Barriers to Entry in the Healthcare Markets

Winners and Losers from Certificate-of-Need Laws

Thomas Stratmann and
Matthew C. Baker

MERCATUS WORKING PAPER

3434 Washington Blvd., 4th Floor, Arlington, Virginia 22201
www.mercatus.org

Thomas Stratmann and Matthew C. Baker. "Barriers to Entry in the Healthcare Markets: Winners and Losers from Certificate-of-Need Laws." Mercatus Working Paper, Mercatus Center at George Mason University, Arlington, VA, 2017.

Abstract

Certificate-of-need (CON) laws in 21 states restrict medical providers from acquiring imaging equipment, including magnetic resonance imaging (MRI), computed tomography (CT), and positron emission tomography (PET) scanners. Using difference-in-difference methods to control for state invariant characteristics, we test the effect of those restrictions on incumbent hospitals and entry into the imaging market. We find that states with CON laws demonstrate less market entry and lower market penetration of nonhospital and new hospital providers than do states that do not have those laws. Further, hospitals that opened before the implementation of a CON law face less competition in CON states than in non-CON states. We also study the effect of CON laws on consumers, which we measure as patient access to imaging services. We find that residents in CON states are more likely to travel outside their home county to obtain imaging services than are their counterparts in non-CON states.

JEL code: I180

Keywords: barriers to entry, certificate-of-need laws, medical imaging services, health care, healthcare, Medicare, regulation

Author Affiliation and Contact Information

Thomas Stratmann
Professor of Economics
Department of Economics, George Mason University
tstratma@gmu.edu

Matthew C. Baker
PhD student
Department of Economics, George Mason University
matthewcbaker13@gmail.com

This paper can be accessed at https://www.mercatus.org/publications/healthcare-barriers-to-entry-certificate-of-need-winners-losers

Barriers to Entry in the Healthcare Markets:

Winners and Losers from Certificate-of-Need Laws

Thomas Stratmann and Matthew C. Baker

Conventional economic wisdom holds that barriers to entry have negative and unintended consequences on consumer choice. The healthcare industry, however—more than other sectors of the economy—is a prominent example of a field in which many public officials and medical providers challenge and act against conventional economic wisdom, often accepting and promoting such restrictions. Arrow famously highlighted some of those idiosyncrasies (1963, 955), writing that "[t]he most striking departure from competitive behavior is restriction on entry to the [healthcare] field." Arrow pointed to laws enshrining limits to the provision of medical inputs, medical school restrictions, and licensing requirements, which have a "direct and unsubtle restriction on the supply of medical care" (1963, 955).

The conventional argument for restrictive healthcare laws is that they benefit the patient. For example, proponents of supply restrictions in the healthcare industry argue that consumer choice is best served when an already-licensed provider must obtain government permission to operate before offering new medical services. One prominent example of such supply controls is a certificate of need (CON), a legal document required in many states before a licensed medical provider may acquire, expand, or offer a new facility or service or purchase certain types of medical equipment, such as imaging scanners.

As of 2016, 21 states have some type of CON requirement for the purchase of scanners for imaging services.[1] On average, application fees are $32,000; however, total costs associated with the process to obtain regulatory permission to provide the medical service requested can exceed $5 million for a single application (Conley and Valone 2011), which exceeds the average price of a magnetic resonance imaging (MRI) machine.[2] The costs include consulting fees as well as review and appeal fees, and the process can take up to three years.

New York first introduced CON laws to the United States in 1964 to contain healthcare costs.[3] Proponents justified CON laws on the premise that unregulated market competition drives medical providers to overinvest in facilities and equipment, resulting in increased cost of medical care. They therefore lobbied for restricting market expansion and for regulators to permit only those expansions in which the medical provider could demonstrate a clear public need.

Early studies of those laws failed to show that they delivered their promised results. In general, those studies found no evidence of reduced investment by hospitals (Hellinger 1976; Salkever and Bice 1976) or of cost control (Joskow 1980, 1981; Sloan 1981; Sloan and Steinwald 1980). Since New York's adoption of CON requirements, a wide range of studies have examined the effect of CON laws on hospital cost, price, and efficiency. Some researchers provide evidence that CON laws are associated with higher hospital costs (Lanning, Morrisey, and Ohsfeldt 1991). Other research, however, implies that CON laws do not affect efficiency in a typical metropolitan hospital (Bates, Mukherjee, and Santerre 2006).

[1] In 2016, 36 states have some type of certificate-of-need requirement. Some requirements regulate the opening of hospitals, others of burn care centers, and others of neonatal intensive care units. The American Health Planning Association (AHPA) classifies more than 30 categories for which medical providers must obtain a CON, depending on their state.
[2] According to price guides for medical imaging equipment, prices for MRI machines can be as low as $150,000: https://info.blockimaging.com/bid/92623/mri-machine-cost-and-price-guide.
[3] Simpson (1985) provides a brief and comprehensive history of CON legislation.

Largely because of limited evidence that CON requirements curtailed healthcare costs, the federal government repealed national CON laws for many services in 1987, leaving regulation of certificate-of-need programs to individual states. Since then, several states have repealed their CON laws. The results of more recent research are mixed, but generally highlight CON laws' failures to meet expectations.[4] More recently, proponents have supported CON laws on the basis that they ensure consumer access to healthcare in rural communities, higher quality of care, and the provision of charity care.[5] Charity care, proponents argue, is cross-subsidized by the increased profits from certificate-of-need restrictions.

In this paper, we study who benefits and who loses from CON laws. Using difference-in-difference methods, we identify how CON laws affect marketplace entry of three regulated imaging services: MRI, computed tomography (CT), and positron emission tomography (PET) scans. We compare CON and non-CON states on use of and access to imaging services, separating the effects according to different provider types. We use Medicare claims to measure quantity of services and patient access.

In our study, we test economic theory predictions regarding the effects of barriers to entry, as well as whether CON laws have anticompetitive effects. We focus on how CON laws affect a number of factors, including quantity of services provided, number of suppliers of

[4] A study by Rivers, Fottler, and Frimpong (2010) finds no evidence that CON laws are associated with reduced hospital costs, but it does find evidence that stringent CON programs increase costs by 5 percent. Another study finds that hospital efficiency at the state level was not improved by CON laws (Ferrier, Leleu, and Valdmanis 2010). Most recently, Rosko and Mutter (2014), using stochastic frontier analysis, find that states with CON laws show increased cost efficiency. Although little research has been devoted specifically to CON regulations for advanced imaging services, some research shows that CON laws are not associated with lower hospital investment in new computed tomography (CT) technology (Ladapo et al. 2009).

Other studies focus on the effect of CON laws on market structure and competition (Eichmann and Santerre 2010), presenting evidence that CON laws decrease competition among medical service providers. Other scholars provide evidence that the number of providers and the use of certain services are affected by CON laws (Ho 2006; Short, Aloia, and Ho 2008).

[5] See, for example, AHPA n.d.; Cauchi and Noble 2016; and Rawlings 2016.

services, differences among supplier types, and consumer access to services. Further, we study whether CON laws have a disproportionate effect on different provider types. We identify the causal parameter of interest using a difference-in-difference regression approach.

First, we test the hypothesis that CON laws provide legal protection against potentially competitive new entrants—that is, whether incumbent providers are advantaged by reduced competition from other providers. We focus on incumbent hospitals that opened before CON laws were implemented compared with other medical providers offering imaging services.[6]

To measure the level of proliferation of imaging services in hospitals relative to other medical providers, we compare the use of imaging services in CON states and in non-CON states. We focus on those types of equipment for two reasons: they are widely used, and there is competition between many types of medical providers. In contrast, competition for the provision of neonatal intensive care is limited primarily to hospitals. We test the hypothesis that CON laws benefit providers with larger incumbent power. To do so, we test whether hospitals, relative to other, nonhospital providers, provide more imaging services in CON states than in non-CON states. We also analyze whether that difference is less prominent for new hospitals compared with hospitals that were already open when current CON laws were being established.

We find that hospitals established after the introduction of CON laws, as well as all types of nonhospitals, demonstrate lower medical use of imaging services than do other providers. We do not find a similar reduction by hospitals established before the introduction of the CON law, however. We provide evidence that CON laws reduce the overall number of medical providers, suggesting less availability of imaging services to patients in CON states. Consistent with that

[6] Aside from the argument that CON laws have a directly uncompetitive effect, some opponents also suggest that hospitals are advantaged because incumbent hospitals have sufficient recourses to absorb application and legal fees associated with CON laws, whereas their potential challengers may not (Ginsburg 2010).

finding, we show that patients are more likely to seek imaging services farther from their place of residence when they live in a state that restricts the provision of imaging machines through CON laws. Our findings show that up to 5.5 percent of patients in CON states travel out of their county of residence to receive care for MRI, CT, and PET scans.

Hypotheses

For our hypotheses, we consider CON laws, which require state government permission to purchase imaging scanners, such as MRI, CT, and PET scanners. Our predictions are grounded in the theoretical models of regulation, originated by Stigler (1971) and Peltzman (1976). Those models generate the hypotheses that economic regulations tend to benefit incumbent providers and are barriers to entry into the marketplace. Thus, those models make predictions regarding the economic effects of CON laws and predict that those effects differ across provider types, including new hospitals, incumbent hospitals, and nonhospitals.

The goal of CON laws is to limit entry of new providers by requiring a provider to demonstrate community "need" before opening, expanding, or providing a new service. To obtain a CON, a provider must file a lengthy application. Those applications often result in litigation, spanning several years.[7] Incumbent providers, such as preexisting hospitals, tend to be better organized than nonhospitals, which include independently practicing physicians, group practices, and other ambulatory care settings. The reason is that hospitals have access to more financial resources compared with independent providers and are members of well-organized state and national hospital organizations that provide expertise and lobbying services. Hospitals, with greater market power and more effective political organizations, face fewer barriers in

[7] See, for example, *Colon Health Centers of Am., LLC v. Hazel*, 813 F.3d 145 (4th Cir. 2016).

obtaining CONs from state agencies. Thus, we predict a larger differential in the provision of imaging services between hospitals and nonhospitals in states with CON laws.

This hypothesized difference in the market share of hospitals between CON and non-CON states may be due to several different mechanisms. First, if CON regulators tend to reject nonhospital providers at higher rates than hospitals, then hospitals will enter the market at a higher rate than nonhospitals. While hospitals might not be more numerous in CON states than in non-CON states, their nonhospital counterparts will be less numerous, leading to a larger market share for hospitals in CON states. Second, nonhospital providers may preempt the rejection by forgoing an application in the first place, choosing to work in another state instead, or even choosing another specialty with fewer or no CON restrictions. Third, nonhospital providers may find an alternative way into the market, such as by cooperating with hospitals. Hospital-physician integration establishes a financial agreement between the two provider types to split compensation for services. For example, if a physician practicing in radiology worked for a hospital's outpatient department instead of for an independent practice, this physician might be more likely to gain CON approval.

Anecdotal evidence supports our prediction. According to a survey by the National Institute for Health Care Reform, physicians report greater difficulties than do hospitals in entering new markets, and they cite CON laws as the primary barrier to entry (Yee et al. 2011). Several legal battles have illustrated the political divide between hospitals and other providers.[8] Further, amid recent state legislature rulemaking, opponents of CON laws have found themselves opposed by lobbying and donations from hospital associations (Salzer 2015; Fletcher 2015).

[8] See, for example, Salzer 2015 and Borden 2015.

Hypothesis 1: CON laws restrict imaging services supplied by nonhospital providers when compared with imaging services supplied by hospital providers.

The initial justification for CON laws was that new market entrants pose a competitive threat to preexisting hospitals and that CON laws should ensure less competition. The reasoning was that less competition would reduce the quantity of medical services provided as well as their prices. CON laws give incumbent competitors the opportunity to object to an approval of a CON application. Thus hospital providers, who tend to be politically organized, have the option to oppose the approval of providers who want to open or expand. We predict that this mechanism will lead to less provision of medical services by nonhospital providers. That is, states with a CON law for imaging services will have less entry by nonhospital providers relative to states without such a law.

Hypothesis 2: CON laws restrict imaging services from new hospital providers relative to services provided by incumbent hospital providers.

Our hypothesis predicts a lower quantity of services, and so we expect that there will be fewer providers and that the effect will be asymmetric across provider types. We predict that the number of new hospital providers per capita will be lower in CON states compared with non-CON states, whereas preexisting hospitals will exhibit no difference.

Hypothesis 3: Because of provider restrictions, patients in CON states have fewer options for care.

Given that CON laws may bar potential market entrants from providing services, CON laws will affect the patient experience with respect to the number of providers from which patients can

choose. If CON laws limit entry, then individuals have less choice in where they can obtain imaging services. Fewer providers imply fewer choices for consumers. We expect that the number of providers by type for this hypothesis will mirror the results for hypotheses 1 and 2, in which new hospitals and nonhospitals are most affected by CON laws.

Hypothesis 4: Patients in CON states are more likely to seek care outside their county of residence.

The availability of medical services predicts patient satisfaction and access to care (Penchansky 1981). Since Medicare and Medicaid prices for imaging services are fixed—thus providers may not increase prices when facing higher demand—a limited offering of imaging services might lead to excess demand. The market for care can respond to excess demand in many ways when providers are unable to increase prices. One such outcome is by increasing waiting times. In that case, patients have an incentive to search for providers that offer shorter waiting times, and those providers might be outside patients' community. Thus, patients in CON states face fewer choices and have an incentive to travel farther to find a provider of imaging services. As a result, they may be more likely to travel outside their county of residence to obtain care.

Data and Empirical Models

CON Laws for Imaging Services and Main Data Sources

For each regulated facility or piece of equipment, the American Health Planning Association (AHPA) classifies each of the 50 states and the District of Columbia as either having a CON law or having no CON law for the purchase of equipment for specific medical services. We use the AHPA data for classifying states by CON laws for imaging technologies in 2013 (AHPA 2013).

Separate laws govern MRI scanners, CT scanners, and PET scanners, and we analyze the effect of each of those laws.

Figures 1, 2, and 3 (pages 32–33) show maps of all US states, indicating the states where each of the three imaging CON laws applies. There is a large overlap among the three imaging CON laws by state. States with a CON law for one type of imaging service tend to have CON laws for other types. The maps also highlight the regional clustering of the CON laws. Along with Alaska and Hawaii, states in the eastern and southeastern half of the United States tend to have CON laws.

We link the CON law data to claims data from Medicare's five percent Standard Analytic Files (SAF) for fee-for-service (FFS) beneficiaries from calendar year 2013. The claims data, which we obtained from the Centers for Medicare and Medicaid Services (CMS), provide a snapshot of current differences across states and counties. Since there has been very little recent change in CON requirements for MRI, CT, and PET scans by state, there is little variation across time that would allow us to identify a CON treatment effect by using panel data methods. The SAF claims data include the Carrier limited data set (LDS) file for physician Medicare Part B claims, as well as the Inpatient LDS and the Outpatient LDS files for facility claims data. Those files contain information on the patient's state and county of residence, as well as the state and county of service of the provider on the claim.

We identify claims that include the use of diagnostics and treatment through MRI, CT, and PET scanners. Healthcare Common Procedure Coding System (HCPCS) codes from the LDS files provide us with the information to identify those claims. The counts for each type of scanner are aggregated to the state level for analysis.

We also use the Medicare data to compute the number of providers of each imaging service—MRI, CT, and PET scan. That number is a count of the number of unique providers that

filed a claim for each type of imaging service. The data further allow us to distinguish between hospital and nonhospital providers, as well as the county in which the provider's medical office is located. We use geographic information from Medicare's Provider of Services file to determine the county and state of each hospital. Information for nonhospital location is derived from the National Provider Identifier (NPI) data in the CMS Medicare Provider Utilization and Payment Data for Physician and Other Suppliers.

From the same Medicare database we obtain a count of the number of Medicare beneficiaries by state. That count is the number of beneficiaries by state from the Medicare Geographic Variation file. We then divide the number of scans in the state by the number of FFS beneficiaries. Thus, our dependent variable measures the use of imaging services per beneficiary. For each state, we multiply the counts by 20 to represent 100 percent of beneficiaries instead of 5 percent. Then we divide each of our use statistics by the total number of beneficiaries in the state to arrive at per-beneficiary values. Hospital market share is defined as the number of procedures provided by a hospital in a given state divided by the number of procedures performed by all types of providers, both hospital and nonhospital, in a state for a specific imaging service.

To control for the demand for healthcare services, we use the socioeconomic characteristics for the entire state's Medicare fee-for-service population, measured by average age, percentage male, percentage non-Hispanic white, percentage black, percentage Hispanic, and the average health risk score. The average health risk score is defined by the Hierarchical Condition Category (HCC) model from CMS, which measures the severity of a Medicare patient's medical history. Those data are from Medicare's Geographic Variation database (CMS 2013) and are based on the population of Medicare beneficiaries that are eligible to use FFS services. The data have been aggregated by CMS to the state level. Classifications regarding

which parts of the country are rural versus urban come from the US Census current delineations, released July 2015.

Data for other descriptive statistics variables include (a) the unemployment rate in 2013 from the US Bureau of Labor Statistics; (b) the average household income in 2013 and 1993, which we use to compute a variable that measures the 20-year rates of change, using the US Census estimates; (c) the urban percentage of the population in 2013 and 1993, again to compute a 20-year rate-of-change variable, from the US Census estimates and the Centers for Disease Control and Prevention's (CDC's) urban/rural delineation from the US Census Bureau; and (d) the national health expenditure growth data from 1993 to 2013 from CMS's National Health Expenditures database.

Estimating the Effect of CON Laws on the Quantity of Services Supplied by Provider Type and Number of New Hospitals, Preexisting Hospitals, and Nonhospitals

To test the hypothesis that that CON laws reduce the number of imaging services provided within a state, as well as the hypothesis that CON laws reduce the number of imaging services provided by nonhospitals relative to those of hospitals, we estimate the model

$$(Quantity\ of\ scans\ per\ 1{,}000\ beneficiaries)_{ij} = \beta_0 + \beta_1(CON\ law)_i + \beta_2(Hospital)_j + \beta_3(CON\ law)_i \times (Hospital)_j + \mu_i + \varepsilon_{ij}. \quad (1)$$

The dependent variable is the number of scans in state *i* by provider type *j*. Similarly, we estimate

$$(Number\ of\ providers\ per\ 100{,}000\ beneficiaries)_{ij} = \beta_0 + \beta_1(CON\ law)_i + \beta_2(Hospital)_j + \beta_3(CON\ law)_i \times (Hospital)_j + \mu_i + \varepsilon_{ij}, \quad (2)$$

where the dependent variable is the number of providers per 1,000 beneficiaries in state *i* by provider type *j* and μ_i is a state fixed effect.[9]

In both equations, the *Hospital* variable indicates which provider supplied the scanning services, a hospital or a nonhospital. The *CON law* variable is an indicator variable for the CON law policy in state *i* for the respective imaging service. For example, when the dependent variable is MRI scan within a state, the explanatory variable captures whether that state has a CON law for MRI machines. We estimate three separate specifications for each of the MRI, CT, and PET scan laws. The interaction between the *CON law* variable and the *Hospital* variable takes a value of one if the observation pertains to the delivery of imaging services by a hospital in a CON state and a value of zero otherwise.

In equation (1), we estimate the use difference between CON and non-CON states, and we estimate the difference in the use between hospitals and nonhospitals within a given state. The coefficient β_3 captures whether hospitals in CON states provide more imaging services relative to nonhospitals, conditional on both being in a CON state. The coefficient β_1 captures whether CON laws are negatively correlated with the overall number of scans provided within the state. We estimate those regressions with clustered standard errors at the state level.

Depending on the specification, our dependent variable is scans provided in state *i* by provider *j* for MRI, CT, or PET scans. We measure the dependent variable as the natural logarithm of claims per beneficiary, calculated as the number of claims for each type of scan, by

[9] The number of beneficiaries is a count of the number of Medicare beneficiaries by state from the 2013 Medicare LDS files.

provider category, and divided by the number of beneficiaries (in thousands) eligible for Medicare FFS in the state.[10]

We classify procedures as MRI, CT, and PET procedures using HCPCS codes from hospital revenue centers in the claims data, using the definitions in chapter 13 of Medicare's *Claims Processing Manual* (CMS 2015).

Our data source includes hospital claims and nonhospital claims. Hospital claims include all inpatient, outpatient, and emergency department claims, summed from the Inpatient SAF and the Outpatient SAF, using the hospital revenue center that corresponds to each imaging service. Nonhospital claims are from a subset of the Carrier SAF, using only those services that were delivered outside the hospital inpatient, outpatient, or emergency departments, using the HCPCS codes that correspond to each imaging service. To ensure accuracy and consistency of our data across states, we exclude (a) claims that were not paid by FFS, (b) rejected claims, (c) claims for which Medicare was not the primary payer, and (d) claims containing services provided outside the United States.

As for equation (1), we estimate three specifications for equation (2): one for providers of MRI scans, one for providers of CT scans, and a third for providers of PET scans. When the dependent variable is the number of MRI scan providers, β_3 captures whether a state with an MRI CON law has systematically fewer nonhospital providers of MRI scans relative to the number of hospitals that provide MRI scans.

[10] The measurement of the dependent variable in the form of $\log(x + c)$ allows us to include in the category states with zero claims. In our data, for PET services, 3 of 51 states have no nonhospital claims. The numbers for all MRI and CT claims within a state are greater than zero.

In equation (3), we test for a differential effect of CON requirements on new hospitals and pre-CON hospitals, and in equation (4) we perform a similar test for the number of medical providers, by type.

$$(Quantity\ of\ scans\ per\ 1{,}000\ beneficiaries)_{ij} = \beta_0 + \beta_1(CON\ law)_i + \beta_2(Preexisting\ hospital)_j + \beta_3(CON\ law)_i \times (Preexisting\ hospital)_j + \mu_i + \varepsilon_{ij}, \quad (3)$$

$$(Number\ of\ providers\ per\ 100{,}000\ beneficiaries)_{ij} = \beta_0 + \beta_1(CON\ law)_i + \beta_2(Preexisting\ hospital)_j + \beta_3(CON\ law)_i \times (Preexisting\ hospital)_j + \mu_i + \varepsilon_{ij}. \quad (4)$$

As in the previous regression models, equations (3) and (4) define the *CON requirement* variable as, depending on the specification, either an MRI, a CT, or a PET scan state CON requirement, measured as a binary variable. The unit of observation is the provider type *j* (new hospital or pre-CON hospital) in state *i* for the respective imaging service. The interaction term takes a value of one if the observation is located in a CON state and pertains to a hospital that provided Medicare services more than 20 years ago, and takes a value of zero otherwise.

In equations (3) and (4), we define *New hospital* as a hospital providing Medicare services since 1993 or later. The reason we choose this cutoff, at 20 years before our 2013 data, is that CON states made little or no significant changes to their CON laws after the early 1990s. Although many state laws changed in the years preceding 1993, in comparison, relatively few states had changed their CON imaging laws after that date. For example, 26 states had repealed CON laws for MRI by 1993, compared to 32 by 2013; 35 states had repealed CON laws for CT by 1993, compared to 38 by 2013; and 36 states had repealed CON laws for PET by 1993, compared to 31 by 2013.

Data for our other control variables include (a) the unemployment rate in 2013 from the US Bureau of Labor Statistics; (b) the average household income in 2013 and 1993, which we use to compute a variable that measures the to 20-year rates of change, using the US Census estimates; (c) the urban percentage of the population in 2013 and 1993, again to compute a 20-year rate-of-change variable, from the US Census estimates and the CDC's urban/rural delineation from the US Census Bureau; and (d) the national health expenditure growth data from 1993 to 2013 from CMS's National Health Expenditures database.

Estimating the Effect of CON Laws on Patient Cost and Access

To test whether CON laws increase the percentage of patients who travel to obtain medical services, we estimate the probability that a patient travels outside his or her county of residence with ordinary least squares.

$$\pi_i = \Pr(Y_i = 1) = \beta_0 + \beta_1 CON_i + \boldsymbol{X}_i\boldsymbol{\delta} + \varepsilon_i. \quad (5)$$

Y is defined as traveling outside one's location of residence, where *Y = 1* represents receiving care from a provider in a county other than where the patient resides, and *Y = 0* represents receiving care from a provider within the patient's county of residence. We determine whether the patient travels out of county by comparing the patient's place of residence and the provider's place of service, as documented in the Inpatient, Outpatient, and Carrier SAF files, and provider location data from CMS. We cluster standard errors at the county level. The variable for *CON* equals one if the patient resides in a CON state and zero if the patient resides in a non-CON state. We proceed in an analogous manner for seeking CT and PET scan services. Because the model tests limitations to the supply and the resulting spillover of excess demand for imaging services, we do not include the CON status of the destination county. We assume that

limitations on patient choice will result in spillover demand into both CON and non-CON counties and are not interested in whether the spillover flows into counties in states with or without CON requirements. Services that are out-of-county for one patient are in-county for other patients, so we treat spillover demand as multidirectional. All else equal, we would expect the amount of travel in and out of a county to be similar across states.

The $\boldsymbol{X}$ vector in model (5) includes a set of dummy control variables measuring residents' propensity to travel to obtain medical care, including patient age, sex, and race and whether the patient lives in a metropolitan county, a micropolitan county, or a rural county, as defined by the Census Bureau. The controls also include the population density of the county, measured as residents per square land mile, and an average health risk score. The density of the county controls for area characteristics, such as road patterns and traffic, that might influence the propensity to travel from one's residence. This score is calculated by the HCC model from the CMS, measuring the severity of a Medicare patient's medical history. Those data are from Medicare's Geographic Variation database (CMS 2013) and are based on the population of Medicare beneficiaries that are eligible to use FFS services.

Results

In this section of the paper, table 1 reports descriptive statistics from our claims data by state, disaggregated by CON status. Table 2 presents fixed-effect regression results to compare the effect of CON on the quantity of services across provider types. Table 3 repeats that model for the number of suppliers rather than the quantity of services. Tables 4 and 5 summarize those results to directly compare across provider types and scan type. Tables 6 and 7 address patient

access to care, with the former providing summary statistics from our claim-level data; and table 7 specifies a model for patient travel.

Descriptive Statistics

Table 1 (page 34) presents descriptive statistics for CON and non-CON states, as well as t-tests for differences between CON and non-CON states. The table includes all variables used in our regressions, as well as the number of providers for imaging scans from different provider types—including disaggregate rates for new hospitals, pre-CON hospitals, and nonhospitals—for each type of imaging service.

Table 1, panel A shows differences between states with and without MRI CON laws, showing differences for four categories: (a) the number of providers of MRI scans per 100,000 beneficiaries, (b) the number of MRI scans per MRI scan provider, (c) the number of MRI scans per 1,000 beneficiaries, and (d) hospitals' market share for MRI scans. Panel B shows the analogous differences for CT scans, and panel C shows those differences for PET scans. All panels also report means and differences in socioeconomic characteristics by the type of CON law considered in each of those panels.

All three panels in table 1 reveal consistently fewer medical providers in CON states for all MRI, CT, and PET scan provider types—that is, all hospitals, new hospitals, older hospitals, and nonhospital providers—across states with MRI, CT, and PET CON laws. Some of those differences are statistically significant. For the number of scans per provider, table 1 shows that new hospitals and nonhospital providers have fewer scans per beneficiary in CON states, whereas pre-CON hospitals show no statistically significant difference in number of scans regardless of CON status.

Similarly, with respect to the number of scans per 1,000 beneficiaries, table 1 reports that all provider categories show the pattern of fewer scans provided in states with CON laws. Table 1 also shows that hospitals, especially hospitals that began service before 1993, have a higher market share on average in CON states than in non-CON states.

All panels of table 1 show modest differences in socioeconomic characteristics between states with CON laws and states without CON laws. With the exception of the racial variables, the demographic characteristics are balanced between CON and non-CON states, and the differences in means for the latter variables are not statistically significant. As displayed in figures 1, 2, and 3, states with CON laws for each imaging service tend to cluster in the East, where fewer non-Hispanic whites and fewer Hispanics but more African–Americans reside. In our regressions, we control for state differences through fixed effects. Racial differences between CON and non-CON states seem to have no effect on state growth. Our state growth variables—that is, the change in (a) the proportion of the state that is rural, (b) household income growth, and (c) health expenditures growth—measured from 1993 to the present are very similar between CON and non-CON states.

Figures 4 and 5 display state data for the dependent variables of interest for our fixed-effects regressions separated by CON and non-CON states, plotting providers per beneficiary by scans per beneficiary. Figure 4 (page 41) corresponds to rates for nonhospital providers, and figure 5 (page 44) corresponds to new hospital providers that began operating since 1993. In both provider cohorts, across all three scan types, CON states demonstrate different patterns for the number of scans and providers than non-CON states.

In the graphs, the right end shows states with high numbers of scans per beneficiary, and large values tend to be non-CON states. On the other hand, CON states tend to cluster along the

left side of each graph. The top of the graph represents a high concentration of providers of scans and tends to be populated with non-CON states, whereas the bottom of the graph tends to be populated with CON states. That effect is pronounced across nonhospital providers and new hospital providers.

The Effect of Certificate-of-Need Laws by Type of Provider

The regressions in table 2 and 3 test our hypotheses that CON laws have a selectively negative effect on the provision of imaging services. Table 2 (page 47) reports the fixed-effects regression testing the effect of CON laws on the quantity of services provided. First, panel A presents results from the fixed-effects regressions for hospitals and nonhospitals, with one specification each for MRI, CT, and PET CON laws. For each type of scan, we use a single specification because the fixed effects absorb any state differences.

For all PET imaging services, the coefficient on *CON law* is statistically significantly different from zero at the 10 percent level, implying that we find an effect of CON on nonhospitals. For MRI and CT imaging services, the coefficient achieved statistical significance at the 15-percent level. Those negative coefficients imply a negative association between CON laws and the quantity of nonhospital scans.

The coefficients on *CON law* × *Hospital*, which represents the difference between the effect on hospitals and the effect on nonhospitals, is uniformly positive across scan type, implying a large difference between CON association for different provider types. If CON laws uniformly affected each provider type equally, the coefficient on this variable would be zero.

Those results provide an estimate of the size of the relationship between state CON laws and the number of scans provided within the state. For MRI scans, the magnitude of the coefficients on

CON law is −0.31, implying that CON laws are associated with a (exp(−0.31) −1) decrease in the quantity of MRI scans in nonhospitals (a 27 percent decrease). We also observe the coefficient on (*CON law*) × (*Hospital*) to test for differences between hospital and nonhospital relationships to CON. For MRI scans, the coefficient is 0.41, implying a (exp(−0.41) −1) difference, or a relationship with CON laws of 34 percent fewer services at nonhospitals than at hospitals.

The results for CT and PET scans are similar to those for MRIs. Interpreting the coefficients in the same manner as for MRIs, nonhospitals are associated with a 41 percent decrease in the quantity of CT scans and a 45 percent decrease in the quantity of PET scans. The differences between hospitals and nonhospitals are 42 percent less for nonhospital CT scans and 48 percent less for nonhospital PET scans. Overall, our hypothesis tests show no statistically significant effect of CON laws on hospitals' quantity of scans testing the sum of $B_2(Hospital)_j + B_3(CON\ law)_i \times (Hospital)_j$. Those findings are consistent with the hypothesis that CON laws benefit hospitals relative to other providers and that hospitals might not be affected by CON laws.

The point estimates on the variable *Hospital* controls for the difference between hospital and nonhospital volume of services. For MRI scans, we observe a larger coefficient on *Hospital* than for CT and PET scans because of the higher proportion of nonhospital provision among MRI scans compared with other types of scans.

Assuming that our fixed effects capture all variables that simultaneously affect use and the adoption of the CON law, the CON law is uncorrelated with the error term in the regression equation. In this case, CON is exogenous conditional on the controls, and we can give the point estimates a causal interpretation.[11]

[11] Our models use services provided in the state for dependent variable, rather than using the services obtained by residents of the state. After testing the results using claims by residents of the state instead, we found that the results were nearly identical.

The analysis from table 2, panel A, demonstrates the effect of CON laws on the quantity of services at hospitals and nonhospitals. Panel B repeats that regression within the hospital cohort, separated into new hospitals and preexisting hospitals. Figure 6 (page 49) illustrates why those hospital cohorts are meaningfully different with respect to provision of hospital services. Figure 6, panels A, B, and C—the market share for new hospitals—show that new hospitals (that opened in 1993 to 2013) are significantly underrepresented in CON states relative to non-CON states. CON states are defined as states that had repealed CON laws by 2013, most commonly in the 1980s. According to the chart, the difference between CON and non-CON states with respect to hospital market share begins to emerge in the 1980s, when states began to repeal their CON laws following the repeal of the federal mandate. Hospitals that opened before the 1980s (specifically, in 1975–1979) have similar market shares in CON and non-CON states. In fact, CON states experienced slightly higher market shares from hospitals that opened during that timeframe than non-CON states. This shows that the reduced market share for new hospitals did not begin until states began repealing CON laws. In the 1990s, the market share between new hospitals in CON and non-CON states further diverge: depending on the type of scan, hospitals opening during the 1995–1999 timeframe captured between 0.8 and 1.1 percent of the market in non-CON states but were able to capture just 0.2 to 0.3 percent of the market in CON states. This may be because there are fewer new hospitals opening in CON states, or because the ability to provide services may be restricted by CON laws. The results from both table 2 (relationship between number of scans and CON) and table 3 (relationship between number of providers and CON) distinguish between these two possibilities, showing that both mechanisms play a role in reducing market share for new hospitals.

The divergence of new hospitals in CON states from new hospitals in non-CON states appears in table 2, panel B, which demonstrates the quantity of services for each of the two types. The results on the interaction variable between preexisting hospitals and the presence of a CON law provides strong evidence that CON laws affect new hospitals differently than pre-CON hospitals. Those results are further summarized and discussed in tables 4 and 5.

The effect of CON laws on the quantity of scans provided by preexisting hospitals is given by the sum of the coefficient on *CON law* plus the coefficient on (*CON law*) × (*Preexisting hospital*). That value in table 2, panel B, is small and not statistically significantly different from 0, implying that we find no effect of CON on incumbent hospitals, with the exception of the data on MRI scans, which show a modest positive effect of CON on incumbent hospitals.

The Impact of Certificate of Need Laws on the Number of Providers

Table 3 (page 51) presents models similar to those in table 2, instead using the number of providers of scans as the dependent variable. Panel A shows the effect of CON laws for hospital and nonhospital providers with respect to the number of each type of provider, and panel B shows the effect of CON laws for new and preexisting hospitals. We estimate separate regressions for each type of scan—that is, providers of MRI, CT, and PET scans.

For the hospital and nonhospital model in table 3, panel A, the results for the number of providers mirror the results for quantity of services provided, showing statistically significantly negative relationships between CON and nonhospital providers at the 15 percent level for MRI and CT scans and at the 1 percent level for PET scans. Among nonhospital providers, CON laws are associated with 0.147 fewer MRI providers, 0.122 fewer CT providers, and 0.031 fewer PET providers per 1,000 beneficiaries. For MRI and PET scans, we find no relationship between the

number of providing hospitals, based on the hypothesis test for the sum of the coefficient on *CON law* plus the coefficient on (*CON law*) × (*Hospital*). For CT scans, we find that the number of hospitals is negatively related to CON laws.

Similar patterns continue to emerge in table 3, panel B, which compares the number of new hospitals to the number of pre-CON hospitals. New hospitals per 1,000 beneficiaries are negatively related to CON laws, but preexisting hospitals are not. The size of the coefficients is 0.025 fewer new MRI hospitals, 0.054 fewer new CT hospitals, and 0.002 fewer PET hospitals, all statistically significant at the 5 percent level. Those results did not hold for other hospitals starting before 1993, with near-0 relationships based on the sum of the coefficient on *CON law* plus the coefficient on (*CON law*) × (*Preexisting hospital*).

The results in tables 4 and 5 (page 53) summarize the regression coefficients on *CON law* for all provider types and all scan types. The results for the number of providers mirror the results for the quantity of services, both demonstrating that CON laws are unrelated to total provision in hospitals and to provision in preexisting hospitals but are negatively related to provision in new hospitals and nonhospitals. The association with CON for hospitals' number of scans is small, ranging from only 3 to 10 percent, but a breakdown across preexisting hospitals and new hospitals shows that the effect differentiates within hospital types, with preexisting hospitals gaining between 11 and 20 percent additional scans in CON states and new hospitals losing between 25 and 76 percent of scans.

Those results are mirrored in panel B, showing that the number of nonhospital providers and new hospital providers are affected the most. In fact, the hospital cohort is negatively affected, ranging from −0.1 to −5.0 providers per 100,000 beneficiaries. That effect does not hold for all hospital types because preexisting hospital providers are slightly more common in

CON states, by 0.1 to 0.8 per 100,000 beneficiaries. For PET scans, the effect on hospitals is nearly 0, with the only large effect occurring in nonhospital providers.

The Effect of Certificate-of-Need Laws on Patient Access and Travel Distance

Tables 6 and 7 (page 54) present our results from testing the hypothesis that CON laws increase the likelihood that individuals in CON states incur larger travel times than those in states without CON. Table 6 provides summary statistics, showing that the differences between CON and non-CON states are most pronounced in out-of-county travel. Table 7 drills down to that metric, showing that after controlling for socioeconomic characteristics, the magnitude of the effect varies by scan type and by distance from the patient's residence. The coefficient on CON shows a more statistically significant chance of traveling for MRI and CT services based on traveling out of county, with weaker results for PET scans.[12]

Those coefficients imply that CON laws are associated with patients' decision to obtain care out of county, increasing their chance of traveling by 3.7 to 5.5 percent, depending on the type of scan.[13] Those results are produced by aggregating both hospital and nonhospital claims, demonstrating that among all service settings, CON laws are related to patients' decisions about their care. The coefficients on the control variables show that urban areas, especially metropolitan areas, have less out-of-county travel and that older patients are less likely to travel.

[12] We compared those ordinary least squares (OLS) results to a probit model and found that the standard errors and *p*-values were very close in magnitude, with no variable changing its statistical significance at the 5 percent or 10 percent threshold. In the OLS models, no MRI or CT claims and fewer than 3 percent of PET claims had a predicted value greater than one or less than zero.

[13] We ran a similar regression on the propensity to travel out of state rather than out of county. The relationship between CON and the chance of traveling out of state was positive but smaller and not statistically significant.

Conclusions

Our results provide evidence that market entry for new hospital and nonhospital providers is limited by CON laws, whereas incumbent hospital providers remain largely unaffected. The magnitude of the coefficients implies that the association of the CON policy with new hospital and nonhospital providers is substantial, ranging from −25 percent to −76 percent, depending on the type of scan and the type of provider. For incumbent hospitals, the effect is nearly zero. The strength of those results is highlighted by the persistence in differences seen in the descriptive statistics amid control variables for healthcare demand, patient risk, and demographics.

The results for hospitals are consistently different from the results for nonhospitals, and the results for new hospitals are consistently different from those for pre-CON hospitals. That explains some of the differences in market share across CON states and non-CON states; older hospital providers have a stronger market presence in CON states and are shielded by CON laws that leave them largely unaffected.

The statistically significant difference between hospitals and nonhospitals and between new hospitals and pre-CON hospitals supports our theoretical framework, which hypothesizes that nonhospital providers experience greater barriers to providing imaging services under CON laws than do hospital providers. Our difference-in-difference results imply that CON laws widen the differences between hospitals and nonhospitals, disadvantage new hospitals in establishing imaging services, and protect existing hospitals.

The results also identify a mechanism affecting the quantity of services. Table 3 and our regression on the number of providers indicate that CON laws seem to largely limit new hospitals and nonhospitals from providing services, with far fewer of those provider types offering MRI, CT, or PET services in CON states.

Our results for patient travel inform several claims from our theoretical framework. First, they support the idea that CON laws may harm consumers because patients living in CON states are induced to travel more often than are patients living in non-CON states. The propensity for residents of CON states to travel to obtain medical services can be attributed to any of several factors: higher costs, lower access to care, or a smaller selection of services. The existence of the latter factor is supported by our results for the number of providers, several types of which may be restricted by CON laws.

In our use regression and patient access regression, nonhospital services display a strong association with CON, but hospital services do not. A possible explanation is that some market players are prevented from entering the market for MRI, CT, and PET scans in those states, squeezing out people who live in those states from getting care from those nonhospital providers and spilling some of the demand over to other states or hospitals. Another explanation is that hospitals in CON states may attract consumers who would otherwise prefer to travel to a nonhospital provider but who were limited by lower accessibility in CON states.

Together, the results support our hypotheses. Fewer MRI, CT, and PET scans are provided in states with CON laws, but the effect across all provider types is not consistent, resulting in winners and losers of market share. New hospitals and nonhospital providers face a negative outcome, whereas other provider types gain. More research is needed on why additional costs and barriers in the healthcare industry restrict certain market providers and how they may affect where services occur.

References

American Health Planning Association (AHPA). 2013. *National Directory: State Certificate of Need Programs, Health Planning Agencies*. Annual volumes, 1994–2013. Falls Church, VA: American Health Planning Association. http://www.ahpanet.org/national_directory.html.

American Health Planning Association (AHPA). n.d. "Improving Health Care: A Dose of Competition, AHPA Response." Fact sheet. Accessed January 5, 2017. http://www.ahpanet.org/files/AHPAargfavorCON.pdf.

Arrow, Kenneth J. 1963. "Uncertainty and the Welfare Economics of Medical Care." *American Economic Review* 53 (5): 941–73. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2585909/pdf/15042238.pdf.

Bates, Laurie J., Kankana Mukherjee, and Rexford E. Santerre. 2006. "Market Structure and Technical Efficiency in the Hospital Services Industry: A DEA Approach." *Medical Care Research and Review* 63 (4): 499–524. http://journals.sagepub.com/doi/pdf/10.1177/1077558706288842.

Borden, Jeremy. 2015. "S.C. House Votes to End CON Health Care Regulations." (Charleston, S.C.) *Post and Courier*, April 28. http://www.postandcourier.com/politics/s-c-house-votes-to-end-con-health-care-regulations/article_29e80332-461e-554d-9c43-20fb43bd3aaf.html.

Cauchi, Richard, and Ashley Noble. 2016. "CON—Certificate of Need Laws." National Conference of State Legislatures website. http://www.ncsl.org/research/health/con-certificate-of-need-state-laws.aspx#Program.

Centers for Medicare and Medicaid Services (CMS). 2013. Geographic Variation Public Use Files. Accessed June 1, 2015. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Medicare-Geographic-Variation/GV_PUF.html.

———. 2015. *Medicare Claims Processing Manual.* Publication no.100-04. Accessed August 30, 2015. https://www.cms.gov/regulations-and-guidance/guidance/manuals/internet-only-manuals-ioms-items/cms018912.html.

Conley, Regina, and Paul Valone. 2011. "Certificate of Need: The Cost of the Process." Raleigh, NC: Civitas Institute. Accessed October 21, 2015. https://www.nccivitas.org/2011/certificate-of-need-the-cost-of-the-process.

Eichmann, Traci L., and Rexford E. Santerre. 2010. "Do Hospital Chief Executive Officers Extract Rents from Certificate of Need Laws?" *Journal of Health Care Finance* 37 (4): 1–14. https://www.ncbi.nlm.nih.gov/pubmed/21812351.

Ferrier, Gary D., Hervé Leleu, and Vivian G. Valdmanis. 2010. "The Impact of CON Regulation on Hospital Efficiency." *Health Care Management Science* 13 (1): 84–100. doi:10.1007/s10729-009-9113-z.

Holly Fletcher. 2015. “Senate Hearing Points to Brewing Certificate of Need Battle.” *Tennessean*, November 16. http://www.tennessean.com/story/money/industries/health-care/2015/11/16/senate-hearing-points-brewing-certificate-need-battle/75865448/.

Ginsburg, Paul B. 2010. “Wide Variation in Hospital and Physician Payment Rates Evidence of Provider Market Power.” HSC Research Brief No. 16, Center for Studying Health System Change, Washington, DC. http://www.hschange.org/CONTENT/1162/.

Hellinger, Fred J. 1976. “The Effect of Certificate-of-Need Legislation on Hospital Investment.” *Inquiry: A Journal of Medical Care Organization, Provision and Financing* 13 (2): 187–93. https://www.jstor.org/stable/29770998?seq=1#page_scan_tab_contents.

Ho, Vivian. 2006. “Does Certificate of Need Affect Cardiac Outcomes and Costs?” *International Journal of Health Care Finance and Economics* 6 (4): 300–24. doi:10.1007/s10754-007-9008-9.

Joskow, Paul L. 1980. “The Effects of Competition and Regulation on Hospital Bed Supply and the Reservation Quality of the Hospital.” *Bell Journal of Economics* 11 (2): 421–47. http://www.jstor.org/stable/3003372.

———. 1981. *Controlling Hospital Costs: The Role of Government Regulation*. Health and Public Policy series, book 2. Cambridge, MA: MIT Press.

Ladapo, Joseph A., Jill R. Horwitz, Milton C. Weinstein, G. Scott Gazelle, and David M. Cutler. 2009. “Adoption and Spread of New Imaging Technology: A Case Study.” Health Affairs 28 (6): w1122–32.

Lanning, Joyce A., Michael A. Morrisey, and Robert L. Ohsfeldt. 1991. “Endogenous Hospital Regulation and Its Effects on Hospital and Nonhospital Expenditures.” *Journal of Regulatory Economics* 3 (2): 137–54. http://EconPapers.repec.org/RePEc:kap:regeco:v:3:y:1991:i:2:p:137-54.

Peltzman, Sam. 1976. “Toward a More General Theory of Regulation.” NBER Working Paper No. 133, National Bureau of Economic Research, Cambridge, MA. http://www.nber.org/papers/w0133.

Rawlings, R. Brent. 2016. “The Importance of COPN: Serving the Public Need, Supporting Virginia’s Health Care System.” *VHHA’s Focus*, Virginia Hospital and Healthcare Association, January-February. http://www.vhha.com/communications/wp-content/uploads/sites/16/2016/02/VHHA-January-February-FOCUS-Publication.pdf.

Penchansky, Roy, and J. William Thomas. 1981. “The Concept of Access: Definition and Relationship to Consumer Satisfaction.” *Medical Care* 19 (2): 127–40.

Rivers, Patrick A., Myron D. Fottler, and Jemima A. Frimpong. 2010. “The Effects of Certificate-of-Need Regulation on Hospital Costs.” *Journal of Health Care Finance* 36 (4): 1–16. https://www.vdh.virginia.gov/Administration/documents/COPN/Jamie%20Baskerville%20Martin/Rivers%20et%20al.pdf.

Rosko, Michael D., and Ryan L. Mutter. 2014. "The Association of Hospital Cost-Inefficiency with Certificate-of-Need Regulation." *Medical Care Research and Review* 71 (3): 280–98. http://journals.sagepub.com/doi/abs/10.1177/1077558713519167.

Salzer, James. 2015. "Lawmakers Not Happy about Cancer Center Rule Change." *Atlanta Journal-Constitution*, September 15. http://www.myajc.com/news/state--regional-govt--politics/lawmakers-not-happy-about-cancer-center-rule-change/C6aJwFjks0UkcnDamz9zfN/.

Salkever, David S., and Thomas W. Bice. 1976. "The Impact of Certificate-of-Need Controls on Hospital Investment." *Milbank Memorial Fund Quarterly: Health and Society* 54 (2): 185–214. http://www.jstor.org/stable/3349587.

Short, Marah N., Thomas A. Aloia, and Vivian Ho. 2008. "Certificate of Need Regulations and the Availability and Use of Cancer Resections." *Annals of Surgical Oncology* 15 (7): 1837–45. doi:10.1245/s10434-008-9914-1.

Simpson, James B. 1985. "State Certificate-of-Need Programs: The Current Status." *American Journal of Public Health* 75 (10): 1225–29. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1646383/pdf/amjph00286-0111.pdf.

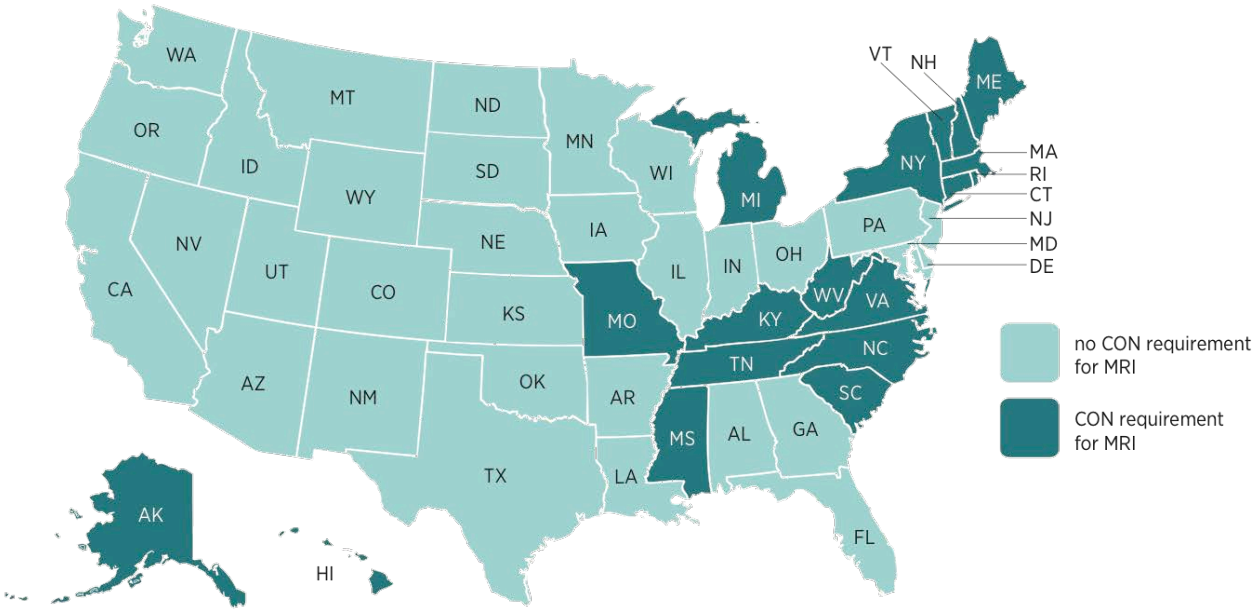
Sloan, Frank A. 1981. "Regulation and the Rising Cost of Hospital Care." *Review of Economics and Statistics* 63 (4): 479–87. http://www.jstor.org/stable/1935842.

Sloan, Frank A., and Bruce Steinwald. 1980. "Effects of Regulation on Hospital Costs and Input Use." *Journal of Law and Economics* 23 (1): 81–109. http://www.jstor.org/stable/725286.

Stigler, George J. 1971. "The Theory of Economic Regulation." *Bell Journal of Economics and Management Science* 2 (1): 3–21. http://www.jstor.org/stable/3003160.

Yee, Tracy, Lucy B. Stark, Amelia M. Bond, and Emily Carrier. 2011. "Health Care Certificate-of-Need (CON) Laws: Policy or Politics?" NIHCR Research Brief No. 4, National Institute for Health Care Reform (NIHCR), Auburn Hills, MI. Accessed September 18, 2015. http://www.nihcr.org/CON_Laws.html.

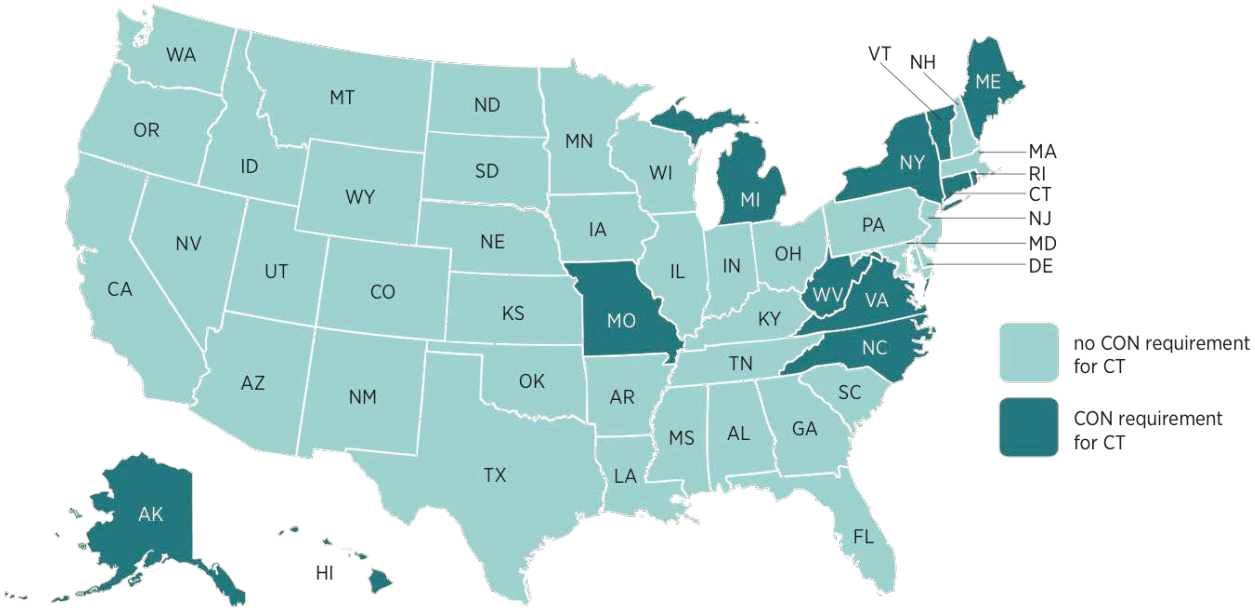
Figure 1. Certificate-of-Need (CON) Law for MRI Services, by State



Note: MRI = magnetic resonance imaging.

Source: American Health Planning Association.

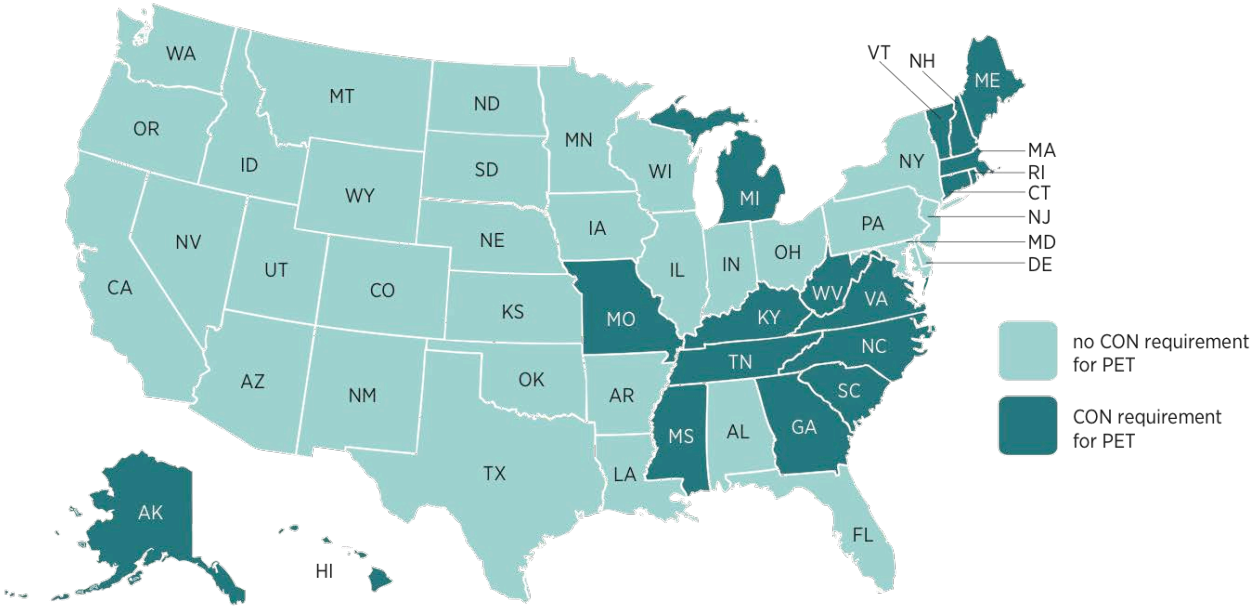
Figure 2. Certificate-of-Need (CON) Laws for CT Services, by State



Note: CT = computed tomography.

Source: American Health Planning Association.

Figure 3. Certificate-of-Need (CON) Laws for PET Services, by State



Note: PET = positron emission tomography.

Source: American Health Planning Association.

Table 1. Summary Statistics

Panel A. MRI Scans

	No CON laws	CON laws	Test for differences (*p*-value)
Number of states	32	19	
Number of providers of MRIs per 100,000 beneficiaries			
Hospitals	14.66 (4.66)	13.01 (3.28)	0.18
New hospitals (start year 1993 to present)	4.65 (2.80)	2.18 (2.08)	0.00
Preexisting hospitals (start year before 1993)	10.02 (3.12)	10.82 (3.10)	0.38
Nonhospital physicians	65.07 (23.38)	50.41 (28.56)	0.05
Number of MRI scans per provider			
Hospitals	835.54 (395.49)	990.58 (325.22)	0.16
New hospitals (start year 1993 to present)	271.87 (180.30)	229.37 (221.04)	0.48
Preexisting hospitals (start year before 1993)	1,078.66 (498.70)	1,147.71 (314.45)	0.59
Nonhospital providers	149.62 (52.51)	161.99 (52.55)	0.42
Number of MRI scans per 1,000 beneficiaries			
Hospital	110.50 (28.05)	123.89 (43.74)	0.19
Hospital (log)	4.68 (0.27)	4.78 (0.30)	0.23
New hospital	11.04 (8.05)	2.84 (3.01)	0.00
New hospital (log)	2.23 (0.80)	1.10 (0.73)	0.00
Preexisting hospital	99.46 (27.41)	121.05 (44.14)	0.04
Preexisting hospital (log)	4.57 (0.28)	4.75 (0.31)	0.04
Nonhospital	95.58 (41.97)	76.78 (38.74)	0.12
Nonhospital (log)	4.48 (0.43)	4.17 (0.75)	0.07

continued on next page

	No CON laws	CON laws	Test for differences (*p*-value)
Market share			
Hospital	0.55 (0.13)	0.63 (0.15)	0.05
New hospital	0.06 (0.04)	0.02 (0.02)	0.00
Preexisting hospital	0.49 (0.12)	0.61 (0.15)	0.00
Nonhospital	0.45 (0.13)	0.37 (0.15)	0.05
Care obtained outside patient's state/county of residence			
Percent traveling out of state	0.145	0.177	0.17
Percent traveling out of county	0.439	0.474	0.28
State characteristics			
Number of states—West	11	2	
Number of states—South	7	7	
Number of states—Midwest	10	2	
Number of states—Northeast	4	8	
Medicare fee-for-service beneficiaries	593,809 (574,057)	469,928 (406,387)	
Average age	75.41 (0.67)	75.42 (0.69)	0.94
Percentage male	44.29 (1.80)	43.34 (1.90)	0.08
Percentage non-Hispanic white	86.46 (8.67)	81.84 (19.14)	0.24
Percentage black	5.43 (5.85)	9.46 (13.56)	0.15
Percentage Hispanic	4.24 (5.57)	2.01 (1.89)	0.10
Average HCC score	0.92 (0.07)	0.95 (0.08)	0.15
Unemployment	6.55 (1.61)	7.14 (1.39)	0.19
Household income	53,169 (7,170)	54,527 (10,382)	0.58
Proportion rural growth 1993–2013	0.00 (0.06)	–0.02 (0.08)	0.58

continued on next page

	No CON laws	CON laws	Test for differences (*p*-value)
Household income growth 1993–2013	0.06 (0.09)	0.08 (0.12)	0.52
Health expenditures growth 1993–2009	1.87 (0.38)	1.77 (0.38)	0.34

Note: Includes 50 states and the District of Columbia. Values in parentheses are standard deviations.
CON = certificate of need; HCC = Hierarchical Condition Category.

Panel B. CT Scans

	No CON laws	CON laws	Test for differences (*p*-value)
Number of states	38	13	
Number of providers of CTs per 100,000 beneficiaries			
Hospitals	20.79 (8.20)	15.81 (4.81)	0.04
New hospitals (start year 1993 to present)	9.88 (7.07)	4.48 (3.78)	0.01
Preexisting hospitals (start year before 1993)	10.90 (3.56)	11.33 (3.56)	0.71
Nonhospital physicians	58.37 (23.47)	46.20 (24.37)	0.12
Number of CT scans per provider			
Hospitals	2,442.06 (1,593.56)	2,978.77 (1,199.27)	0.27
New hospitals (start year 1993 to present)	545.56 (655.39)	272.00 (253.36)	0.17
Preexisting hospitals (start year before 1993)	3,766.92 (1,692.30)	3,883.83 (1,149.71)	0.82
Nonhospital providers	125.95 (44.26)	109.61 (43.67)	0.25
Number of CT scans per 1,000 beneficiaries			
Hospital	409.09 (91.81)	432.47 (140.90)	0.50
Hospital (log)	5.99 (0.23)	6.02 (0.35)	0.73
New hospital	33.09 (25.28)	8.65 (7.37)	0.00
New hospital (log)	3.26 (0.81)	1.85 (1.10)	0.00

continued on next page

	No CON laws	CON laws	Test for differences (*p*-value)
Preexisting hospital	376.00 (97.49)	423.82 (142.17)	0.18
Preexisting hospital (log)	5.90 (0.27)	6.00 (0.35)	0.29
Nonhospital	73.54 (40.83)	55.70 (37.63)	0.17
Nonhospital (log)	4.17 (0.53)	3.66 (1.22)	0.04
Market share			
Hospital	0.85 (0.07)	0.88 (0.10)	0.20
New hospital	0.07 (0.05)	0.02 (0.02)	0.00
Preexisting hospital	0.78 (0.10)	0.86 (0.09)	0.01
Nonhospital	0.15 (0.07)	0.12 (0.10)	0.20
Care obtained outside patient's state/county of residence			
Percent traveling out of state	0.101	0.133	0.09
Percent traveling out of county	0.369	0.367	0.94
State characteristics			
Number of states—West	11	2	
Number of states—South	11	3	
Number of states—Midwest	10	2	
Number of states—Northeast	6	6	
Medicare fee-for-service beneficiaries	574,002 (531,927)	470,651 (482,959)	
Average age	75.37 (0.63)	75.54 (0.78)	0.43
Percentage male	44.11 (1.72)	43.41 (2.26)	0.25
Percentage non-Hispanic white	86.70 (8.44)	79.01 (22.30)	0.08
Percentage black	6.01 (6.32)	9.61 (15.72)	0.25
Percentage Hispanic	3.73 (5.25)	2.46 (2.04)	0.40

continued on next page

	No CON laws	CON laws	Test for differences (*p*-value)
Average HCC score	0.93 (0.07)	0.95 (0.09)	0.25
Unemployment	6.67 (1.57)	7.06 (1.49)	0.43
Household income	52,892 (8,218)	55,963 (8,972)	0.26
Proportion rural growth 1993–2013	0.00 (0.06)	−0.02 (0.09)	0.59
Household income growth 1993–2013	0.07 (0.09)	0.07 (0.14)	0.93
Health expenditures growth 1993–2009	1.87 (0.35)	1.73 (0.45)	0.25

Note: Includes 50 states and the District of Columbia. Values in parentheses are standard deviations.
CON = certificate of need; CT = computed tomography; HCC = hierarchical condition category.

Panel C. PET Scans

	No CON laws	CON laws	Test for differences (*p*-value)
Number of states	31	20	
Number of providers of PETs per 100,000 beneficiaries			
Hospitals	4.94 (1.98)	4.82 (2.53)	0.85
New hospitals (start year 1993 to present)	0.34 (0.38)	0.14 (0.22)	0.03
Preexisting hospitals (start year before 1993)	4.60 (1.82)	4.69 (2.51)	0.89
Nonhospital physicians	4.93 (4.26)	1.81 (1.62)	0.00
Number of PET scans per provider			
Hospitals	260.24 (95.51)	311.44 (129.38)	0.11
New hospitals (start year 1993 to present)	260.40 (293.22)	196.88 (140.28)	0.56
Preexisting hospitals (start year before 1993)	260.67 (96.75)	318.47 (137.60)	0.08
Nonhospital providers	69.48 (60.68)	66.58 (67.45)	0.88

continued on next page

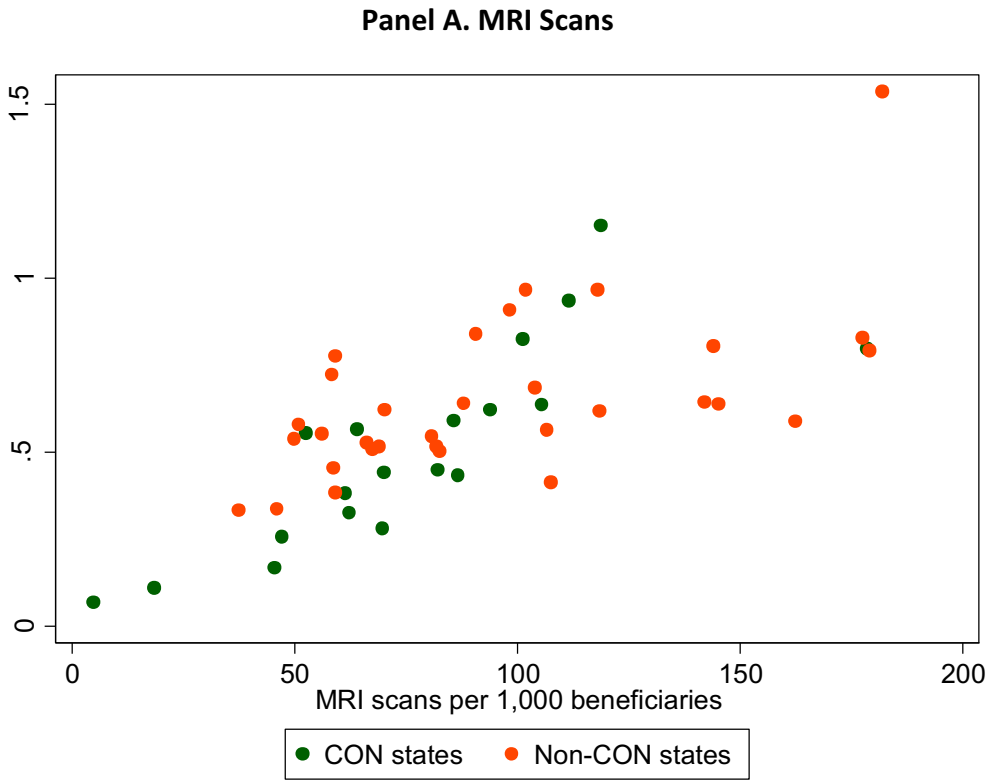
	No CON laws	CON laws	Test for differences (*p*-value)
Number of PET scans per 1,000 beneficiaries			
Hospital	12.54 (6.90)	14.17 (8.13)	0.44
Hospital (log)	2.50 (0.45)	2.57 (0.64)	0.68
New hospital	0.79 (1.05)	0.21 (0.30)	0.02
New hospital (log)	0.45 (0.50)	0.16 (0.23)	0.02
Preexisting hospital	11.75 (6.47)	13.96 (8.05)	0.28
Preexisting hospital (log)	2.44 (0.46)	2.55 (0.63)	0.46
Nonhospital	3.79 (4.12)	1.37 (1.95)	0.02
Nonhospital (log)	1.23 (0.83)	0.64 (0.63)	0.01
Market share			
Hospital	0.78 (0.20)	0.90 (0.15)	0.02
New hospital	0.05 (0.06)	0.01 (0.02)	0.01
Preexisting hospital	0.73 (0.20)	0.89 (0.15)	0.00
Nonhospital	0.22 (0.20)	0.10 (0.15)	0.02
Care obtained outside patient's state/county of residence			
Percent traveling out of state	0.134	0.167	0.35
Percent traveling out of county	0.487	0.492	0.90
State Characteristics			
Number of states—West	11	2	
Number of states—South	6	8	
Number of states—Midwest	10	2	
Number of states—Northeast	4	8	
Medicare fee-for-service beneficiaries	633,314 (599,425)	414,890 (325,426)	

continued on next page

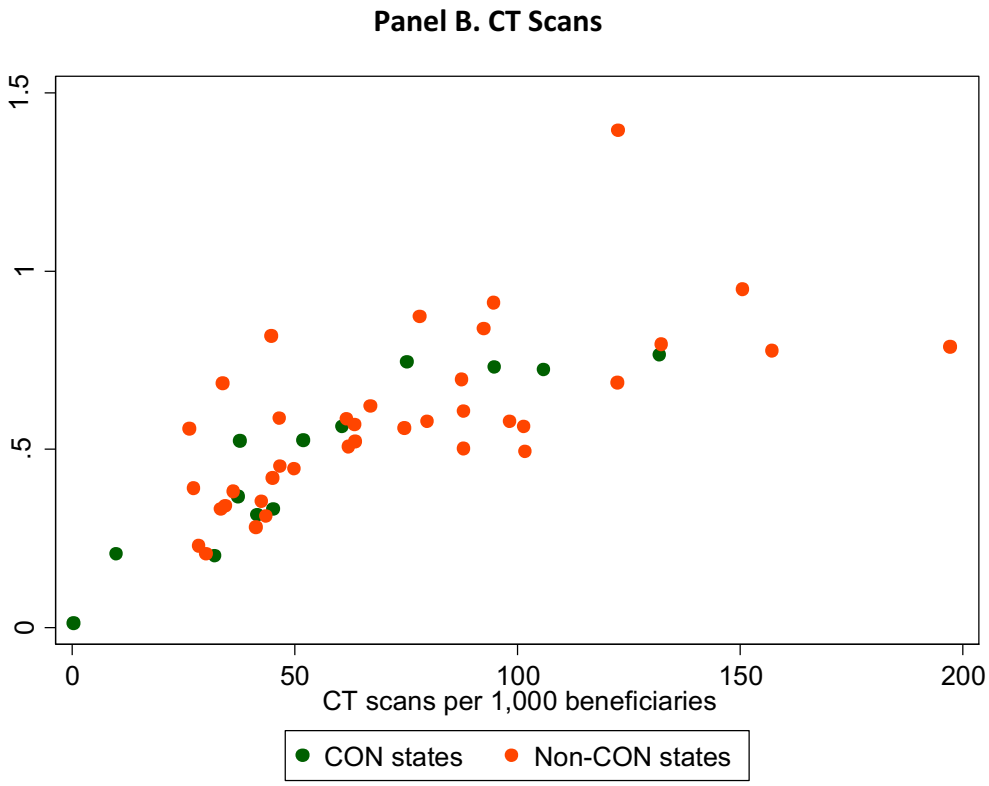
	No CON laws	CON laws	Test for differences (*p*-value)
Average age	75.45 (0.68)	75.35 (0.67)	0.60
Percentage male	44.25 (1.88)	43.45 (1.81)	0.14
Percentage non-Hispanic white	86.53 (8.82)	81.96 (18.62)	0.24
Percentage black	4.95 (5.46)	9.99 (13.31)	0.07
Percentage Hispanic	4.48 (5.62)	1.75 (1.53)	0.04
Average HCC score	0.93 (0.07)	0.95 (0.07)	0.30
Unemployment	6.53 (1.62)	7.15 (1.37)	0.16
Household income	53,382 (7,235)	54,129 (10,206)	0.76
Proportion rural growth 1993–2013	−0.01 (0.05)	−0.01 (0.08)	0.82
Household income growth 1993–2013	0.07 (0.09)	0.07 (0.12)	0.88
Health expenditures growth 1993–2009	1.86 (0.39)	1.80 (0.38)	0.62

Note: Includes 50 states and the District of Columbia. Values in parentheses are standard deviations.
CON = certificate of need; HCC = hierarchical condition category; PET= positron emission tomography.

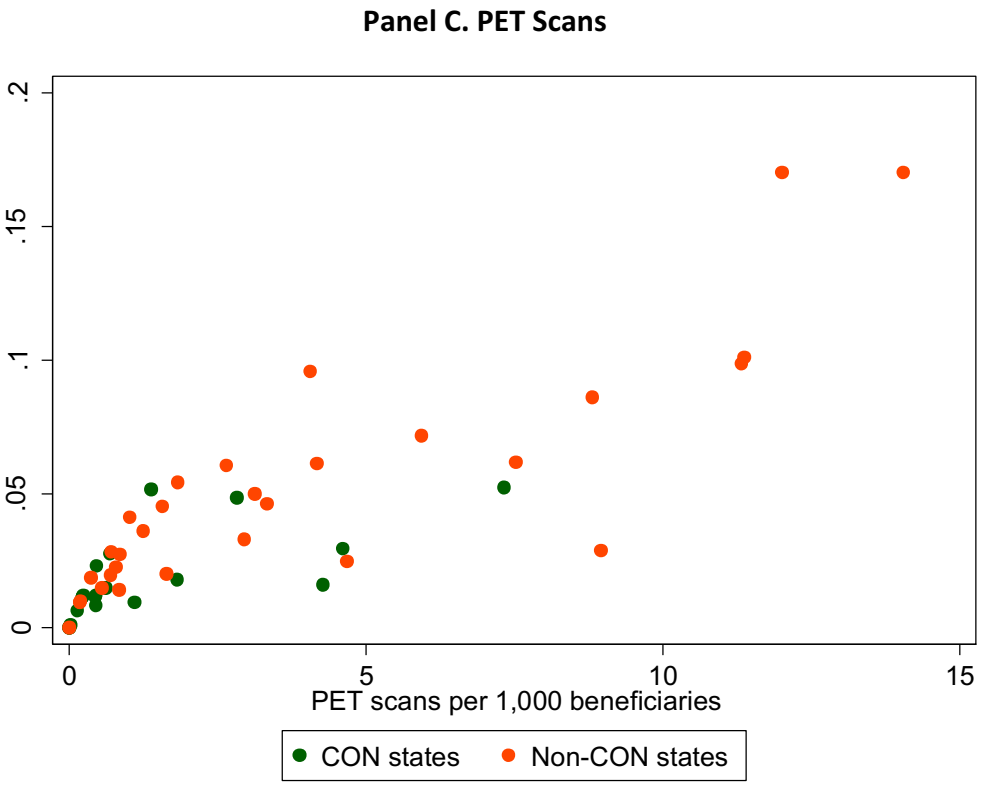
Figure 4. Number of Nonhospital Providers and Number of Scans Provided by Nonhospitals



Note: CON = certificate of need, MRI = magnetic resonance imaging.

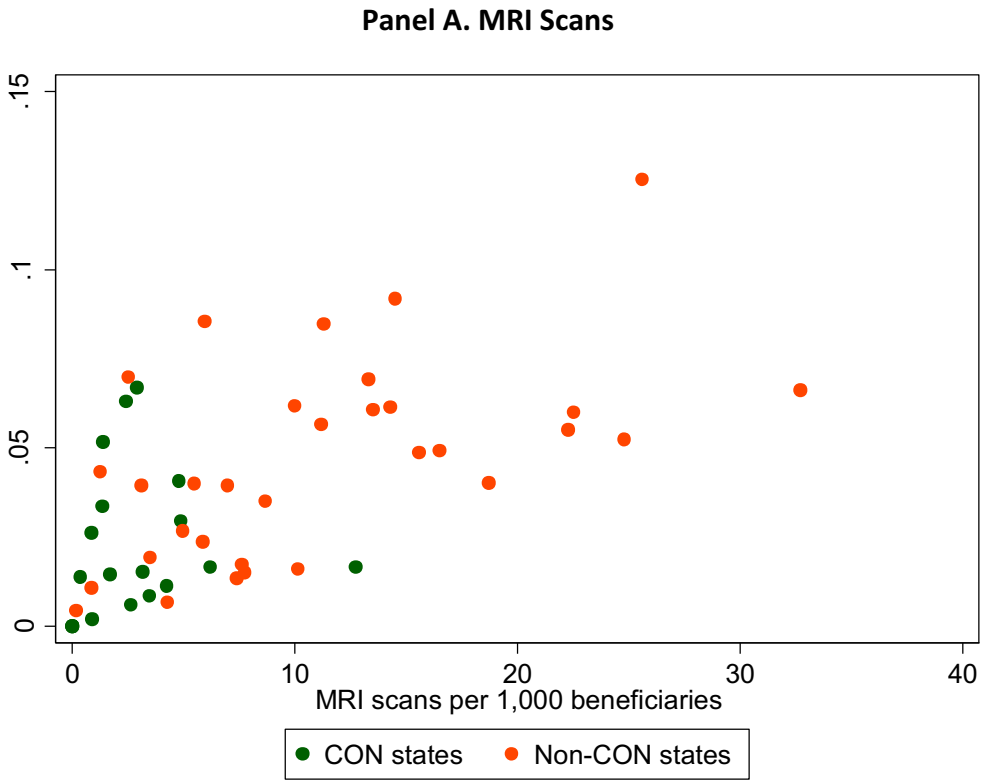


Note: CON = certificate of need, CT = computed tomography.

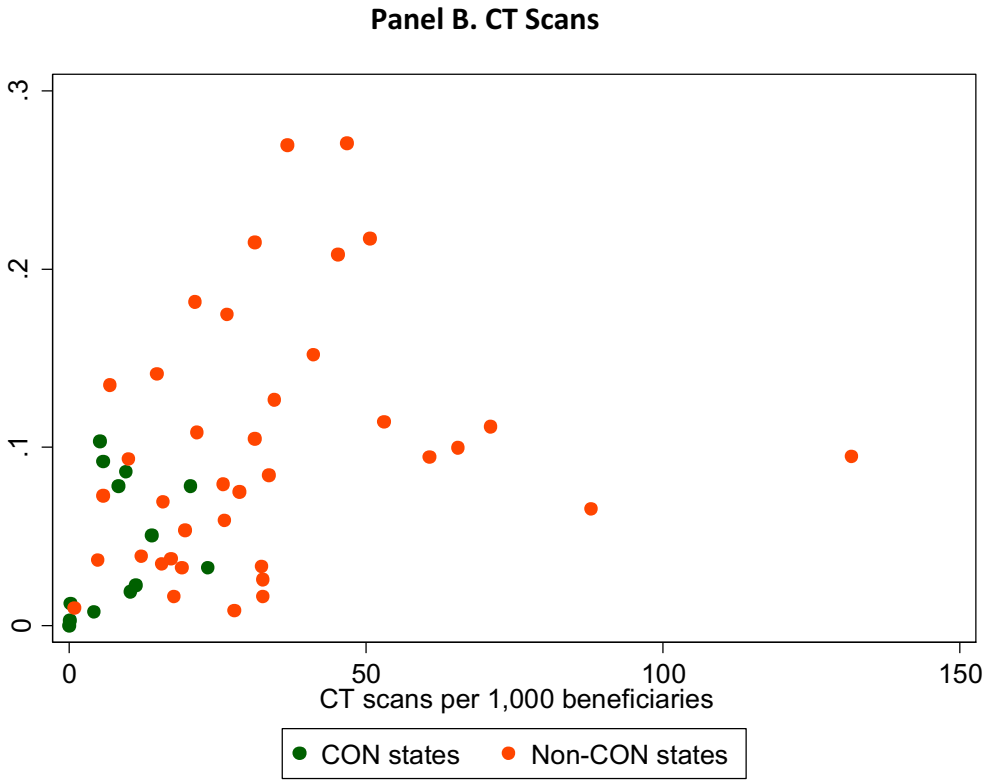


Note: CON = certificate of need, PET = positron emission tomography.

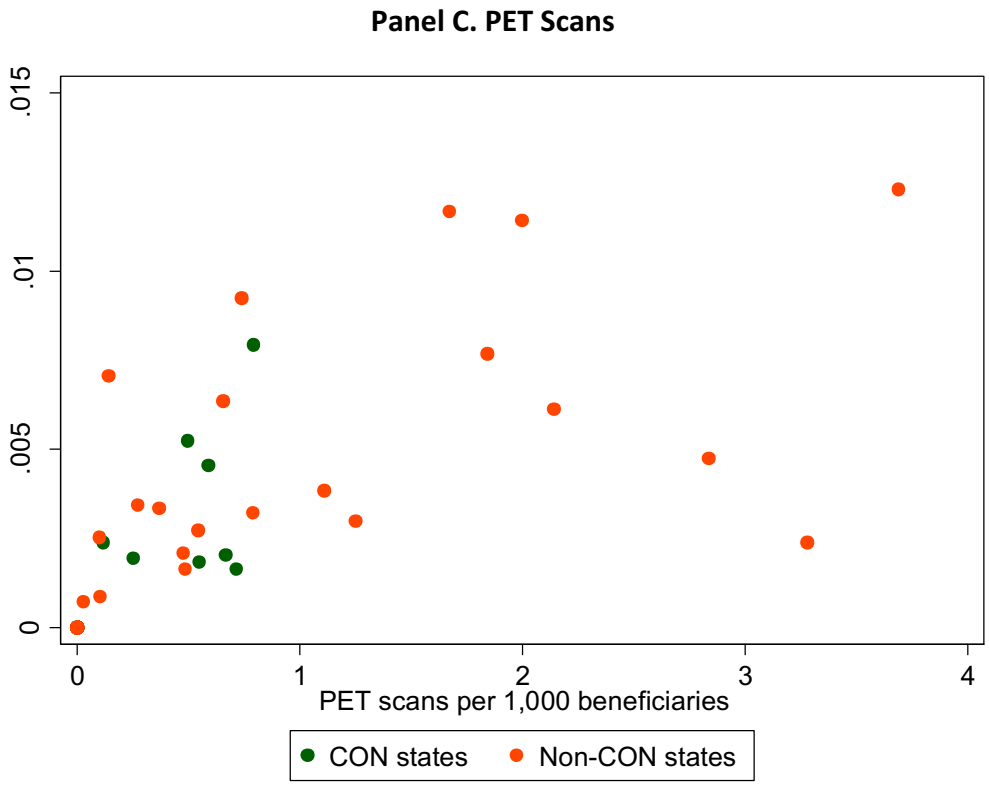
Figure 5. Number of New Hospital Providers and Number of Scans Provided by New Hospitals by CON Status



Note: CON = certificate of need, MRI = magnetic resonance imaging.



Note: CON = certificate of need, CT = computed tomography.



Note: CON = certificate of need, PET = positron emission tomography.

Table 2. Effect of CON Laws on Types of Providers

Panel A. Hospitals vs. Nonhospitals

	Log MRI scans per 1,000 beneficiaries	Log CT scans per 1,000 beneficiaries	Log PET scans per 1,000 beneficiaries
Number of observations	102	102	102
CON law	−0.31+ (0.19)	−0.52+ (0.34)	−0.59*** (0.20)
CON law × Hospital	0.41* (0.21)	0.55+ (0.36)	0.65** (0.26)
Hospital	0.20** (0.09)	1.82*** (0.09)	1.27*** (0.17)
Constant	4.48*** (0.08)	4.17*** (0.09)	1.23*** (0.15)
R^2	0.18	0.76	0.60
Hypothesis tests—p-*values*			
$B_{\text{CON law}} = 0$	0.102	0.133	0.005
$B_{\text{CON law} \times \text{Hospital}} = 0$	0.050	0.128	0.014
$B_{\text{CON law}} + B_{\text{CON law} \times \text{Hospital}} = 0$	0.241	0.777	0.704

+ statistically significant at the 15 percent level, * statistically significant at the 10 percent level, ** statistically significant at the 5 percent level, *** statistically significant at the 1 percent level.

Note: Includes one observation for each setting for each of 50 states and the District of Columbia. Values in parentheses are robust standard errors. CON = certificate of need; CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography.

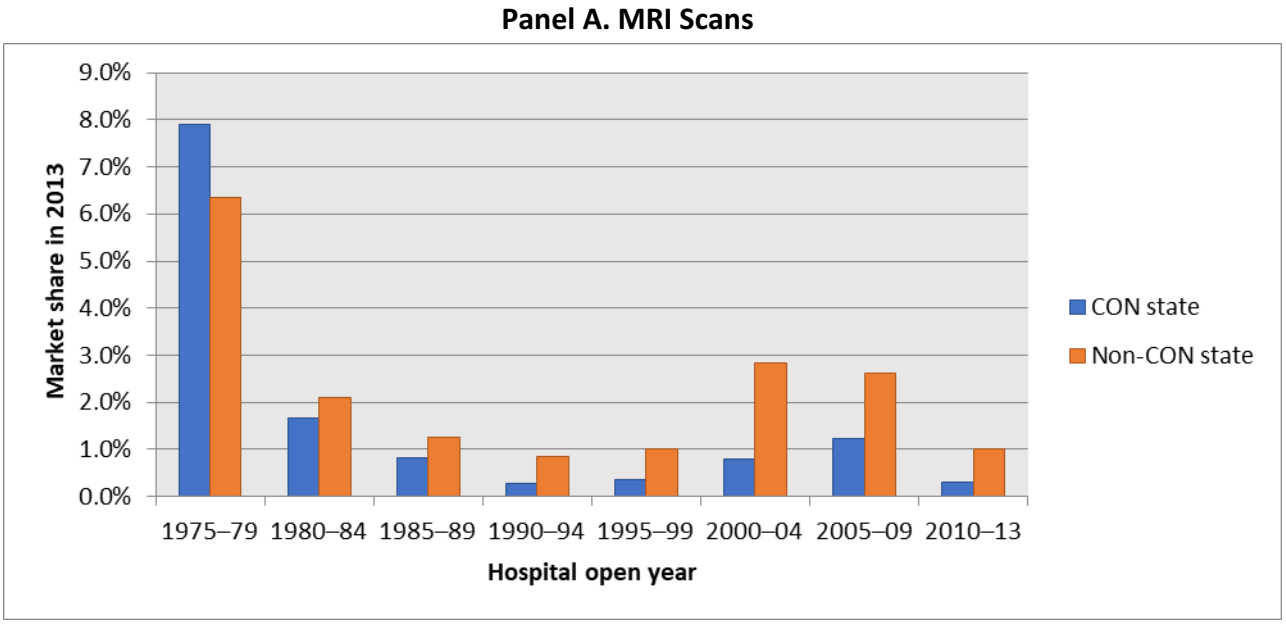
Panel B. New Hospitals and Preexisting Hospitals

	Log MRI scans per 1,000 beneficiaries	Log CT scans per 1,000 beneficiaries	Log PET scans per 1,000 beneficiaries
Number of observations	102	102	102
CON law	−1.13*** (0.22)	−1.41*** (0.33)	−0.29*** (0.10)
CON law × Preexisting hospital	1.31*** (0.23)	1.51*** (0.34)	0.40** (0.19)
Preexisting hospital	2.34*** (0.15)	2.63*** (0.14)	1.99*** (0.12)
Constant	2.23*** (0.14)	3.26*** (0.13)	0.45*** (0.09)
R^2	0.87	0.86	0.85
Hypothesis tests—p-*values*			
$B_{\text{CON law}} = 0$	0.000	0.000	0.007
$B_{\text{CON law} \times \text{Preexisting hospital}} = 0$	0.000	0.000	0.074
$B_{\text{CON law}} + B_{\text{CON law} \times \text{Preexisting hospital}} = 0$	0.038	0.777	0.704

+ statistically significant at the 15 percent level, * statistically significant at the 10 percent level, ** statistically significant at the 5 percent level, *** statistically significant at the 1 percent level.

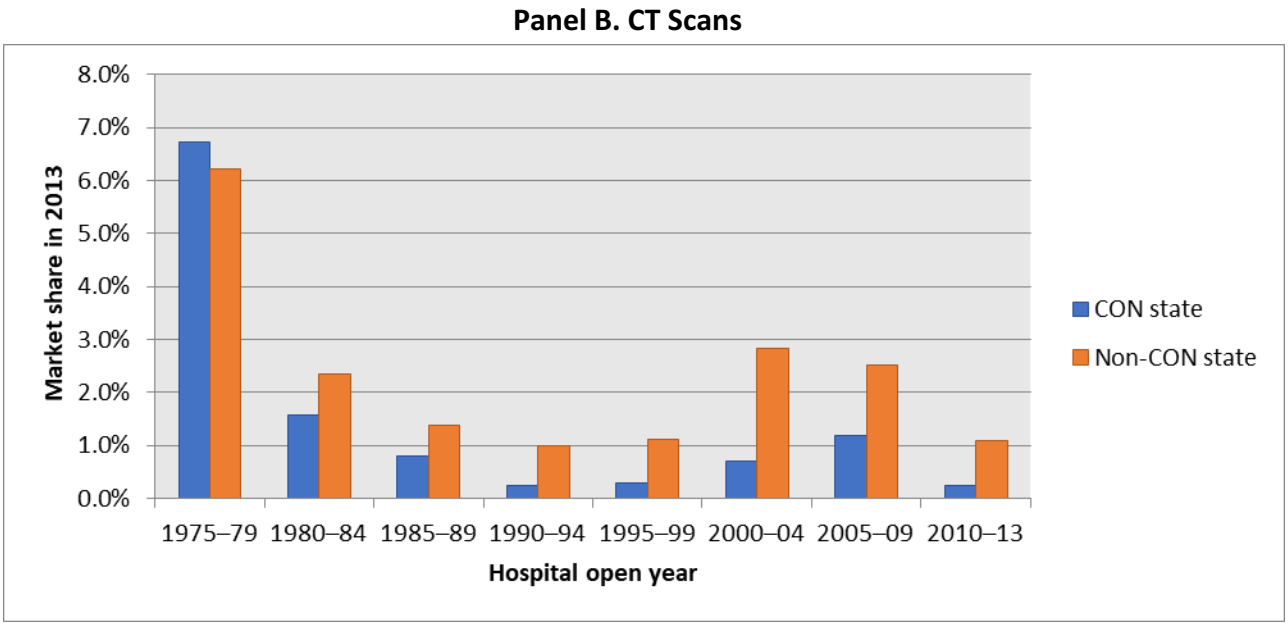
Note: Includes one observation for each setting for each of 50 states and the District of Columbia. Values in parentheses are robust standard errors. CON = certificate of need; CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography.

Figure 6. Market Share by Hospital Start Year



Note: CON = certificate of need; MRI = magnetic resonance imaging.

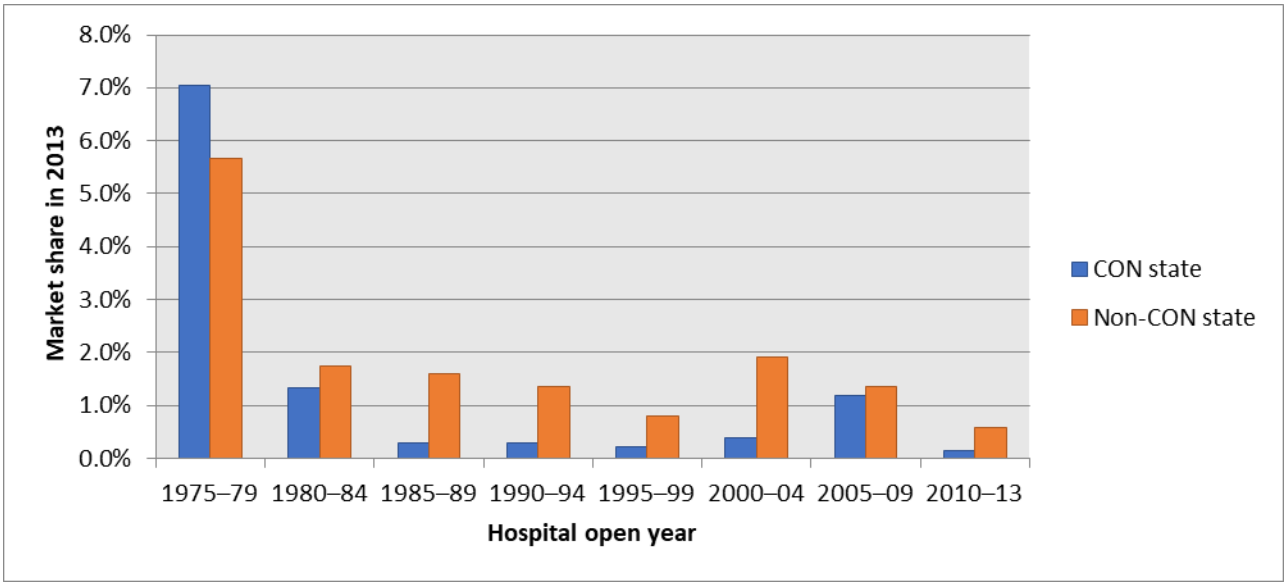
Source: Analysis of Medicare claims data CY2013, including inpatient and outpatient hospital claims.



Note: CON = certificate of need; CT = computed tomography.

Source: Analysis of Medicare claims data CY2013, including inpatient and outpatient hospital claims.

Panel C. PET Scans



Note: CON = certificate of need; PET = positron emission tomography.

Source: Analysis of Medicare claims data CY2013, including inpatient and outpatient hospital claims.

Table 3. The Effect of CON Laws on the Number of Providers

Panel A. Hospitals vs. Nonhospitals

	MRI providers 1,000 beneficiaries	CT providers per 1,000 beneficiaries	PET providers per 1,000 beneficiaries
Number of observations	102	102	102
CON law	−0.147* (0.077)	−0.122+ (0.077)	−0.031*** (0.008)
CON law × Hospital	0.130* (0.078)	0.072 (0.079)	0.030*** (0.011)
Hospital	−0.504*** (0.042)	−0.376*** (0.041)	0.000 (0.008)
Constant	0.651*** (0.042)	0.584*** (0.038)	0.049*** (0.008)
R^2	0.63	0.53	0.16
Hypothesis Tests—p-*values*			
$B_{\text{CON law}} = 0$	0.060	0.115	0.000
$B_{\text{CON law} \times \text{Hospital}} = 0$	0.099	0.364	0.006
$B_{\text{CON law}} + B_{\text{CON law} \times \text{Hospital}} = 0$	0.141	0.009	0.858

+ statistically significant at the 15 percent level, * statistically significant at the 10 percent level, ** statistically significant at the 5 percent level, *** statistically significant at the 1 percent level.

Note: Includes one observation for each provider type for each of 50 states and the District of Columbia. Values in parentheses are robust standard errors. CON = certificate of need; CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography.

Panel B. New Hospitals and Pre-CON Hospitals

	MRI providers 1,000 beneficiaries	CT providers per 1,000 beneficiaries	PET providers per 1,000 beneficiaries
Number of observations	102	102	102
CON law	−0.025*** (0.007)	−0.054*** (0.015)	−0.002** (0.001)
CON law × Preexisting hospital	0.033*** (0.011)	0.058*** (0.019)	0.003 (0.007)
Preexisting hospital	0.054*** (0.007)	0.010 (0.013)	0.043*** (0.003)
Constant	0.046*** (0.005)	0.099*** (0.012)	0.003*** (0.001)
R^2	0.60	0.16	0.49
Hypothesis Tests—p-*values*			
$B_{\text{CON law}} = 0$	0.001	0.001	0.017
$B_{\text{CON law × preexisting hospital}} = 0$	0.005	0.003	0.657
$B_{\text{CON law}} + B_{\text{CON law × preexisting hospital}} = 0$	0.372	0.707	0.895

+ statistically significant at the 15 percent level, * statistically significant at the 10 percent level, ** statistically significant at the 5 percent level, *** statistically significant at the 1 percent level.

Note: Includes one observation for each provider type for each of 50 states and the District of Columbia. Values in parentheses are robust standard errors. CON = certificate of need; CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography.

Table 4. Difference-in-Difference Summary of the Quantity of Scans. Effect of CON Laws by Provider Type and Imaging Service, Summarized from Table 2.

	CON effect (% of scans)			
Type of scan	Hospital scans	Nonhospital scans	Pre-CON hospital scans	New hospital scans
MRI	+10	−27	+20	−68
CT	+3	−41	+11	−76
PET	+6	−45	+12	−25

Note: Calculated by exponentiation of the coefficient on CON law in table 2A for nonhospitals, the coefficients on CON laws plus the coefficient on (CON law × Hospital) in table 2A, the coefficient on CON law in table 2B for new hospitals, and the coefficients on CON laws plus the coefficient on CON law × Preexisting hospital in table 2B. CON = certificate of need, CT = computed tomography, MRI = magnetic resonance imaging, PET = positron emission tomography.

Table 5. Difference-in-Difference Summary of the Number of Providers per 100,000 Beneficiaries. Effect of CON Laws by Provider Type and Imaging Service, Summarized from Table 3.

	CON effect per 100,000 beneficiaries			
Type of scan	Hospital providers	Nonhospital providers	Pre-CON hospital providers	New hospital providers
MRI	−1.7	−14.7	0.8	−2.5
CT	−5.0	−12.2	0.4	−5.4
PET	−0.1	−3.1	0.1	−0.2

Note: Calculated by exponentiation of the coefficient on CON Law in Table 3A for nonhospitals, the coefficients on CON Laws plus the coefficient on (CON law × Hospital) in table 3A, the coefficient on CON Law in table 3B for new hospitals, and the coefficients on CON laws plus the coefficient on CON law × Preexisting hospital in table 3B. Values are converted from per-1,000-beneficiary to per-100,000-beneficiary. CON = certificate of need, CT = computed tomography, MRI = magnetic resonance imaging, PET = positron emission tomography.

Table 6. Descriptive Statistics Aggregate Travel Rates by Residence in a CON State and a Non-CON State

	MRI		CT		PET	
	Patients in CON states	Patients in non-CON states	Patients in CON states	Patients in non-CON states	Patients in CON states	Patients in non-CON states
n=	80,917	176,606	156,287	560,725	5,895	15,718
Out of state %	10.8	10.4	8.1	7.8	9.6	8.4
Out of county %	47.6	39.7	38.5%	34.5	52.8	43.5

Note: Includes residents of all 50 states and the District of Columbia claim counts includes a 5 percent sample of Medicare beneficiaries. CON = certificate of need; CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography.

Table 7. Effect of CON Laws on Patients' Probability of Traveling Outside Their County of Residence—OLS Regression Results

	MRI scans	CT scans	PET scans
Number of observations	257,523	717,012	21,613
Lives in a CON state	0.055***	0.037**	0.038+
Age 70–74	−0.001	0.012***	−0.009
Age 75–79	−0.024***	−0.010***	−0.037***
Age 80–84	−0.052***	−0.040***	−0.069***
Age 85+	−0.080***	−0.071***	−0.103***
Male	0.016***	0.032***	0.021***
Non-Hispanic white	0.022	0.030**	0.028
Black	−0.026	−0.042***	−0.049
Asian	−0.021	−0.041***	−0.062
Hispanic	−0.037**	−0.010	0.020
Native American	0.066**	0.038	0.125
Lives in a metropolitan area	−0.460***	−0.441***	−0.576***
Lives in a micropolitan area	−0.306***	−0.323***	−0.343***
Density: people per square mile	0.000	−0.000	−0.000
Constant	0.806***	0.724***	0.939***

+ statistically significant at the 15 percent level, * statistically significant at the 10 percent level, ** statistically significant at the 5 percent level, *** statistically significant at the 1 percent level.

Note: Includes residents of all 50 states and the District of Columbia. CON = certificate of need; CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography.