent of specialists' entry. I also estimate a version of the model where the reverse is true. In both versions, the entry decisions of specialists of different types are strategically independent, so they do not enter into the model. Under this assumption, conditions (2) and (3) are sufficient to guarantee a unique equilibrium. As illustrated in Figure 2.1, there is no area of overlap between equilibria.

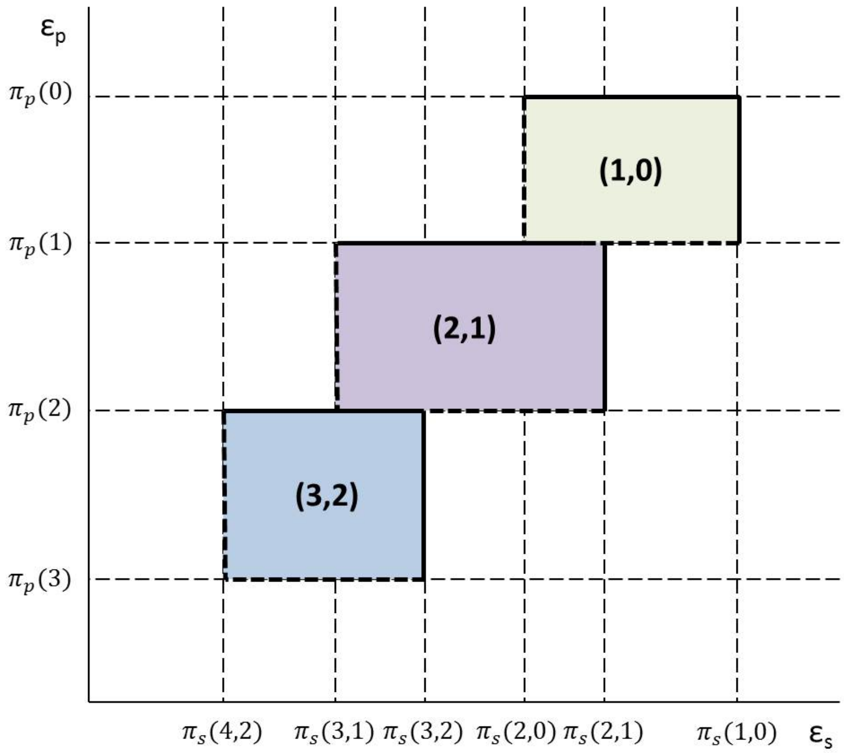


Figure 2.1: *Nash Equilibria with One-Sided Complementarity*

Assuming that ε has a bivariate normal density, $f(\cdot)$, the probability of observing a particular market outcome, (n_s, n_p) is

$$\Pr(n_s, n_p) = \int_{\pi_s(n_s+1,n_p)}^{\pi_s(n_s,n_p)} \int_{\pi_p(n_s,n_p+1)}^{\pi_p(n_s,n_p)} f(\varepsilon_s, \varepsilon_p) d\varepsilon_p d\varepsilon_s. \tag{2.4}$$

Two-Sided Complementarity

A fuller version of the model allows both primary care physicians' and specialists' entry decisions to be strategic complements. In this case, multiple Nash equilibria exist. The multiplicity of equilibria for (n_s, n_p) occurs with $(n_s + 1, n_p + 1)$ and $(n_s - 1, n_p - 1)$. See the Appendix to Schaumans and Verboven (2008) for a proof of this. Figure 2 illustrates the multiplicity of equilibria for $(n_s, n_p) = (2, 1)$. By assuming that firms enter sequentially, $(n_s - 1, n_p - 1)$ can be eliminated as an equilibrium.

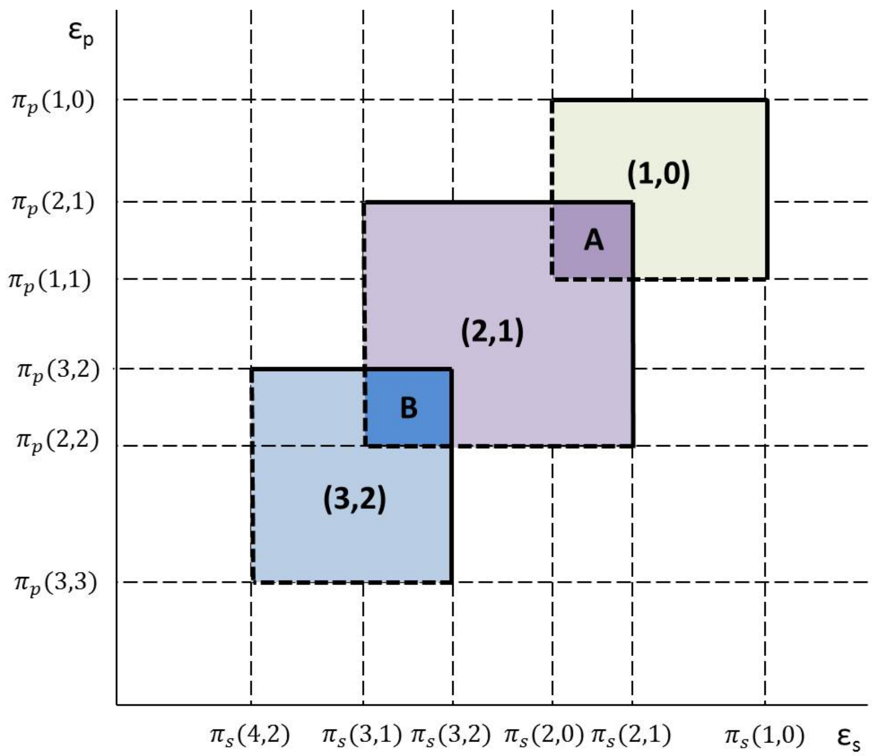


Figure 2.2: *Nash Equilibria with Two-Sided Complementarity*

Doctors choose their profession before the start of the game and then each doctor enters after observing the previous entry decisions. Suppose $(\varepsilon_s, \varepsilon_p)$ is such that (n_s, n_p) or $(n_s + 1, n_p + 1)$ could be an equilibria, as illustrated in Figure 2.2 by the region A for $(n_s, n_p) = (2, 1)$. In this case, it is beneficial for a third specialist to enter if and only if a second primary care physician enters. However, if a third specialist enters, it is optimal only if a second primary care physician enters. Therefore, if sequential moves are allowed, the third specialist will enter, knowing a second primary care physician will enter upon seeing his entry. Thus, only the Nash equilibria with the largest number of entrants will be played.

In the example where $(n_s, n_p) = (2, 1)$ shown in Figure 2.2, the probability of observing $(2, 1)$ is therefore the region bounded below by $\pi_s(3, 1)$ and $\pi_p(2, 2)$ and above by $\pi_s(2, 1)$ $\pi_p(2, 1)$ minus region B. This probability for the general case of (n_s, n_p) is

$$\begin{aligned}\Pr(n_s, n_p) &= \int_{\pi_s(n_s+1,n_p)}^{\pi_s(n_s,n_p)} \int_{\pi_p(n_s,n_p+1)}^{\pi_p(n_s,n_p)} f(\varepsilon_s, \varepsilon_p) d\varepsilon_p d\varepsilon_s \\ &\quad - \int_{\pi_s(n_s+1,n_p)}^{\pi_s(n_s+1,n_p+1)} \int_{\pi_p(n_s,n_p+1)}^{\pi_p(n_s+1,n_p+1)} f(\varepsilon_s, \varepsilon_p) d\varepsilon_p d\varepsilon_s,\end{aligned}$$

where $f(\cdot)$ is joint normal density.

2.5 Empirical Estimation

2.5.1 Econometrics

I estimate the models presented in Section 4.2 using maximum likelihood, where each observation is a single market. The contribution to the likelihood function of a single market with observed market outcome (n_s, n_p) is given by $\Pr(n_s, n_p)$ as defined in Equation 4. This probability can be rewritten as a function of the normal CDF, $\Phi(\cdot)$:

$$\begin{aligned}\Pr(n_s, n_p) &= \Phi(\pi_p(n_s, n_p), \pi_s(n_s, n_p)) - \Phi(\pi_p(n_s+1, n_p), \pi_s(n_s, n_p)) \\ &- \Phi(\pi_p(n_s, n_p), \pi_s(n_s+1, n_p)) + \Phi(\pi_p(n_s, n_p+1), \pi_s(n_s+1, n_p))\end{aligned}$$

I normalize the mean of $\Phi(\cdot)$ to 0 and the variances σ_s and σ_p to 1. Given these normalizations, the covariance matrix of $\Phi(\cdot)$ is

$$\Sigma = \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix},$$

where ρ is the correlation coefficient between ε_s and ε_p.

I estimate the observed payoff function for each market m as a function of observed market characteristics and number of firms:

$$\pi_i(n_s, n_p) = X\beta_i - \alpha_i^j + \gamma_i^k / n_i, \tag{2.5}$$

where X^m is a vector of observed market characteristics, including a constant, α_i^j is a parameter present when there are j firms of type i in the market, and γ_i^k is a parameter present when there are k firms of the other type in the market. To reflect the fact that the effect of the other type of firms on profit may be smaller when there are more own type firms, γ_i^k is divided by n_i^m. I set $\pi_s(0, n_p)$ and $\pi_p(n_s, 0)$ equal to ∞ to account for the fact that if $\varepsilon = \infty$ were drawn, observed payoffs would have to be infinite for a firm to enter. Similarly, I set $\pi_s(N_s+1, n_p)$ and $\pi_p(n_s, N_p+1)$ equal to $-\infty$, where N_s and N_p are the largest numbers of specialists and primary care physicians observed in the data. Since there are no observations with entrants greater than N_s and N_p, the observed payoff functions for these market outcomes is not identified. Therefore, if $\varepsilon > \pi_s(N_s, n_p)$ or $\varepsilon > \pi_p(n_s, N_p)$, N_s or N_p firms, respectively, will be observed in the market. Since the payoff functions include constants, not all of the α_i values can be identified. Therefore, I normalize α_i^1 and γ_i^0 to 0.

It is possible the γ_i^k terms are picking up a correlation in primary care providers' and specialists' unobserved location preferences rather than or in addition to complementarities. I attempt to minimize this possibility in two ways. The first is by including market characteristics such as income and population that should control for some amenities of a location. The second way is by drawing the error terms from a joint normal density with a non-zero correlation, ρ. The ρ parameter in the model should account for unobserved preferences that are uncorrelated with the observed characteristics. As expected, when the model is run allowing no correlation of unobservables (ρ=0), the estimates of the γ_i^k obtained are more positive.

There are least two obvious ways in which the complementarities estimates could be biased. The first is if unnobservables are correlated with the covariates. If this is the case, then the β's could be biased and as a consequence the γ's. For example, suppose that doctors like to golf and are therefore more likely to locate in markets with golf courses. If golf courses are located in counties with high income, the coefficient on income may be biased since golf course location is not included in the model. However, this should not inflate the γ estimates directly since the ρ term will control for correlation of specialists' and primary care providers' unobserved preferences. Biasedness may also occur if the functional form is not linear.

In order for the empirical results to be consistent with the model, the parameter estimates must satisfy the following conditions based on the assumptions about the form of the payoff function in Section 4.1:

$$\alpha_i^{j+1} \geq \alpha_i^j \tag{2.6}$$

$$\gamma_i^{k+1} \geq \gamma_i^k \tag{2.7}$$

$$\alpha_i^{j+1} - \gamma_i^{k+1}/(j+1) \geq \alpha_i^j - \gamma_i^k/j, \tag{2.8}$$

Equation (6) requires that the estimates satisfy Assumption 1, which states that firms of the same type are strategic substitutes. It requires that a larger number of firms of the same type has a larger negative impact on observed payoffs. Since α_i^1 is normalized to 0, all estimates of α_i^j must be positive. Equation (7) requires that the estimate satisfy Assumption 2, which states that firms of different types are strategic complements. It requires that a larger number of firms of the other type have a larger positive impact on observed payoffs. Since γ_i^1 is normalized to 0, all estimates of γ_i^k must be positive. Finally, Equation (8) aligns with Assumption 3, which states that the marginal effect on payoffs of an additional firm of the same type entering is greater than marginal effect that a firm of the other type entering would have. The model is internally consistent only if Equations (6) - (8) are satisfied.

I include α_i^j parameters for every number of primary care providers and specialists observed in the data. As an example, there may be up to 33 primary care physicians and 8 general surgeons in a market. Therefore, I estimate coefficients for $\alpha_p^2, ..., \alpha_p^{33}$ and $\alpha_s^2, ..., \alpha_s^8$. When estimating the model with one-sided complementarity, I include no fixed effects for γ_i^k above the highest significant effect I obtain, at which point I assume that additional other-type entrants have no effect on payoffs and set the remaining γ_i^k equal. For example, if γ_p^3 is the last significant other-type fixed effect, then I set $\gamma_s^3 = \gamma_s^4 = \cdots = \gamma_s^{33}$. When estimating the model with two-sided complementarity, I include only γ_i^1. In this case, $\gamma_s^1 = \gamma_s^4 = \cdots = \gamma_s^{33}$.

2.5.2 Results

I estimate the full model that allows for two-sided complementarity, as described in Sections 4.2.2 and 5.1, for each of the seven specialties listed in Section 3. For four specialties – cardiology, general surgery, neurology, and gastroenterology – the model produces positive estimates of γ_s^2 or γ_p^1, which is consistent with strategic complementarity. Table 2.4 presents these parameter estimates. The parameter estimates on both γ_s^1 and γ_p^1 are significant for gastroenterology, which is consistent with a model of two-sided complementarity. The parameter estimates on γ_s^1, but not γ_p^1, are significant for cardiology and general surgery. This suggests that these specialists view PCPs as complements, but the reverse is not true. In contrast, only γ_p^1 is significant for neurology, suggesting that PCPs view neurologists as complements. Significant estimates of γ suggest that the presence of other-type doctors in a market have an impact on a physician's payoff function. For example, the γ_s^1 value for cardiologists suggests that having a primary care physician present in the market is equivalent to a 0.46 point increase in log(population), which is equivalent to an increase of about 5,340 people for the average-sized county of 9,136 people in the data.

For other three specialties – obstetrics and gynaecology, orthopedics, and otolaryngology – the estimation process does not yield any significant positive estimates of γ_i^k (not shown). Obtaining estimates of γ close to zero does not necessarily mean that the other-type physicians have no impact on a physician's payoff function. In the estimated model, this is also consistent with the physicians being strategic substitutes. Because the model does not allow for negative values of γ_i^k, the estimation procedure will produce values of γ_i^k near zero when the services are strategic substitutes. Therefore, these results suggest that obstetrics and gynaecology, orthopedics, and otolaryngology services may be strategic substitutes, rather than strategic complements, with PCP services. Given that it specialties may be either strategic complements or substitutes with PCP services, a less restrictive model that allows different types physicians to be either strategic substitutes or complements may be a valuable extension to this literature.

Note that the degree of strategic complementarity between two specialties may differ by market size. The model I estimate deals with this in part by dividing the parameter for other-type physicians by the number of own-type physicians in the market, thus allowing other-type physicians to be more important when there are fewer same-type physicians. However, the importance of other-type physicians may vary by market size in other ways not captured in the model, which estimates only one parameter value of γ. I argue that by restricting the sample to rural markets (counties not in or adjacent to MSAs), the estimates of γ obtained are those most policy-relevant, since rural markets are often the targets of policies aimed at reducing physician shortages. Nevertheless, urban areas also experience physician shortages, and estimating strategic complementarity between physicians in these markets is an area for future research.

I also estimate versions of the model that allow for only one-sided complementarities, as described in Sections 4.2.1 and 5.1, for general surgeons. With this model I am able to estimate multiple γ_i^k. Table 2.5 presents these estimates, alongside the estimates for the full model. The own-type fixed effects α_s^j and α_p^j are positive, significant, and increasing in both versions, which satisfies Equation (6). The other-type fixed effects for primary care physicians, γ_p^k, are generally increasing, as required by Equation (7), and γ_p^3, γ_p^4, and γ_p^5 are significant. However, the other-type fixed effects for general surgeons, γ_s^k, are negative and decreasing. These results suggest that general surgeons are strategic complements in primary care physicians' entry decisions. However, they imply that primary care physicians either act as strategic substitutes for or are not a significant factor in general surgeons' entry decisions. In order for the results of the model that includes γ_p^k to be fully consistent with the model, Equation (8) must also be satisfied. I find that Equation (8) is satisfied for 685 observed market configurations, or about 75 percent of markets included in the estimation. In general, the results suggest that the model of Schaumans and Verboven (2008) may not fully describe the strategic interaction in the market for physicians.

2.6 Conclusion

This paper presents and estimates a model of physician entry that allows strategic interactions to vary by specialty. I estimate a model that allows for strategic substitutability with other firms of the same specialty and two-sided complementarity with firms of the other type. Using this model, I find evidence that primary care physicians and specialists may view each other as strategic complements. However, the results are not always consistent with a model of strategic complementarity.

The logical next step for this analysis is to estimate a model that allows for both strategic complements and substitutes, which has not previously been estimated in the literature. This model would allow one physician type to be a strategic complement for the other, while the other is a strategic substitute. It would also allow for entry decisions to be either strategic complements or substitutes for a given specialty depending on the number of physicians in the market. For example, when few primary care physicians are present, they may be strategic complements for specialists, as more primary care physicians provide more referrals. However, as more primary care physicians enter and the market becomes more saturated, primary care physicians may provide more services similar to those provided by specialists in order to distinguish themselves from other primary care providers, and thus act as substitutes for specialists.

Table 2.1: *Summary Statistics*

Variable	Description	Mean	Std. Deviation
PCP	Number of primary care physicians	7.54	7.86
Cardiology	Number of cardiologists	0.19	0.62
GI	Number of gastroenterologists	0.06	0.32
General Surgery	Number of general surgeons	0.87	1.42
Neurology	Number of neurologists	0.10	0.38
ObGyn	Number of gynaecologists	0.70	1.40
Orthopedics	Number of orthopedists	0.48	1.10
ENT	Number of otolaryngologists	0.14	0.48
ln(Population)	Log of population	9.12	1.01
Hospitals	Number of hospitals (2010)	0.88	0.64
ln(Income)	Log of median household income	10.58	0.21
Population 65+	Fraction of the population aged 65 and older	0.18	0.05

NOTE: Includes 919 markets (counties) after eliminating counties within or adjacent to metropolitan statistical areas, as well as counties with large numbers of physicians for computational feasibility.

Table 2.2: *Market Counts by Number of Physicians*

	Number of Physicians										
Specialty	0	1	2	3	4	5	6	7	8	9	10+
Primary Care	128	86	90	78	59	63	47	42	34	27	265
Cardiology	810	67	25	9	7	1	0	0	0	0	0
Gastroenterology	874	36	7	1	0	1	0	0	0	0	0
General Surgery	563	146	94	56	28	17	8	6	1	0	0
Neurology	849	49	19	2	0	0	0	0	0	0	0
Obstetrics and Gynaecology	665	85	68	40	30	16	7	7	1	0	0
Orthopedics	700	111	50	35	10	7	1	2	2	0	1
Otolaryngology	825	66	21	4	3	0	0	0	0	0	0

NOTE: Includes 919 markets (counties) after eliminating counties within or adjacent to metropolitan statistical areas, as well as counties with large numbers of physicians for computational feasibility.

Table 2.3: *Market Outcomes per Capita*

		General Surgeons per 100,000 Residents											
		0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18+	20+	Total
Primary Care Physicians per 100,000 Residents	0-5	127	0	0	0	0	0	0	0	0	0	1	128
	5-10	11	0	0	0	0	0	0	0	0	0	0	11
	10-15	11	0	0	1	0	2	1	0	0	0	0	15
	15-20	27	0	0	3	0	0	0	0	0	0	0	30
	20-25	26	0	1	0	0	0	1	0	0	0	0	28
	25-30	33	0	3	0	1	1	1	1	0	0	0	40
	30-35	39	1	7	3	3	1	2	1	1	0	2	60
	35-40	44	4	5	2	3	0	1	0	0	1	2	62
	40-45	33	5	6	7	2	1	2	2	1	0	1	60
	45-50	37	2	8	5	5	4	2	2	0	1	0	66
	50-55	23	3	9	10	3	4	3	3	2	0	2	62
	55-60	26	3	4	6	6	4	5	1	0	1	0	56
	60-65	21	1	3	2	5	5	1	0	2	1	2	43
	65-70	18	1	4	6	3	2	5	1	3	2	1	46
	70-75	13	2	1	1	0	4	1	4	1	1	4	32
	75-80	9	1	1	1	5	4	6	1	0	0	3	31
	80-85	8	0	1	2	0	5	2	5	3	0	1	27
	85-90	9	0	2	1	2	4	2	2	0	0	2	24
	90-95	9	0	0	0	1	0	1	2	1	0	1	15
	95-100	12	0	0	0	1	3	0	1	0	1	1	19
	100+	28	1	1	1	5	3	5	2	2	3	13	64
	Total	564	24	56	51	45	47	41	28	16	11	36	916

NOTE: Includes 919 markets (counties) after eliminating counties within or adjacent to metropolitan statistical areas, as well as counties with large numbers of physicians for computational feasibility.

Table 2.4: *Estimation Results: Two-Sided Complementarity*

	Full Model Including Both γ_s and γ_p							
	Cardiology		Gastroenterology		Gen. Surgery		Neurology	
	Specialists' Payoff							
Constant	-9.83	(1.71)	-6.67	(2.38)	-25.82	(2.56)	-19.16	(0.54)
ln(Population)	1.26	(0.45)	1.21	(0.14)	1.27	(0.10)	1.35	(2.45)
Hospitals	0.27	(0.19)	0.20	(0.32)	0.58	(0.07)	0.35	(4.18)
ln(Income)	-0.43	(0.32)	-0.77	(0.39)	1.14	(0.20)	0.27	(6.23)
Population 65+	0.30	(0.31)	4,570.12	(1,368.54)	3.91	(0.88)	2.96	(0.26)
α_s^2	0.46	(0.16)	0.51	(0.24)	0.58	(0.05)	0.45	(0.43)
α_s^3	0.91	(0.24)	-	-	1.20	(0.08)	1.38	(1.31)
α_s^4	1.24	(0.24)	-	-	1.76	(0.15)	-	-
γ_s^1	0.58	(0.06)	0.90	(0.26)	0.45	(0.00)	0.72	(1.09)
	Primary Care Physicians' Payoff							
Constant	-26.62	(1.18)	-27.81	(1.87)	-26.83	(1.87)	-26.63	(1.17)
ln(Population)	1.84	(0.37)	2.01	(0.23)	1.85	(0.06)	1.84	(12.90)
Hospitals	0.76	(0.18)	0.76	(0.25)	0.76	(0.07)	0.76	(1.72)
ln(Income)	1.03	(0.42)	1.05	(0.25)	1.05	(0.16)	1.04	(9.70)
Population 65+	3.61	(0.33)	6,019.05	(741.14)	3.60	(0.75)	3.61	(1.02)
α_p^2	0.83	(0.19)	0.79	(0.08)	0.82	(0.07)	0.83	(0.34)
α_p^3	1.53	(0.10)	1.47	(0.10)	1.51	(0.08)	1.53	(0.63)
α_p^4	2.06	(0.08)	1.99	(0.13)	2.01	(0.08)	2.05	(0.84)
γ_p^1	0.00	(0.20)	11.76	(5.66)	0.02	(1.23)	4.42	(0.80)
ρ	0.57	(0.09)	0.12	(0.19)	0.50	(0.09)	0.43	(7.38)

NOTE: N=919 markets (counties). Standard errors are in parentheses. Estimates of the coefficients $\alpha_p^5, ..., \alpha_p^{33}$ are not shown. Estimates of the coefficients $\alpha_s^5, ...\alpha_s^{N_s}$ are not shown for Cardiology and General Surgery.

Table 2.5: *General Surgery Estimation Results: All Models*

	γ_s only		γ_p only		γ_s and γ_p	
	General Surgeons' Payoff					
Constant	-24.71	(2.93)	-26.30	(3.00)	-25.82	(2.56)
ln(Population)	1.35	(0.08)	1.34	(0.09)	1.27	(0.10)
Hospitals	0.64	(0.08)	0.54	(0.08)	0.58	(0.07)
ln(Income)	1.07	(0.23)	1.17	(0.24)	1.14	(0.20)
Population 65+	3.95	(1.06)	3.98	(1.10)	3.91	(0.88)
α_s^2	1.16	(0.18)	0.81	(0.06)	0.58	(0.05)
α_s^3	1.98	(0.25)	1.48	(0.08)	1.20	(0.08)
α_s^4	2.64	(0.28)	2.06	(0.10)	1.76	(0.15)
γ_s^1	-0.04	(0.38)	-	-	0.45	(0.00)
γ_s^1	-0.34	(0.37)	-	-	-	-
γ_s^1	-0.78	(0.36)	-	-	-	-
	Primary Care Physicians' Payoff					
Constant	-26.52	(2.29)	-25.00	(2.13)	-26.83	(1.87)
ln(Population)	1.85	(0.07)	1.77	(0.07)	1.85	(0.06)
Hospitals	0.77	(0.06)	0.74	(0.07)	0.76	(0.07)
ln(Income)	1.02	(0.19)	0.94	(0.17)	1.05	(0.16)
Population 65+	3.60	(0.85)	3.45	(0.85)	3.60	(0.75)
α_p^2	0.83	(0.08)	0.81	(0.08)	0.82	(0.07)
α_p^3	1.54	(0.09)	1.50	(0.09)	1.51	(0.08)
α_p^3	2.06	(0.10)	2.02	(0.10)	2.01	(0.08)
γ_p^1	-	-	0.14	(0.54)	0.02	(1.23)
γ_p^2	-	-	2.44	(1.59)	-	-
γ_p^3	-	-	9.91	(3.45)	-	-
γ_p^4	-	-	13.60	(5.60)	-	-
γ_p^5	-	-	16.23	(7.79)	-	-
ρ	0.56	(0.04)	0.31	(0.11)	0.50	(0.09)

NOTE: N=919 markets (counties). Standard errors are in parentheses. Estimates of the coefficients on $\alpha_s^5, ...\alpha_s^8$ and $\alpha_p^5, ..., \alpha_p^{33}$ are not shown.

References

American Hospital Association (2008-2013): "AHA Annual Survey Database," *[Dataset]*, provided by the National Bureau of Economic Research.

Arrow, K. J. (1963): "Uncertainty and the Welfare Economics of Medical Care," *The American Economic Review*, 53, 941–973.

Baker, L. C., M. K. Bundorf, and D. P. Kessler (2015): "The Effect of Hospital/Physician Integration on Hospital Choice," *National Bureau of Economic Research Working Paper*.

Boccuti, C., C. Fields, G. Casillas, and L. Hamel (2015): "Primary Care Physicians Accepting Medicare: A Snapshot," *Kaiser Family Foundation Issue Briefs*.

Bresnahan, T. F. and P. C. Reiss (1991): "Entry and competition in concentrated markets," *Journal of Political Economy*, 977–1009.

Burns, L. R., J. C. Goldsmith, and A. Sen (2013): "Horizontal and vertical integration of physicians: a tale of two tails," *Adv Health Care Manag*, 15, 39–117.

Carlin, C. S., R. Feldman, and B. Dowd (2016): "The Impact of Hospital Acquisition of Physician Practices on Referral Patterns," *Health Economics*, 25, 439–454.

Centers for Medicare and Medicaid Studies (2008-2014): "Medicare Data on Provider Practice and Specialty," *[Dataset]*, provided by the Research Data Assistance Center (University of Minnesota).

——— (2009-2014): "Physician Shared Patient Patterns," *[Dataset]*.

——— (2013-2014): "Physician Compare," *[Dataset]*.

Christianson, J. B., C. S. Carlin, and L. H. Warrick (2014): "The dynamics of community health care consolidation: Acquisition of physician practices," *Milbank Quarterly*, 92, 542–567.

Ciliberto, F. and D. Dranove (2006): "The effect of physician-hospital affiliations on hospital prices in California," *Journal of Health Economics*, 25, 29–38.

Cuellar, A. E. and P. J. Gertler (2006): "Strategic integration of hospitals and physicians," *Journal of Health Economics*, 25, 1–28.

Cutler, D. M. and F. S. Morton (2013): "Hospitals, market share, and consolidation," *JAMA*, 310, 1964–1970.

Farmer, F. L., C. S. Stokes, R. H. Fiser, and D. P. Papini (1991): "Poverty, Primary Care and Age-Specific Mortality," *The Journal of Rural Health*, 7, 153–169.

Ferrante, J. M., E. C. Gonzalez, N. Pal, and R. G. Roetzheim (2000): "Effects of physician supply on early detection of breast cancer," *The Journal of the American Board of Family Practice*, 13, 408–414.

Fleming, N. S., S. D. Culler, R. McCorkle, E. R. Becker, and D. J. Ballard (2011): "The financial and nonfinancial costs of implementing electronic health records in primary care practices," *Health Affairs*, 30, 481–489.

Gaynor, M. S., S. A. Kleiner, and W. B. Vogt (2013): "A structural approach to market definition with an application to the hospital industry," *The Journal of Industrial Economics*, 61, 243–289.

Health Resources and Services Administration (2013): "Area Health Resource Files," *[Dataset]*.

Ho, K. and A. Pakes (2013): "Hospital Choices, Hospital Prices and Financial Incentives to Physicians," *NBER Working Paper*.

——— (2014): "Hospital choices, hospital prices, and financial incentives to physicians," *American Economic Review*, 104, 3841–3884.

Huckman, R. S. (2006): "Hospital integration and vertical consolidation: An analysis of acquisitions in New York State," *Journal of Health Economics*, 25, 58–80.

Kane, C. K. and D. W. Emmons (2013): "New data on physician practice arrangements: private practice remains strong despite shifts toward hospital employment," *American Medical Association*, 4, 1–16.

Kessler, D. P. and M. B. McClellan (2000): "Is Hospital Competition Socially Wasteful?" *The Quarterly Journal of Economics*, 115, 577–615.

Kirchhoff, S. M. (2013): "Physician practices: Background, organization, and market consolidation," *Congressional Research Service Report for Congress*.

Koch, T., B. Wendling, and N. Wilson (2016): "How Vertical Integration Affects The Quantity and Cost of Care for Medicare Beneficiaries," *Working Paper*.

Kocher, R. and N. R. Sahni (2011): "Hospitals' race to employ physicians - the logic behind a money-losing proposition," *New England Journal of Medicine*, 364, 1790–1793.

Liss, D. T., J. Chubak, M. L. Anderson, K. W. Saunders, L. Tuzzio, and R. J. Reid (2011): "Patient-reported care coordination: associations with primary care continuity and specialty care use," *The Annals of Family Medicine*, 9, 323–329.

Macinko, J., B. Starfield, and L. Shi (2007): "Quantifying the health benefits of primary care physician supply in the United States," *International Journal of Health Services*, 37, 111–126.

Nakamura, S. (2010): "Hospital mergers and referrals in the United States: patient steering or integrated delivery of care?" *INQUIRY: The Journal of Health Care Organization, Provision, and Financing*, 47, 226–241.

Nakamura, S., C. Capps, and D. Dranove (2007): "Patient admission patterns and acquisitions of feeder hospitals," *Journal of Economics & Management Strategy*, 16, 995–1030.

Newhouse, J. P., A. P. Williams, B. W. Bennett, and W. B. Schwartz (1982): "Does the geographical distribution of physicians reflect market failure?" *The Bell Journal of Economics*, 493–505.

Obama, B. (2016): "United States health care reform: progress to date and next steps," *JAMA*, 316, 525–532.

O'Malley, A. S. and J. D. Reschovsky (2011): "Referral and consultation communication between primary care and specialist physicians: finding common ground," *Archives of internal medicine*, 171, 56–65.

Pauly, M. (1980): *Doctors and Their Workshops: Economic Models of Physician Behavior*, University of Chicago Press.

Peikes, D., A. Chen, J. Schore, and R. Brown (2009): "Effects of care coordination on hospitalization, quality of care, and health care expenditures among Medicare beneficiaries: 15 randomized trials," *JAMA*, 301, 603–618.

QuickStats (2015): "Percentage of Physicians Who Have Electronic Access to Patient Health Information from Outside Their Medical Practice, by State — United States," *Morbidity and Mortality Weekly Report*.

Rosenthal, M. B., A. Zaslavsky, and J. P. Newhouse (2005): "The geographic distribution of physicians revisited," *Health Services Research*, 40, 1931–1952.

Schaumans, C. (2008): "Strategic interaction between general practioners and specialists: implications for gatekeeping," *CES-Discussion paper series*.

Schaumans, C. and F. Verboven (2008): "Entry and regulation: evidence from health care professions," *RAND Journal of Economics*, 39, 949–972.

Schencker, L. (2015a): "Adventist Health System to pay $118.7 million settlement over Stark, False Claims allegations," *Modern Healthcare*.

——— (2015b): "Florida Health system to pay $69.5 million over Stark, False Claims allegations," *Modern Healthcare*.

——— (2015c): "Tuomey will pay U.S. $72.4 million to duck $237 million False Claims verdict," *Modern Healthcare*.

——— (2016): "South Carolina hospital to pay $17 million over physiican pay allegations," *Modern Healthcare*.

Shea, D., B. Stuart, J. Vasey, and S. Nag (1999): "Medicare physician referral patterns." *Health Service Research*, 34, 331–348.

Shi, L. (1992): "The relationship between primary care and life chances," *Journal of health care for the poor and underserved*, 3, 321–335.

Shi, L., J. Macinko, B. Starfield, J. Xu, J. Regan, R. Politzer, and J. Wulu (2004): "Primary care, infant mortality, and low birth weight in the states of the USA," *Journal of Epidemiology and Community Health*, 58, 374–380.

Starfield, B., L. Shi, A. Grover, and J. Macinko (2005): "The effects of specialist supply on populations' health: assessing the evidence," *Health Affairs*, 103, 23–18.

United States Court of Appeals for the Ninth Circuit. 778 F.3d 775 (2015): "St. Alphonsus Med. Ctr. v. St. Luke's Health Sys." *United States Court of Appeals for the Ninth Circuit.*