NBER WORKING PAPER SERIES

CROSS BORDER EFFECTS OF STATE HEALTH TECHNOLOGY REGULATION

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Working Paper 19801
http://www.nber.org/papers/w19801

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
January 2014

Previously circulated as "Challenges to Regulatory Decentralization: Lessons from State Health Technology Regulation." We thank Bob Cooter, Leemore Dafny, John DiNardo, Jonathan Kolstad, Ellen Meara, Austin Nichols, Jon Skinner, Doug Staiger, and seminar participants at the Berkeley School of Law, Cornell University Law School, Dartmouth Institute for Health Policy & Clinical Practice, Northwestern University Institute for Policy Research, University of Michigan Law School, and the University of Victoria Department of Economics for helpful comments. We also thank Michael Harhay, Lynn McClelland, Sarah Palmer, and Matthew Parson for research assistance. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 19801
January 2014, Revised November 2014
JEL No. H70,I11,I18,K32,L1,L52

ABSTRACT

Certificate of Need Laws (CON), state laws requiring providers to obtain licenses before adopting healthcare technology, have been controversial. The effect of CON on technology supply has not been well established. In part this is because analyses have focused on state-level supply effects, which may reflect either the consequence of CON regulation on supply or the cause for its adoption or retention. Instead, we focus on the cross-border effects of CON. We compare the number and location of magnetic resonance imaging providers in counties that border states with a different regulatory regime to: 1) counties in the interior of states, 2) counties on state borders with the same regulatory regime on both sides, and 3) counties on borders with different regulatory regimes, but with a large river on the border. We find there are 6.4 fewer MRIs per million people in regulated counties that border counties in unregulated states than in unregulated counties that border regulated counties. This statistically significant finding that regulatory spillover can be sizable should be accounted for in future research on state-based health technology regulation. In addition, it suggests state experiences may not accurately predict the effects of CON if it were implemented nationally.

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An online appendix is available at:
http://www.nber.org/data-appendix/w19801

1. Introduction

Certificate of Need Laws (CON) − state licensing regimes that restrict the adoption and modification of health technology by existing providers and new entrants–have generated controversy since their adoption in the 1970s. Proponents have urged the adoption of CON in markets like health care where incomplete information and agency problems can lead to overinvestment in high-fixed-cost technologies. The argument is that direct regulation would work to control costs, constrain investment, and improve quality in markets (Salkever 2000). Opponents cite the anti-competitive nature of such regulation, particularly its susceptibility to capture, and have urged repeal of remaining certificate of need laws (see, e.g., Epstein and Hyman, 2013; Cordato, 2007). Empirical research has not resolved these debates.

Here we seek to inform this larger debate by exploring how CON affects the provision of a regulated technology by examining the effects of CON regulation on the location of free-standing Magnetic Resonance Imaging (MRI) providers. We hypothesize that if the CON regulation is binding we would see the technology being provided in unregulated states to serve nearby populations in regulated states. Specifically, we test whether MRI providers disproportionately locate in unregulated states in counties that border states regulated by CON licensing laws.

Previous research has focused on statewide effects of CON. It is difficult to determine if CON changes supply decisions or downstream outcomes using this approach because a state's decision to adopt or retain CON regulations can be as much a reaction to existing provider supply as a cause of future provider supply. By focusing on whether counties border a state with a different regulatory regime, we can overcome this limitation by contrasting these counties with three other types of counties: 1) counties in the interior of states that don't face a border at all, 2) counties on state borders with the same regulatory regime on both sides, and 3) counties on borders with different regulatory regimes, but with a large river on the border.

In addition, previous research has largely focused on capital and labor intensive technologies such as percutaneous coronary interventions (PCI) and open heart surgery. These technologies are typically provided in hospitals, which are both likely to seek a CON for these services and unlikely to respond to regulation of an individual technology by relocating. On the contrary, free-standing MRI providers comprise a relatively fluid market for analysis of the potential effects of technology regulation. These results can inform regulation regarding the increasing number of services that are being offered outside of hospitals.

Our results show a sizeable and statistically-significant cross-border effect of CON regulation on the location of MRI providers. Among counties located on state borders where one state regulates MRI entry and the other state does not, there is more likely to be an MRI provider in the unregulated county than in the regulated county. Moreover, we confirm our results by linking the effect to the relative ease of travelling across state borders; we find the difference between regulated and unregulated border counties to stem almost exclusively on state borders that are *not* separated by rivers, borders that are presumably easier for potential patients and staff to cross.

These results point to several conclusions. First, the effects of state regulation include not only the effects on residents in those states, but there are spillover effects that should not be ignored. Previous research on CON has focused on the former and, as Cotet has argued in another context, when "border effects are important, specifications that fail to control for spillovers lead to biased estimates of the impact of the law." (Cotet, 2012, pg. 203) In particular, studies that find fewer providers in CON states may overstate the implications of regulation for potential patients who live close to non-CON states. On the other hand, this spillover effect may help explain why many studies have been unable to attribute differences in costs or quality to CON regulation. Second, our results suggest that where state regulations have spillover effects on other states, states may not serve as effective sites to evaluate the effectiveness of those regulations. As a result, the effectiveness of state regulations may not inform the effectiveness of the regulation if it were implemented nationally.

The paper proceeds as follows. Part 2 outlines the purposes and history of CON legislation, summarizes previous research, and provides a conceptual framework for understanding provider location in response to regulation. Part 3 describes our data and the descriptive statistics. Part 4 describes our empirical framework for estimating the cross-border effects of CON regulation, reports the results, and describes limitations of the analysis. Part 5 concludes.

2. Health Planning and Certificate of Need Regulation: Background, Previous Research, and Institutional Context

a. Background. Certificate of Need (CON) laws require health care organizations to obtain permits from a state regulatory agency before building new health care facilities, offering new medical services, or acquiring certain medical technology. Although the first CON laws were implemented in New York in 1964 and a few other northeastern states shortly thereafter, such programs have their roots in earlier federal health planning efforts, such as the 1946 Hospital Survey and Construction Act (The Hill-Burton Act), meant to increase access to care, improve quality, and control costs (Hamilton, 1986). The premise of capital investment restrictions such as CON restrictions was that in markets for health care -- markets characterized by failures that make price competition an untenable method for providing an efficient level of care -- regulation controlling the supply of medical providers and health care services would prevent excess capacity, duplicative and unnecessary service provision caused by provider-induced demand, and spiraling costs (Finkler, 1985).

Virtually every state adopted CON requirements in response to two federal statutes -- the Social Security Act of 1972 (which conditioned Medicare and Medicaid payments on reviews for large capital expenditures) (Section 1122, 1972), and the 1974 National Health Planning and Resources Development Act (which offered financial incentives for states to establish review procedures for new clinical services, inpatient technology acquisition, and capital expenditures greater than $150,000). Early state CON requirements applied to inpatient hospital services, but in the 1980s many states expanded their CON regimes to control the growth of ambulatory services such as diagnostic imaging.

After 1986, when President Reagan signed the law repealing the National Health Planning Act, many states eliminated some or all of their CON requirements based on evidence that the planning authorities had proved "costly to the Federal Government, in the last analysis without benefit, and even detrimental to the rational allocation of economic resources for health care." (Yakima Valley, 2011). Even more recently, in 2004 the Federal Trade Commission and the U.S. Department of Justice urged the remaining states with CON requirements to "reconsider whether these programs best serve their citizens' health care needs," in large part because of their failure to contain costs and anticompetitive risks. (U.S. Federal Trade Commission, 2004). Nonetheless, state CON laws remain remarkably stable; states that repealed their CON laws tended to do so in the late 1970s and through the 1980s, with little change since then. (NCSL, 2014).

b. Previous Research on CON. Previous research evaluating the effects of direct regulation such as CON has generated mixed results. (Salkever 2000). However, research comparing the experiences of regulated to unregulated states has often concluded that CON has been ineffective at limiting supply, controlling costs, or improving quality. (Conover and Sloan, 1998). The earliest research on the effects of CON on costs, investments, and service diffusion in hospitals generated disparate results. Russell (1979) found some evidence that CON limited investments in specialty services. However, in sum, early research tended to find that that capital expenditure controls such as CON did not constrain costs, but may have limited the supply of beds within individual hospitals (Salkever, 2000). For example, Salkever and Bice (1979) studied the effects of regulation in those states that were early adopters of CON programs and found no conclusive evidence that CON had effects on costs or quality. Another early study found mixed results on the effects of CON, but largely concluded that regulation not only failed to control costs but may well have increased costs and labor inputs. (Sloan and Steinwald, 1980).

Later studies were similarly mixed. Some found that CON increased costs (Lanning, Morrisey and Ohsfeldt 1991; Antel, Ohsfeldt and Becker 1995), while another found that CON programs reduced per-capita acute care spending by 5 percent, but did not affect total per-capita spending, suggesting that providers responded to cost-containing regulation by increasing costs elsewhere (Conover and Sloan 1998).

Only a few studies focused on CON as applied to ambulatory services such as diagnostic imaging. They were conducted soon after regulation of outpatient and free-standing medical services was implemented and focused exclusively on technology diffusion rates. For example, using data from the American College of Radiology, Hillman and Schwartz (1985) conducted telephone interviews with MRI installers and employees in the marketing departments of MRI manufacturers to track all the early adoption of MRI conducted through CON applications; they found that MRI diffused more slowly than Computed Tomography (CT) in free standing facilities, and concluded that Medicare's prospective payment system and CON regulations explained the difference. Steinberg et al. (1985) made similar claims, as well as identifying clinical, technical, and other economic issues as the reason that MRIs diffused comparatively slowly with only 108 machines in place by the end of 1984.

The most recent CON research has focused on a few hospital-based services, particularly invasive cardiac treatments, and has also generated mixed results regarding its effectiveness at controlling costs, limiting quantity, and improving quality. Cutler et al. (2010) concluded that the removal of CON in Pennsylvania was welfare neutral; in that case, increased entry into cardiac surgery led to a redistribution of patients to higher quality surgeons, an effect that approximately offset the losses due to increased fixed costs. Studies of the effects of CON on the volume of cardiac services typically found that the average number of procedures performed per hospital in states without cardiac CON was significantly lower than in regulated states (Ho 2004; Vaughan-Sarrazin et al., 2002). Studies further link the relatively high volume at hospitals in regulated states with better health outcomes. For example, Vaughan-Sarrazin and colleagues (2002) found lower mortality in regulated states, and Popescu and colleagues found that patients in regulated states were less likely to need revascularization services than those in unregulated states (2006). Moreover, Ho (2007) demonstrated that the number of hospitals offering intensive cardiac services (coronary artery bypass grafting and PCI) was lower in states with CON than in others, and that CON was associated with fewer PCIs per capita (Ho, 2007). In her most recent work, Ho (2009) used a difference and difference approach that substantiated some of her earlier findings. She analyzed states that discontinued CON between 1989 and 2002 and found no change in utilization rates after the elimination of regulation (Ho, 2009). Some researchers have considered the effects of CON on access, for example finding that the loosening of CON rules was associated with increased access to cardiac care for African-Americans as well as with reductions in health disparities (Delia et al 2009).

Our research, in the context of this previous work, is significant in at least four important respects. First, to our knowledge there is no previous research on the effects of CON on practice location. Second, strategic practice location may result in spillovers that have not previously been accounted for in this body of work evaluating state-specific cost and quality outcomes resulting from CON regulation. Third, because CON regulations occur at the state level, previous research has been limited in their ability to control for the fact that states that retained CON regulations are different from those that did not in ways that are relevant to current health technology markets. Our research focuses on border counties. This allows us to use interior counties to remove any state-specific fixed effects. We also can control for border-specific effects because not all borders face regime changes.

Fourth, although ambulatory services such as free-standing MRI, which are relatively easy to move, are likely to be more responsive to entry regulation than are hospital-based services such as cardiac treatment, existing research focuses on the latter. The lower costs of the MRI technology also probably make providers relatively nimble; a new cardiac catheterization laboratory (in the range of $3 million and up[1]) also costs more than an MRI machine (depending

[1] Costs range depending on the type of equipment, including whether it is new or used. The most recent New York applications for new laboratories that we could find were roughly $3.5 million. Mount Sinai hospital requested the purchase of two new labs for a total of $7,139,016 (New York Department of Health, 2010) and Orange Regional Medical Center requested one new lab for $3,462,325 (New York Department of Health, 2008).

on the power of the unit, an MRI costs between roughly $1 to $3 million dollars, and the price of a common whole-body scanner -- a 1.5 tesla unit -- is $1.25 million) (Cosmus and Parizh, 2011).

Moreover, hospital-based technologies are provided to relatively sick patients, those who are either inpatients or likely have more limited ability to travel compared to patients seeking diagnostic imaging at a free-standing center. On the contrary, even though increased travel for patients may be costly -- and at some distance patients may forgo care entirely -- patients can likely more easily travel to free-standing MRI offices than to hospitals. This is especially true given that some MRI machines can be located anywhere one can site a trailer, particularly with the development of compact scanners. As a result of these differences, MRI providers can be relatively nimble in their responses to regulation and competition. We assume that the relative ease of entry on the supply side and patient travel on the demand side makes MRI markets good markets in which to consider responsiveness to state technology regulation. Given the growth of services provided on an outpatient basis, primarily due to an increase of service provision outside of hospitals (MedPac, 2012), studying free-standing providers like MRI will yield increasingly generalizable results.

C. Institutional Context

Our study rests on several assumptions about the responsiveness of entrepreneurs and firms to direct technology regulation. First, we hypothesize that a provider considering serving a population in a regulated area would prefer to locate the business in a nearby unregulated location if one is available as long as travel costs from the regulated area are minimal. We make this assumption because opening a new imaging center in a regulated state can add additional costs to starting a business in terms of the financial costs to assemble a CON application, time costs of waiting for approval, and uncertainty regarding whether a potential competitor with a

CON license would challenge the application. But providers weigh these costs against the benefits of locating where there is unmet demand for care, demand that may be greater in regulated areas near unregulated areas where licensing costs can be easily avoided.

Second, the financial benefit from locating on the other side of a state border depends crucially on whether patients are covered by their insurance plans when they see providers across state lines. Although insurers do not typically sell insurance across state lines, they do typically include out-of-state providers in their preferred networks when the market spans multiple states.[2] Insurers also do generally reimburse for out of state care, albeit with less favorable cost-sharing, when providers are outside of their preferred network.

Finally, one might reasonably assume that the threat of entry across a state border would push states to eliminate CON if neighboring states have done so. In this case, regulating may mean allowing a neighboring state to capture tax and labor benefits that travel across borders with new business. And, as can be seen in Figure 1, the states that have retained CON are clustered in a few regions of the U.S. leaving a limited number of states with MRI CON that face these border issues. There are, however, several reasons why states may maintain CON. For example, health care cost control may be a more important or salient issue for politicians. Or, even if politicians might wish to eliminate direct regulation, the organizations that benefit from CON such as large hospitals and major teaching centers also have considerable influence over politicians.

[2] Although this may not be true for every insurer, there is sufficient evidence that insurance coverage is not a barrier for out of state care. First, beneficiaries in traditional Medicare can obtain care from any provider who accepts Medicare. Second, although we could not find a single authoritative source to indicate whether insurers include out of state MRI providers in their networks, we used the provider search functions for various insurers (e.g., Blue Cross Blue Shield in Michigan and Kentucky) to search for imaging providers and found that networks typical include both in and out of state providers. In addition, it is always possible for a beneficiary to seek care on an out-of-network basis with an out-of-state provider. Third, although we have been told by several state Medicaid offices that they do not reimburse providers in other states, we visited one Ohio provider that told us it accepted Michigan Medicaid. Finally, many patients pay for imaging on an out-of-pocket basis.

3. Data and Descriptive Statistics

3.A. Data

Determining whether a state regulates health technology adoption is difficult. CON laws and related regulations appear in different types of statutes and are enforced by different agencies (for example, departments of state health planning, public health, health and human services) depending on the state, and once found the statutory language is often ambiguous. The laws vary a great deal in terms of which services and equipment are regulated and how the regulations are triggered (e.g., by listed services, size of capital investment, or whether the purchase is for new or replacement equipment). Moreover, even when licensing laws are on the books, regulators may not enforce those laws. This means that the secondary sources listing state regulatory regimes, the sources upon which most empirical research relies, may be unreliable.

We assembled an original dataset of state CON laws as applied to MRI for all states except Alaska and Hawaii. First, we researched current statutes and regulations in 2011-2012 to determine which states had CON for MRI. At least two lawyers, including a law librarian, and a law student reviewed each state's statutes to determine whether it applied to free-standing MRI providers. To resolve disagreements among the coders and to determine whether state regulators actively enforced their CON for MRI, we conducted further research, mainly by contacting regulators by phone or email in almost every state we designated as having, at least, a general CON program (i.e., states with CON for any major technology, even if the written laws did not appear to apply to diagnostic imaging).[3] Figure 1 identifies states with CON for any service,

[3] We contacted regulators by phone or electronic mail in all but twelve states. Additional research makes us confident that we classified those states correctly because there we found corroborating evidence – such as an updated state website that suggested an active regulatory

CON for MRI, and no CON as of 2012. The states with CON for MRI are concentrated in the Midwest, Northeast, and Southwest.

We also assembled a dataset containing virtually all free-standing MRI facilities in the continental United States by using address lists of accredited MRI facilities. We obtained these lists in December 2012 from the websites of the two agencies that accredit MRI facilities -- American College of Radiology (ACR) and Intersocietal Accreditation Commission (IAC). We believe we have close to a universe of the facilities existing at that time because all outpatient imaging providers, including both practitioners and facilities, were required by the Medicare Improvement for Patients and Providers Act of 2008 to obtain accreditation from one of three CMS-designated accreditation organizations, including the ACR and the IAC, by January 1, 2012 to be reimbursed by Medicare for the technical component of various imaging procedures including MRI.[4] Because these regulations did not start until 2012, reliable time series data on accredited MRI facilities were unavailable. The third organization, the American Hospital Association, accredits hospitals and, therefore, is unlikely to include freestanding facilities. After removing duplicates, we identified 6104 facilities and their locations from the ACR and an additional 662 from the IAC. We then used their addresses to collapse the dataset to the county level and constructed two MRI county-level variables: the number of MRI providers in each county and whether the county had any free-standing MRI providers.

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program or such as press reports or website evidence that showed the state had discontinued their regulatory programs many years ago.

[4] Medicare Improvements for Patients and Providers Act of 2008 122 Stat. 2532Section 135, codified at 42 U.S.C.A § 1395m (e). For the definition of provider see Social Security Act §1861(d). The term “supplier” means, unless the context otherwise requires, a physician or other practitioner, a facility, or other entity (other than a provider of services) that furnishes items or services under Medicare.

We identified counties that lie along state borders using spatial joins in ArcGIS (using ArcGIS v10). We identified borders separated by rivers using a visual identification of major rivers on the border. County-level demand and supply side controls came from the 2012-2013 Area Resource File (AHRF) (US Department of Health and Human Services).

3.B. Descriptive Statistics

We describe our constructed county-level dataset in Table 1 by whether the county is in a non-CON (unregulated) or CON (regulated) state. There are 2.5 MRI providers per county in non-CON counties and 1.6 in CON counties. However, more people live in unregulated counties; therefore, when normalized by each million people in the county, there are more providers in CON counties (11.4 providers per million people in non-CON counties and 11.7 providers per million people in CON counties). There are also about an equal number of counties with at least one MRI in regulated and unregulated counties (Unregulated = 36.8% v. Regulated = 36.7%).

We do not draw conclusions as to whether the quantity of MRI providers in these counties is influenced by their regulatory environment because these counties are quite different in some respects. On the one hand, as shown in Table 1, they are similar in terms of some demographic characteristics associated with health status and health care use, such as age (population > ages 18-64 is 59.7% in regulated counties v. 58.1% in unrelated counties; population >64 is 14.9% in regulated counties v. 15.6% in unregulated counties), education (population >25 years with college education is 13.0% in regulated counties v. 14.3% in unregulated counties), and median household income ($42,574 in regulated counties v. $44,903 in unregulated counties). However, unregulated counties are quite different from regulated counties in other respects; they have larger populations (Mean=109,092 in unregulated counties v. 82,569 in regulated counties), are less dense (164 people per square mile in unregulated counties v. 358 in regulated counties), more rural (measured by non-metro and rural classifications), and have more hospital beds per population (374 beds per 100,000 in unregulated counties v. 325 in regulated counties.). These differences between the counties in regulated and unregulated states may be related to the reasons that states decided to either retain or eliminate CON regulation after federal incentives for regulation were repealed in 1986.

Moreover, on the one hand, CON regulations were meant to restrict entry, suggesting that if they worked as intended then regulated counties might have fewer providers than unregulated counties. On the other hand, the presence of a CON regulation may also be the result of some set of unobservables. And the reason a state retained CON regulations after changes in federal policy made it possible to repeal them without penalty may have been because of a sense among regulators that there are too many providers. If so, regulated counties may have more providers than unregulated counties, even if the regulations effectively restricted entry.

Given the difficulty of determining how a state's regulatory regime affects differences in the number of providers in regulated compared to unregulated states, we have employed an estimation approach that does not rely on such differences. Because CON regulations are state rather than county regulations, the factors that contributed to whether a state retained regulation should not be reflected in differences between counties within the state. We take advantage of this observation to test whether a state's CON regulation affects the location of MRI providers within that state and across the border in neighboring states depending on whether there is also CON regulation in the neighboring state.

4. Empirical Framework and Results

4.A. Empirical Framework

We compare the numbers of providers among various types of counties -- considering not only whether the county is regulated but where it is located in terms of other counties with the same or different regulatory regimes. We emphasize that we are not looking to test whether CON regulations can reduce the total number of MRIs; rather we focus on the marginal influence of CON near state borders.

Our setup for this hypothesis relies on our classification of counties based on whether they sit on the border of the state and on whether the regulatory regime across that border is the same or different. Thus we defined a county as a border county if it touches another state or as an interior county if the county does not touch another state border or, if it is on a state border, it does not touch another state. For border counties we classified them into two types: a border county that faces the same regulatory regime in the state across the border ("same-regime") and a border county that faces a different regulatory regime in the state across the border ("different-regime").

We test whether different-regime counties differ from other types of counties in their supply of MRI providers. Specifically, we test whether unregulated different-regime counties have more MRI providers than CON different-regime counties. In contrast to general comparisons between CON and non-CON states, we construct comparison groups that should difference out any unmeasured confounding factors between CON and non-CON states. For example, border counties that do not face a regime change provide a useful comparison group as it controls for general differences between CON and non-CON states as well as any specific differences that can be attributed to border counties. We also use the number of MRI providers in interior counties as an alternative way to benchmark the changes that occur between CON and non-CON border counties with regime change.

We offer here a more formal description of this empirical strategy. We test the effect of CON regulation using two measures of MRI location. The first is the number of providers per million people in the county. Because the majority of counties have no MRI providers at all -- the modal number of providers in counties that have any MRI is 1 -- we also estimate these effects on the existence of any MRI provider in the county.

We estimate the following equations:

(1) $MRI/million_i = \beta_o + \beta_1 Different\_regime_i *CON + \beta_2 Interior_i *CON + \beta_3 Different\_regime_i + \beta_4 Interior_i + \beta_5 CON + \beta_6 Demand_i + \beta_7 MedSupply_i + e$

(2) $E(Any\ MRI\ Provider) = \beta_o + \beta_1 Different\_regime_i *CON + \beta_2 Interior_i *CON + \beta_3 Different\_regime_i + \beta_4 Interior_i + \beta_5 CON + \beta_6 Demand_i + \beta_7 MedSupply_i + e$

where (1) estimates the number of MRI providers per million people in a county (MRI/million) and (2) estimates an indicator of any MRI provider in the county (E(Any MRI Provider)). We estimate both models, and all subsequently described models, using Ordinary Least Squares (OLS) with robust standard errors.[5]

CON represents whether a county is regulated or unregulated. In addition to the Different-regime and Interior variables that measure the number of providers in different types of

[5] The binary outcome of Any MRI provider was also estimated using a Probit model where the magnitude of the effects were converted to marginal effects with all control variables set at their means. Because estimates were so close to the OLS estimates, we did not report them. They are available from authors upon request.

counties as described above, we also include control variables for the counties to adjust for any remaining imbalance between the differences in counties that may not be differenced out in the difference-in-difference framework, including variables that may well affect demand or supply of services. Demand includes population and population squared of the county in which the provider is located, the population density (county inhabitants per square mile), and categorical variables using the 2013 rural-urban continuum codes (we classified whether the county is in a metropolitan area, a non-rural non-metropolitan area, or whether the county is rural). Demand also includes the percent of the county living in poverty, the percentage of adults (18-64 years) old, the percentage of adults 65 years of age and older (and, therefore, eligible for Medicare), and the percent of adults in the county with college degrees. MedSupply represents the number of hospital beds per 100,000 in the county.

Our primary hypothesis is that $\beta_1 < 0$, the coefficient on the variable interacting being in a regulated state being located on a state border where contiguous counties across the state border have different regulatory regimes, which would suggest that MRI providers are more likely to locate on the unregulated (non-CON) side of a state border when the choice is available to them in a local market, controlling for the behavior of MRI providers in state border markets where contiguous counties across state borders have the same regulatory regime .

We also test an alternative control group –interior counties – as $\beta_1 – \beta_2 < 0$ -- which allows us to examine the same effect as above, but now using the difference in the number of providers in interior counties as a control. This alternative control is presumably more representative of a county's regulatory regime as the location is less likely to be affected by regulations in other states.

This set up also allows us to look at the single difference within unregulated states. A finding that $\beta_3 > 0$ would suggest that, for unregulated counties on state borders, there are more MRI providers in counties that are contiguous with counties in regulated states (different-regime counties) than in counties that are contiguous with counties in other unregulated states (border-same counties). A finding that $\beta_3 - \beta_4 > 0$ would suggest that there are more MRI providers in unregulated counties on state borders that are contiguous with counties in regulated states (different-regime counties) in interior counties in unregulated states.

Since our hypothesis that providers' higher likelihood of locating near a regulated state when locating in an unregulated state is related to tapping into unmet need in the regulated state, this higher likelihood will be a function of the cost of traveling over the state border, all else equal. Therefore, to further test our results we include a variable for whether borders are separated by a major river as a proxy for the ease of travel over state borders. This approach follows previous research (Hoxby, 2000) and research on urban planning in which the location and size of the bridges necessary to cross rivers are cited as an important professional concern of city planners and traffic engineers because of the central role they play in access and the economy (Levinson and Krizek, 2008). We expect our findings to be stronger where there is a land boundary than where there is a river boundary between states with different regulatory regimes.

To implement this approach, we estimate:

(3) $MRI/million_i = \beta_o + \beta_1 Land\_different\_regime_i *CON + \beta_2 River\_different\_regime_i *CON + \beta_3 River\_same\_regime_i *CON + \beta_4 Interior_i *CON +$

β_5Land_different_regime$_i$ + β_6River_different_regime$_i$ + β_7River_same_regime$_i$ + β_8Interior$_i$ + β_9CON + β_{10}Demand$_i$ + β_{11}MedSupply$_i$ + e

(4) E(Any MRI Provider) = β_o + β_1Land_different_regime$_i$ *CON + β_2River_different_regime$_i$ *CON + β_3River_same_regime$_i$ *CON + β_4Interior$_i$ *CON + β_5Land_different_regime$_i$ + β_6River_different_regime$_i$ + β_7River_same_regime$_i$ + β_8Interior$_i$ + β_9CON + β_{10}Demand$_i$ + β_{11}MedSupply$_i$ + e

Where the equations are the same as equations (1) and (2) with the separation of borders into two types, River and Land. These equations, then, allow the average border effect in the first two equations to be separated into the effects within each of these two types of borders.

We hypothesize here that $\beta_1 < 0$, the coefficient on the variable interacting being in a regulated state * being located on a state border separated by land where contiguous counties across the state border have different regulatory regimes. If $\beta_1 < 0$, this would suggest that MRI providers are less likely to locate on the regulated (CON) side of a state border when travel between the boundaries is relatively easy since finding a bridge is unnecessary, when compared to the difference between CON and non-CON counties on land borders that face the same regulatory regime across their borders. As in initial specifications, we test alternative comparison groups, this time alternatives include the difference in river border counties with a regime change, $\beta_1 - \beta_2 < 0$ and the difference in interior counties, $\beta_1 - \beta_4 < 0$. As above, we also examine the coefficients within unregulated counties.

4.B. Results

In Table 2 the key dependent variables are described by the county types for our analysis strategy. Among the 3,100 counties, 1,138 are border counties. Among the 1,138 border counties, 394 face a change in regulatory regime at the border. Among the 394 facing a regulatory regime change, 234 are on a land border and 160 are on a river border. When broken down by CON and non-CON states, the split is fairly proportional except there are only 5 counties in CON states that are contiguous with a CON county and are separated by a large river on the state border.

As can be seen in Table 2, the raw comparison of MRI providers per million people in a county between regulated and unregulated states show very little difference (0.3). When broken down by border and interior counties the differences are still small and are only negative among border counties (-1.0), meaning that, among counties on state borders, there are fewer providers per million people in regulated than unregulated counties. However, also in the raw data, there are considerably larger differences among those counties that border counties in other states that have different regulatory regimes. Moreover, when broken down further by whether that border is a land or river border, we only see large differences among land borders. The same patterns appear in the raw data that measure whether there is any MRI provider in the county (a dichotomous variable).

For an example of what this might look like on a particular land border, consider the case of the border between Michigan (a regulated state) and Ohio (an unregulated state). Two counties in Michigan -- Lenawee (pop approx. 100,000) and Monroe (pop approx. 150,000) counties each have no MRI providers. The two counties just on across the border in Ohio each have providers -- Lucas County (pop approx. 440,000) has 14 providers and Fulton County, the smallest of the four counties (pop approx. 43,000) has one provider.

We look at these relationships for all counties and more formally in the regression analyses, reported in Tables 3 and 4. As shown in Table 3, Column 1, the key coefficient is -6.4. This suggests there are fewer MRI providers per million people in regulated counties that border counties in unregulated states than in unregulated counties that border regulated counties, after accounting for any differences between regulated and unregulated states in the number of providers in counties contiguous with cross-border counties with the same regulatory regime ($p<0.01$). As can be seen in Table 3, Column 2, after controlling from the demographic and market variables discussed above, the coefficient is nearly the same, -6.9 ($p<0.01$), suggesting that the control groups in our difference-in-difference analysis are highly robust. In Table 3, column 3, where we estimate whether there is any MRI provider in the county, the coefficient is -0.241 ($p<0.001$). Again, there is little change in the coefficient when control variables are added, as can be seen in Table 3, column 4. Finally, we note that the difference-in-differences all remain large and significant when compared to interior counties rather than to other types of border counties.

The results in Table 3, Row 3 show that there are 4.9 more MRI providers per one million residents in unregulated counties that border regulated counties than unregulated counties that border other unregulated counties. This result suggests that most of the difference we identify in the difference-in-difference results is driven by activity on the unregulated side of the border rather than fewer providers on the regulated side of the border.

When we account for the ease of travelling across state borders by introducing the distinction between state borders marked by rivers versus land, as described in equations 3 and 4 and reported in Table 4, we find that the border effects are considerably larger for land borders than river borders. Among border counties where the border is not a large river (land border counties), controlling for demographic and other county characteristics, and after differencing out the effects attributable to merely being on a border (i.e., regulated counties that border counties in other regulated states), there are 11.3 fewer MRI providers per million people in regulated counties bordering unregulated counties. (Table 4, Column 2, P<0.01).

In contrast to the large differences among land border counties contiguous with counties in states with different regulatory regimes, there is very little difference among corresponding counties separated by rivers. For regulated counties with river borders that border unregulated counties the corresponding difference is only -0.2 (SD=2.620). Given these results, if we subtract the coefficients measuring the effects of being on different types of borders from our key coefficient (the -11.3), our results remain large and robust. We note that because there are only 5 CON counties on borders that are contiguous with counties that both have the same regulatory regime and are separated by rivers, the coefficients on --river-same-regime*CON are unstable, but are not statistically significant when control variables are included (-2.14 [SD-4.16]).

We also find the same patterns when we use a dichotomous variable for the existence of any MRI provider in a county (Table 4, Columns 3 & 4). Again the results are large, demonstrating a decline of 0.32 in the proportion of counties with any MRI provider (p<0.001).

For ease of interpretation, we have reported the OLS results in the specifications using a dichotomous variable (Any MRI) on the left hand side. In sensitivity testing, we also applied a Probit specification, estimated at the mean of all the variables, which is more appropriate for dichotomous variables. The results are nearly identical to the main specifications.

4.C. Sensitivity Testing and Limitations

We performed several tests to ensure the robustness of our results. First, we reran our results removing all of the counties in the states that have no boundaries with a different regime across the boundary. This removes 30 percent of all counties, but does not change the results because the identification is mostly within the border changing counties. The results do move slightly as a result of the covariate adjustments. For example, the main coefficient on the interaction in specification 2 in Table 3 is -6.9. The coefficient after removing the 30 percent of counties with no border changes is -6.6. The other specifications all show a similarly small change in the main result. Second, we also reran the results removing one critical state at a time. No single state moves our results. For example, when we remove Pennsylvania, the main coefficient moves from -6.9 to -6.8. The coefficient is -6.7 when Iowa is removed.

In addition, as an alternative to using robust standard errors we estimated our equations with clustering by state. As expected, the standard errors were not sensitive to this alternative.

Finally, we also perform sensitivity tests that focus on the significance of population for the results. As opposed to merely using several adjustments for population, some researchers may favor a model that weights the variables by population. Having applied the tests for determining whether regression weighting is appropriate advanced by Solon, Haider, and Wooldridge (2013), we concluded that the unweighted model is more accurate than the weighted model for several reasons: 1) we have tried to include a full universe of free-standing providers and, therefore do not need weights to account for a skewed sample in our descriptive statistics; 2) we have no reason to believe that the individual-level error terms within the groups of regulated or unregulated border counties are correlated because of some unobserved group-level factors (after all the border counties are in different states); to confirm our intuition, we tested for heteroskedasticity by regressing the squared residuals from the OLS equations on the inverse of the population variable for regulated and unregulated border counties (See a description of this modified Breusch-Pagan test in Solon, 2013). The results were not significant for the regressions testing MRI per population, although they were for the regressions testing whether a county had any MRI at all; and 3) we believe we have the universe of providers and, therefore, do not have endogenous sampling.

However, a fourth reason for weighting in this context is that CON regulations might have a greater or lesser effect in more populous counties, perhaps creating different thresholds for opening any provider site. Nonetheless, the weighted results support our hypotheses that MRI regulation affects the location of providers; however, many estimates are less precise (have higher standard errors) and show considerably smaller effects than those in our preferred specification. We report the descriptive statistics and all of the regression results in both unweighted and weighted form in the online Appendix.

There are several limitations to our study. First, our study is based on cross-sectional estimates, both leaving open the possibility that there is some local difference that contributes to our results and limiting the generalizability of our results over time. We could not perform time-series analyses because the primary sources from which we constructed original databases for this project do not allow us to create panel data. We assembled the MRI provider location data from member lists of MRI certification agencies that we found online in December 2012. However, the CMS requirement to join a certification agency only became effective in January 2012. In addition, we created an original database of states with CON for MRI from both legal research and interviews with regulators about whether the laws are actively enforced. This approach, which we believe makes our data more reliable than had we conducted only statutory and regulatory research, does not allow us to construct a reliable panel.

To address the limitation of cross-sectional analysis, we included both within and cross-state specifications. We also included several independent variables to address potential left out variable bias. Although there may well be remaining bias related to the reasons why some states retained their CON laws, it is difficult to explain why any of those factors would cause freestanding MRI providers to appear on the other side of a state border without there being some excess demand in the CON states.

Second, because the data were unavailable, we were not able to account for the type or number of MRI machines used by each provider, nor were we able to account for the quantity of individual scans provided. Therefore, we are unable to determine whether CON for MRI has had a similar volume effect to those found by other scholars studying CON regulations for different services. Third, all of the states with active CON for MRI are in the Midwest and Northeast, leaving open the possibility that there are regional effects which we were unable to assess.

5. Conclusion

Our robust finding of 6.9 fewer MRI providers per million people in regulated counties that border counties in unregulated states than in unregulated counties that border regulated counties yields several important conclusions and implications for policy. First, we conclude that these effects are large. Given that a typical county has 11.6 MRI providers per million people, our finding suggests that for residents in regulated border counties with nearby unregulated counties, residents would have to cross to border to access 60 percent of the area's supply of MRI providers. Given the size of this effect, it should be accounted for in future research on the effects of state-based health technology regulation.

Second, we find that CON regulations for free-standing MRI affect not only residents in regulated states, but spill over and affect those in unregulated states nearby. This is only a single example of how the effects of state regulation are not, and probably cannot be, confined within a state despite the fact that the regulation of health insurance (via the federal McCarran Ferguson Act which exempts insurance from most federal regulation) and much of the regulation of health care itself (via state licensing laws like CON and state based public health programs) is explicitly state based. Some of the benefits of state regulation, like responsiveness to local citizens, depend on a degree of isolation from the policy choices of other governments, both federal and other states policy choices. (Greve, 2001) If the effects of these policies cannot be contained within a state, the kinds of spillover effects we identify here call into question whether local and state regulators are better positioned, as is often asserted, than the federal government to reflect the preferences of their citizens. Depending on the welfare effects of CON, which are beyond the scope of this study, our findings provide some support for federal intervention in regulation where there are extreme spillover effects across state boundaries.

Third, it is widely believed that a decentralized regulatory system allows states to serve as laboratories, testing various policies so that all levels of government can learn from the experiments. However, large spillover effects undermine the effectiveness of state regulations as a basis to determine whether regulation would work on a larger scale or if it were implemented nationally.

Fourth, these results may inform development of imaging payment policy. While the development of advanced diagnostic imaging – and MRIs in particular - have made important contributions to human health, advanced diagnostic imaging has been identified as an overused technology. (Medicare Payment Advisory Commission, 2005). The overuse of medical technology can have negative health effects, including risks related to MRI technology and contrast agents (U.S. Food and Drug Administration, 2013, U.S. Food and Drug Administration, 2010; Kanda et al., 2013), as well as false positives that lead to further interventions (Chandra and Skinner 2012). The large variation in prices for diagnostic scans suggests there is room for cost-control; in 2012, prices for MRIs in the United States varied a great deal with the 25th percentile at $522, an average price of $1,121, and the 95th percentile at $2,871 (International Federation of Health Plans, 2013). In addition, the tendency for a doctor to order scans appears to be influenced by whether the doctor owns MRI equipment; for example, Baker (2010) found an increase in imaging use and spending on patients shortly after their orthopedist and neurologist acquired MRI equipment and began billing Medicare for scans.

Fifth, and more generally, the Affordable Care Act employs numerous methods that were included as part of an effort to slow spending, particularly spending on over use of technology. These methods include various payment reforms to alter the financial incentives for medical practitioners and organizations to provide services, but they do not include direct regulation of technology through programs such as CON. An accurate assessment of whether direct regulation such as CON can or cannot be effective must consider types of cross-border effects of regulations we analyze here. Because of the increase in care at outpatient and free-standing sites, accounting for spillover effects will become even more important for assessing regulation.

Finally, while our study did not consider the welfare effects of CON an evaluation of which would need to address the effects of barriers to entry on price, volume, and quality we surmise that, all other things equal, exporting patients across state lines is generally not welfare enhancing when the alternative would be to 1) obtain care in their home locations, or 2) not obtain care that is unnecessary. Such costs will, in part, be imposed on the patient who suffers unnecessary travel for needed care or receives travel and unnecessary care. To the extent these patients are insured under Medicare, the federal government will bear the cost burden. We leave these important issues for future research.

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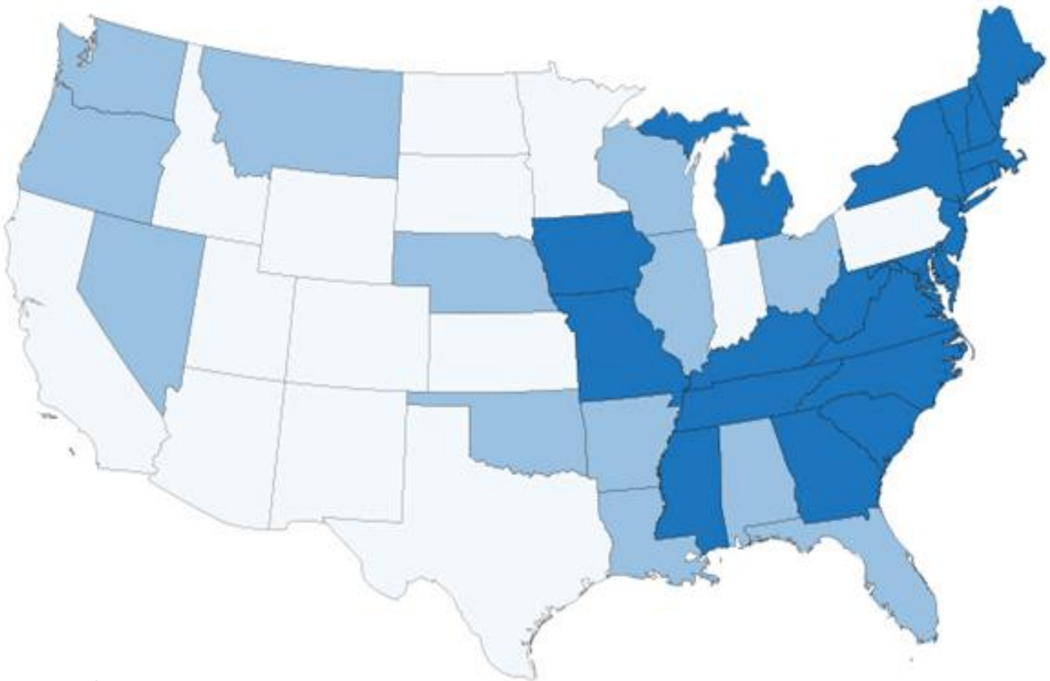
Figure 1. State Certificate of Need Laws, 2012



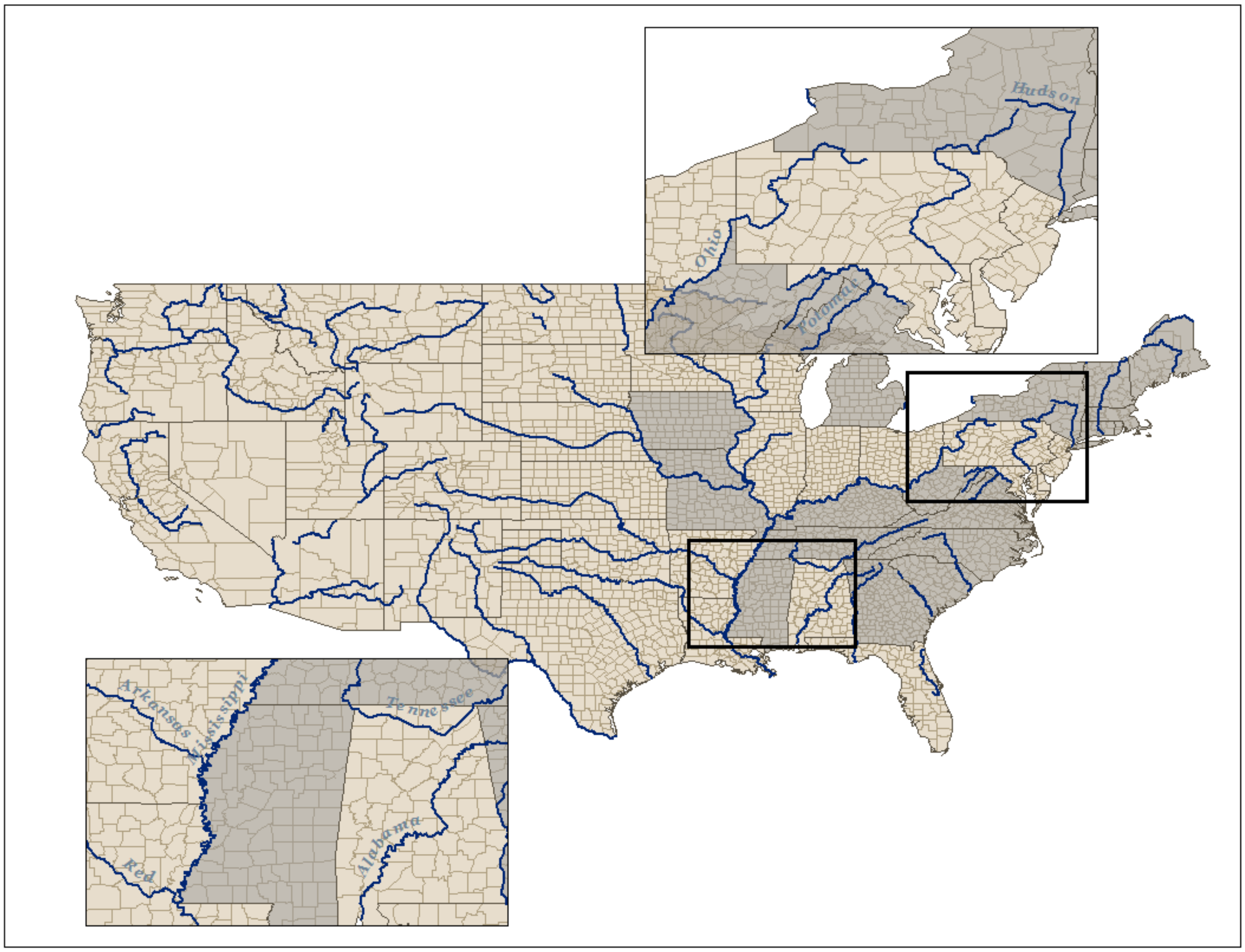
No CON for any service

CON for some services, not MRI

CON for MRI

SOURCES: The designations in this figure are from the authors' primary research including: a 48-state survey of state statutes and regulations, confirmed by interviews with state regulators in departments of health, bureaus of health planning, CON offices, or other relevant state offices.

Figure 2. State Borders with Major Rivers



SOURCES: Templates from ArcGIS. Original source for major rivers from ESRI, Rand McNally & Company, Bartholemew and Times Books, Defense Mapping Agency presently known as National Geospatial-Intelligence Agency.

Table 1. Descriptive Statistics

Variable	All Counties (N=3,100) Mean	All Counties (N=3,100) Std. Dev.	CON Counties (N=1,213) Mean	CON Counties (N=1,213) Std. Dev.	Non-CON Counties (N=1,887) Mean	Non-CON Counties (N=1,887) Std. Dev.
MRI Providers	2.17	7.15	1.63	4.92	2.52	8.26
Population	98,714	314,458	82,569	193,829	109,092	371,568
MRI Providers per million pop	11.6	21.0	11.7	24.5	11.4	18.5
Urban-rural classification: non-metro	0.44	0.496	0.427	0.495	0.448	0.497
Urban-rural classification: rural	0.211	0.408	0.186	0.39	0.227	0.419
Density: pop per square mile	240	1670	358	2515	164	710
Population below poverty line (%)	15.3	6.0	16.7	6.3	14.4	5.7
Median Household Income ($)	43,992	11,328	42,574	11,838	44,903	10,894
Population 18-64 years (%)	58.8	4.5	59.7	4.3	58.1	4.6
Population > 64 (%)	15.3	4.2	14.9	3.6	15.6	4.5
Pop >25 with College Education (%)	13.8	6.0	13.0	6.4	14.3	5.6
Hospital Beds (per 100,000 pop)	355	534	325	488	374	561

SOURCES: Authors' analysis of data on MRI providers from the American College of Radiology (2012) and Intersocietal Accreditation Commission, on rural and urban status from the Centers for Disease Control and Prevention, National Center for Health Statistics Urban-Rural Classification Scheme (2012), and, for the remaining measures, the US Department of Health and Human Resources, Health Resources Administration, Area Resource File (2010).

Table 2. MRI Providers by County Border Classification by Certificate of Need Status

	Number of counties				MRI per million population			Any MRI in county		
	Total	CON	Non-CON		CON	Non-CON	diff	CON	Non-CON	Diff
All counties	3,100	1,213	1,887		11.7	11.4	**0.3**	0.367	0.368	**0.001**
Border	1,138	452	686		10.8	11.8	**-1.0**	0.392	0.362	**-0.030**
Interior	1,962	761	1,201		12.3	11.3	**1.0**	0.352	0.371	**0.019**
				diff	**-1.5**	**0.5**	**-2.0**	**0.040**	**-0.009**	**-0.049**
Border										
Different regime	394	209	185		10	15.3	**-5.3**	0.354	0.486	**0.132**
Same regime	744	243	501		11.5	10.4	**1.1**	0.424	0.315	**-0.109**
				diff	**-1.5**	**4.9**	**-6.4**	**-0.07**	**0.171**	**0.241**
Different regime										
land border	234	123	111		8.3	18.4	**-10.1**	0.309	0.541	**0.232**
river border	160	86	74		12.4	10.8	**1.6**	0.419	0.405	**-0.014**
				diff	**-4.1**	**7.6**	**-11.7**	**-0.110**	**0.136**	**0.246**
Same regime										
land border	662	238	424		11.7	10.6	**1.1**	0.433	0.321	**-0.112**
river border	82	5	77		0.0	9.6	**-9.6**	0.000	0.286	**0.286**
				diff	**11.7**	**1.0**	**10.7**	**0.433**	**0.035**	**-0.398**

SOURCES: Authors' analysis of data on MRI providers from the American College of Radiology (2012) and Intersocietal Accreditation Commission, the Centers for Disease Control and Prevention, National Center for Health Statistics Urban-Rural Classification Scheme (2012), and the US Department of Health and Human Resources, Health Resources Administration, Area Resource File (2010).

Table 3. Regression Results for Border County Classification

	(1) MRI pop	(2) MRI pop	(3) Any MRI	(4) Any MRI
Different regime * CON	-6.431**	-6.929**	-0.241***	-0.238***
	[2.318]	[2.206]	[0.0624]	[0.0523]
Interior * CON	-0.0587	0.0389	-0.128**	-0.102**
	[1.787]	[1.577]	[0.0440]	[0.0357]
Different regime	4.915**	4.301**	0.171***	0.133***
	[1.728]	[1.661]	[0.0422]	[0.0366]
Interior	0.852	-0.0241	0.0560*	0.00672
	[0.983]	[0.956]	[0.0250]	[0.0203]
CON	1.044	1.230	0.108**	0.102**
	[1.371]	[1.314]	[0.0379]	[0.0312]
Control Variables	No	Yes	No	Yes
Constant	10.43***	-0.764	0.315***	0.247
	[0.835]	[7.645]	[0.0208]	[0.147]
Observations	3100	3100	3100	3100
R Squared	0.022	0.1944	0.133	

NOTES: Regressions (1) and (2) estimated by ordinary least squares. Regressions (3) and (4) estimated with a linear probability model; corresponding Probit estimates produced similar results (available from authors). See data description in text for definitions, sources, and list of control variables. Standard errors in brackets. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4. Regression Results for River and Border County Classification

	(1) MRI pop	(2) MRI pop	(3) Any MRI	(4) Any MRI
Land Diff regime*CON	-11.24***	-11.33***	-0.344***	-0.321***
	[2.928]	[2.824]	[0.0744]	[0.0644]
River diff regime*CON	0.447	-0.195	-0.0988	-0.106
	[2.936]	[2.620]	[0.0875]	[0.0701]
River Same regime*CON	-10.72***	-2.150	-0.398***	-0.102
	[2.490]	[4.162]	[0.0649]	[0.0891]
Interior * CON	-0.147	0.116	-0.131**	-0.0985**
	[1.838]	[1.625]	[0.0452]	[0.0368]
Land Different regime	7.802**	7.265**	0.220***	0.186***
	[2.370]	[2.288]	[0.0525]	[0.0466]
River Different regime	0.204	-0.501	0.0847	0.0367
	[1.986]	[1.775]	[0.0615]	[0.0500]
River Same regime	-0.993	-0.883	-0.0350	-0.0411
	[2.231]	[2.101]	[0.0563]	[0.0453]
Interior	0.700	-0.160	0.0506	0.000400
	[1.052]	[1.019]	[0.0267]	[0.0215]
CON	1.133	1.143	0.112**	0.0982**
	[1.435]	[1.375]	[0.0394]	[0.0324]
Control Variables	No	Yes	No	Yes
Constant	10.58***	-1.300	0.321***	0.239
	[0.915]	[7.658]	[0.0227]	[0.147]
Observations	3100	3100	3100	3100
R squared	*0.0220*	*0.1944*	*0.0191*	*0.3511*

NOTES: Regressions (1) and (2) estimated by ordinary least squares. Regressions (3) and (4) estimated with a linear probability model; corresponding Probit estimates produced similar results (available from authors). See data description in text for definitions, sources, and list of control variables. Standard errors in brackets. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.