Do Regulatory Constraints in Health Care Bind? Evidence from High-Skilled Nurses

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If government regulations impose binding constraints, deregulation should result in re-optimization. We examine how hospitals respond to a federal ruling allowing states to opt-out of physician supervision of certified registered nurse anesthetists (CRNAs). Using Medicare claims, we find limited staffing changes. At most, CRNAs are modestly more likely to be matched to a wider subset of anesthesia tasks, while anesthesiologists devote slightly more labor to higher complexity cases. Complementary data suggest that newly trained and mobile CRNAs are attracted to deregulated states. Overall, these regulations appear only weakly binding and consistent with non-price hiring frictions.

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1. Introduction

Health care is one of the most heavily regulated industries in the United States (US). The vast majority of those employed in health care hold a mandatory occupational license, and the specific subfields of medicine, nursing, and dentistry all require universal licensure for anyone intending to practice (Kleiner 2016; Kleiner and Park 2010). Associated regulations also extend beyond licensing and often determine which provider types can offer certain services via "scope of practice" statutes. Unsurprisingly, such laws are sometimes perceived as professional protectionism and draw the ire of workers that they disadvantage.

In theory, deregulation and the removal of barriers to entry will improve efficiency if the marginal social costs of regulation exceed the marginal social benefits of improved care quality. While economic theory has often been successful in predicting the direction and size of market-wide deregulation effects, it has performed less well in identifying when and how deregulation will lead firms to change their operations or uses of technology. This shortcoming is believed to be due to intrinsic features that can be industry specific (Joskow and Rose 1989; Winston, 1993; Peltzman and Winston 2011).[1] In the health care setting, removing scope of practice restrictions on non-physician clinicians has been—as theory would predict—associated with a higher number of non-physician hires (Kuo et al. 2013; Reagan and Salsberry 2013; Sekscenski et al. 1994; Xue et al. 2016), increases in the amount of care they provide to the market (Adams, Ekelund, and Jackson 2003; Wing and Marier 2014; Xue et al. 2016), and lower costs of care (Spetz et al. 2013). However, labor-focused studies have generated mixed results. One study shows more demand for graduate programs during the 1990s as states expanded their legal boundaries for nurse practice (Kalist and Spurr 2004). Some find negative effects on the wages and incomes of those gaining more practice authority (Dueker et al. 2005; Sass and Nichols 1996) while others claim the opposite (Kleiner et al. 2016; Perry 2009).[2]

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[1] Studies across various industries have found modest effects on firm decisions on the intensive margin. For example, the deregulation of airlines led to relatively modest changes in the level and dispersion of worker's wages (Card, 1996). Nananda (2010) find that deregulation of firm sizes in banking led to small or no changes in firm entry sizes, and Alfaro and Chari (2012) show that small firms still face growth constraints even after deregulation of compulsory industrial licensing.

[2] Additionally, some recent research focusing on dentists and dental hygienists shows that more restrictive laws can insulate dentists' incomes Buchmueller, T. C., S. Miller, and M. Vujicic. 2014. "How Do Providers Respond to Public Health Insurance Expansions? Evidence from Adult Medicaid Dental Benefits." *NBER Working Paper Series*(No.20053): 1-58, Kleiner, M. M. and K. W. Park. 2010. "Battles among Licensed Occupations: Analyzing Government Regulations on Labor Market Outcomes for Dentists and Hygienists." Ibid.(16560)..

In this paper, we focus on the labor and operational impacts of deregulation by studying scope of practice laws for high-skilled nurses. Blending of provider types and wider task allocation is becoming increasingly common among clinical practices. Prior research indicates that consumers often express indifference between physician-delivered care and care from an alternative provider (Dill et al. 2013). Quality of care by non-physician clinicians is also on par with that of physicians (Jennings et al. 2015; Kleiner et al. 2016; Laurant et al. 2008; Lenz et al. 2004; Mundinger et al. 2000; Newhouse et al. 2011; Wright et al. 2011). The heightened awareness around health care's regulatory burden has occurred due in part to the Affordable Care Act (ACA) of 2010, which set forth numerous initiatives affecting health care supply, consumption, and financing. The forecasted changes have encouraged speculation that consumer demand may soon outstrip supply—leading some to recommend lifting regulatory barriers on alternative (non-physician) providers to mitigate potential supply-side strains (Bodenheimer and Pham 2010; Hofer, Abraham, and Moscovice 2011; Huang and Finegold 2013; Kirch, Henderson, and Dill 2012).

We leverage related state-specific legislative changes to identify the effects of relaxing clinical practice constraints for certified registered nurse anesthetists (CRNAs). As one of the highest skilled nursing types, CRNAs serve as key inputs in hospital production functions by providing anesthesia care across the gamut of practice settings and surgical/procedural services. However, CRNAs may not necessarily perform these clinical functions absent physician supervision. Their regulatory constraints originated with a federal policy decision that disadvantaged CRNAs in favor of physician-trained anesthesiologists, which was then reversed years later. The latter change opened the door for a variety of states to remove all barriers to independent CRNA practice.

Though seemingly specific, this context offers several important advantages for studying deregulation within the health care industry. Much of the scope of practice literature has focused on nurse practitioners (NPs), who ultimately face three separate domains of regulatory interference: the ability to examine and diagnose, the ability to treat, and the ability to prescribe medications. States differ on which of these three domains require physician involvement and to what degree (Dower, Moore, and Langelier 2013; Fairman et al. 2011; Kuo et al. 2013). Existing studies often rely on changes to one of these three domains—usually a change in prescriptive authority—which may not imply complete practice autonomy due to accompanying regulations

that limit independent practice ((Kaplan et al. 2006); Kleiner et al. 2014; Perry 2009; Stange 2014). This blend of full and partial practice autonomy for NPs complicates interpretation and may be a source of the aforementioned weak and/or conflicting findings on labor-market outcomes.[3] Instead, our study benefits from a precise and uniform policy that unambiguously moves an affected state from requiring physician supervision of CRNAs to not. We also have the advantage of a clinical setting where nurse- and physician-trained providers have a high degree of known substitutability. A greater overlap in skills can mean potentially larger distortions to hospitals' hiring decisions and labor allocations from artificial boundaries imposed by regulators and lawmakers. In turn, these features should add salience to the law changes among market participations.

However, without an empirical analysis, it is still a priori unclear how hospitals would respond to the regulatory move. These statutes ostensibly restrict hospital choice over labor inputs, but they may also be relatively non-binding due to other substitution frictions in the market, such as hospital or consumer preferences, transaction costs, organizational dynamics, or administrative constraints (Laffont and Tirole, 1993). In other words, CRNAs can be an operationally more efficient source of hospital labor, but additional factors, such as physician preferences or malpractice liability, could raise the full costs of relying more on CRNAs and therefore dampen the impact of deregulation.

To test these possibilities, we use extensive Medicare claims data from 2002 to 2013 to first investigate whether CRNA scope of practice laws appear binding. Unlike many related studies that impute nurse skill level and type, our data allow us to clearly identify CRNA providers. We then use standard differences-in-differences analyses to show that hospitals largely maintain the status quo after moving to a more accommodating policy environment for CRNAs. There is limited evidence of task matching changes among procedural anesthesia services, and no differences in CRNA utilization within hospitals' operating rooms. Hospitals are also not obviously substituting away from anesthesiologists or sacrificing care quality once CRNA supervision is no longer required. Hospitals do not appear to re-optimize their anesthesia labor choices when regulatory barriers are removed.

[3] Reagan and Salsberry (2013) even argue that full prescriptive authority still requires a collaborative agreement with physicians, and it is of no practical difference than mandating physician involvement in all aspects of care.

We then explore a series of potential frictions that may restrain labor substitutions even in the absence of regulatory distortions. Specifically, we find empirical support for surgeons dictating the terms of unpaid inputs from hospitals. Hospitals with a higher absolute number of surgeons using their operating suites well as those with a greater share of physicians devoted to surgical care display a weaker response to the policy change. These results are consistent with surgeon preferences—which may favor collaboration with similarly trained MDs, as opposed to nurses—inducing hospitals to overpay for anesthesia services.[4] Yet, we also observe hospitals with less desirable financial positions being more inclined to increase their CRNA reliance after deregulation—suggesting that the incidence of the laws may be unevenly felt across the market. In the near-term, these regulatory burdens have limited practical ramifications but a high affinity for political wrangling.

2. Background on CRNA Deregulation

Provider scope of practice regulations are imposed at both state and federal levels in the US—though more often by the states, which hold control over their local health care licensure laws (Cooper and Aiken 2001). While states are generally uniform on what professional qualifications are needed to be designated a particular provider type, they widely vary on what a specific provider type can do, even for the most educated and clinically trained groups (Pohl et al. 2010; Schiff 2012). State-specific laws range from being fully liberal (i.e., granting practice autonomy to qualified nurses) to being fully restrictive (i.e., requiring joint production of care between nurses and a supervising physician). These differences are the source of regulatory variation that we are primarily interested in, and we focus on legislation affecting on specific type of Advanced Practice Nurses (APNs): CRNAs. All APN types require degrees, such as a master's degree or higher, and certifications on top of a bachelor's nursing degree or four-year nursing program. In this way, APNs represent some of the highest skilled labor available from the US nursing workforce.

[4] The American Medical Association maintains that the training of CRNAs remains inadequate with the "clinical judgement and acumen developed through eight years of medical and anesthesiology training […] cannot be duplicated through nurse anesthetist master's or doctoral degree education programs, or weekend or week long courses focusing on the subject" (AMA, 2009).

2.1. Federal Ruling for CRNAs and State Scope of Practice

Anesthesia care is typically delivered by one of two provider types: anesthesiologists (physicians) or CRNAs (nurses). Both types of anesthesia providers have increased in numbers; however, anesthesiologists' growth has outpaced CRNAs in recent decades, leading them to displace CRNAs in what was previously a nursing dominated field (Cromwell 1999). Despite strong similarities in the clinical services offered, CRNAs are far less costly: according to the Bureau of Labor Statistics, the average annual wage for CRNAs in 2016 was $164,030 versus $269,600 for anesthesiologists.[5] Nevertheless, CRNAs are educated to perform all tasks involving anesthesia as required for state licensure, and hospital accreditation does not require anesthesiologists to be on staff. Some consequently argue that CRNAs are more cost-effective and hence underutilized resources for hospitals (Cromwell and Snyder 2000).

Yet, the choice of labor inputs for anesthesia care is not simple and contains important tradeoffs for hospitals. Since 1989, Medicare (the federal public insurance program primarily for the elderly) would reimburse CRNAs directly for all services rendered. However, hospitals would not be paid for all non-anesthesia related care if the CRNA practiced independently, receiving no physician oversight.[6] This made the exclusive employment of CRNAs financially unattractive for hospitals since they would forfeit the majority of their Medicare reimbursement for each CRNA-administered surgical case (Cromwell 1999).

The process to remove this large, federal disincentive for independent CRNA-use began in the early 1990s and was not legislatively completed until November 13, 2001 when the Centers for Medicare and Medicaid Services (CMS) published its final rule in the Federal Register. At that point, the federal government decided that each state could voluntarily opt-out of the requirement for physician supervision of CRNAs. Hospitals within opt-out states would then receive full Medicare payment for surgical care only involving CRNAs (Downey 2010; Dulisse and Cromwell 2010). Between 2001 and 2004, twelve states opted out, including (in order of legislative change) Iowa, Nebraska, Minnesota, New Hampshire, New Mexico, Kansas, North Dakota, Washington, Alaska, Oregon, and Montana. In 2005, South Dakota and

[5] Anesthesiologist wage data from https://www.bls.gov/oes/current/oes291061.htm. CRNA wage data from https://www.bls.gov/oes/current/oes291151.htm.

[6] We document differences in anesthesia-related Medicare billing in Appendix Table B1.

Wisconsin additionally opted out, and California and Kentucky changed their laws in 2009 and 2012, respectively (see Table 1 for each state's specific law change).[7]

Despite this seemingly significant regulatory change to one of the higher margin service lines for hospitals, we have little empirical evidence on the policy's subsequent effects. Some existing work comments on how restrictive scope of practice can reduce a collaborative mentality between CRNAs and anesthesiologists (Alves 2005), which is said to be challenging at baseline (Jones and Fitzpatrick 2009). Only one study has investigated health outcomes before and after the rule change—finding no indication that the opt-out provision exposed patients to new surgical care risks (Dulisse and Cromwell 2010). The Dulisse and Cromwell (2010) work is limited to a smaller data sample and analytic window when compared to our current study and only examined two outcomes of interest: inpatient mortality and anesthesia complications.[8] Some related research also shows comparable quality across all possible anesthesia care teams: CRNAs only, physicians only, and a mix (Needleman and Minnick 2009). We are not aware of any existing research that assesses the impacts of deregulation in this setting on the production process, such as hospitals' use and task allocation of CRNAs, or the broader market for labor inputs, including the supply of experienced CRNAs.

2.2. Conceptual Framework Around Hospital Staffing Decisions

From a profit-maximizing perspective, hospitals should choose between anesthesiologist and CRNA inputs in a way that minimizes costs (and hence maximizes profits). Standard economic theory implies that hospitals—in the absence of input constraints—will equate the marginal rate of technical substitution, namely the ratio of the marginal products of labor of CRNAs relative to anesthesiologists, to the ratio of marginal costs of CRNA labor relative to the MD. When hospitals are restricted from using CNRAs independently, the choice of inputs will be at a point where the marginal productivity of CRNA labor is likely higher than marginal costs. Thus absent other constraints, removing the regulatory barriers should allow a readjustment that

[7] Colorado changed its CRNA scope of practice requirements in 2010 but only in a limited way, namely restricted to rural designated areas. We exclude Colorado from our analyses for this reason.

[8] The Dulisse and Cromwell (2010) study also did not specifically follow a difference-in-differences research design and accompanying analyses. The authors also focused their work on hospitalization-level analyses, rather than a state policy level look as we do in this work.

will increase CRNA use at the expense anesthesiologists—especially among hospitals with weaker financial positions.

Nevertheless, this theoretical argument masks non-price considerations that hospitals may internalize and lawmakers may overlook. For example, with physician labor heavily supply-constrained, hospitals are forced to compete for top physicians. If CRNA and anesthesiology labor are close but imperfect substitutes, hospitals requiring a non-zero level of anesthesiology labor may have to cater to anesthesiologists' tastes, who in turn may prefer to protect their scope of clinical practice—and therefore restrict the degree of CRNA use. Perhaps more importantly, the tastes of local surgeons can also inhibit a hospital from fully adjusting CRNA inputs post-deregulation if surgeons favor working with fellow physicians over nurse-provided anesthesia care. In the spirit of (Pauly and Redisch 1973), surgeons could coerce hospitals into overpaying for anesthesia labor based on their private preferences and/or desires for income protection, for example, avoiding perceived increases in malpractice risk. Sensitivity to such surgeon demands for anesthesia provider types may be unavoidable in order to recruit and retain surgeon employees or to entice community surgeons who are not vertically integrated to perform their cases within a given hospital—and thereby generate additional, needed revenue for the hospital.

Beyond any physician preference arguments, another potentially influential element at the hospital level is brand image. If exclusive (or extensive) CRNA use is perceived as a signal of lower quality care, then hospitals' substitution behaviors will be restrained to avoid losing business to competitors. Moreover, such perceptions may also be important in malpractice disputes. Hospitals and physicians have generally been held liable, in whole or in part, for CRNA negligence, and surgeons may be uncomfortable admitting to relying on a nurse's clinical judgment out of fear of undermining their own defense (Poirier 2004). Thus, without accompanying tort reforms or low levels of malpractice risk, hospitals may refrain from exercising their full labor choice freedom following a state's opt-out decision.

In each of these ways, additional incentives and practical constraints can shape hospital demand for these input factors independent of any prevailing regulations, and therefore, temper the impact of a law change. However, in highly competitive markets where hospitals are forced to operate with more productive efficiency, these non-price elements may play a weaker role, and hospitals may be more prone to re-optimize their labor choices in response to lighter regulation.

3. Data

Our primary data source is an extensive reservoir of detailed utilization and provider information from the Medicare fee-for-service population. We then leverage several ancillary data sources to offer complimentary evidence on CRNA labor market outcomes before and after the state regulatory changes.

3.1. Medicare Claims Data 2002-2013

Our key data come from administrative Centers for Medicare and Medicaid Services (CMS) Medicare Claims File. For each year between 2002 and 2013, we utilize the 20% Carrier Claims File, which includes all physician and supplier Part B claims data incurred by a random subset of the Medicare-enrolled beneficiaries. Importantly, these data allow us to identify specific provider types; we limit the sample to only providers coded as anesthesiologists or CRNAs.[9] The data also allow us to observe the place of practice, which we limit to hospital settings. According to the American Medical Association's "National Correct Coding Initiative Policy Manual," anesthesiologists and CRNAs can bill for two types of services: anesthesia care and other procedures.[10]

Measured in units of time, anesthesia care includes all services integral to the anesthesia procedure, including the preoperative evaluation of the patient, administration of anesthetic or other medications, postoperative evaluation, and other supportive services. On the other hand, "other procedures" are measured in claim counts, and they are billed when services, not encompassed in the existing (main) anesthesia service, are provided as a separate patient encounter at the request of the operating physician. For example, if an epidural catheter is left in place for postoperative pain management, the anesthesia practitioner cannot report an extra claim for the epidural. However, if the anesthesia practitioner performs general anesthesia and then inserts an epidural at the request of the operating physician, the anesthesia practitioner can report an extra code for the epidural. These "other" procedures include evaluation and management

[9] Prior to 2003, the provider specialty code designated as "CRNA" also included anesthesiologist assistants. All states—except for Alaska—do not exhibit any sharp changes between 2002 and 2003, so we include 2002 in our sample frame and exclude Alaska. Our results are robust to dropping 2002.

[10] The manual is here: <https://www.cms.gov/Medicare/Coding/NationalCorrectCodInitEd/ index.html>.

codes, pain and ventilator management codes such as the placement of external devices (for example, insertion of tubes, catheters, needles, etc.), and radiology codes when anesthesia services are provided in conjunction with radiological procedures.

Because these two groups of procedures are fundamentally different in their reporting type (i.e., time versus claims count) and origin (i.e., anesthesia care versus individual provider services provided in separately identifiable ongoing critical care), we consider them separately in the Medicare claims data. For each service type, we collapse the claims data of 8.9 million anesthesia care episodes and 23.1 million other anesthesia procedures to the state-year-quarter level. We focus on the corresponding claim and provider—anesthesiologist and CRNA— counts. The detailed claims allow us to further examine changes in the distribution of providers by time of the anesthesia care required and care delivery setting. We also construct patient health outcome measures tied to the quality of anesthesia care. Specifically, we generate rates of anesthesia-related complications using the designated ICD-9 diagnoses codes (Appendix A). We also observe allowed Medicare payments associated with each admission and basic patient demographic information, including age, race, and gender for all beneficiaries captured in our data.11

We additionally use the Medicare claims data to explore factors that may affect hospital responses to deregulation. Hospital identifiers are unavailable in the Carrier Claims File, but we limit these complementary analyses to provider zip codes for which there is only one hospital.[12] Thus, data at the zip-code level will reflect hospital-specific characteristics from the hospital-level Healthcare Cost Report Information (HCRIS) data. As a proxy for the sway of preferences among surgeons, we consider both the number of surgeons with claims in a given hospital as well as the share of physicians who are surgeons among a hospital's claims.

3.2. CRNA Workforce Survey Data

For our supplementary analyses, we improve upon studies using the Current Population Survey and American Community Survey datasets by turning to a more detailed dataset that focuses exclusively on the US nursing labor force: the National Sample Survey of Registered

[11] Table B1 (Appendix B) details the coding and payment rules for each provider type, especially in regards to anesthesiologist supervision roles.

[12] We identify zips with only one hospital by using the Healthcare Cost Report Information data.

Nurses (NSSRN). In each wave of the survey, respondents are randomly selected from each state's listing of licensed registered nurses. Through its weighting procedure, the NSSRN survey is designed to be representative of the full nursing workforce at both the state and national levels.

The survey was first administered in 1977 and then every four years from 1980 through 2008; we focus on data from 1992 through 2008. As with many survey-based data sources, a key challenge in using this dataset is ensuring consistent information over time. To that end, we employ the State Public Use Files and variable crosswalk provided by the NSSRN survey administrators to create a consistently coded dataset over our entire study period. We also check the crosswalk for consistency by reviewing the survey questionnaires for each year and the allowed responses for each question of interest. When necessary, we aggregate response categories for a particular question in data waves to ensure uniformity in the variables over time.

We take advantage of the detailed information about the specific APN type, labor force participation, employment characteristics, income, experience and training, and demographic variables in the NSSRN. Specifically, we use the education and principal nursing position variables to identify our key high-skilled APNs (i.e., CRNAs).[13] Among the CRNA population, we focus on worker characteristics, such as having a part-time position, being unmarried and without children, which comprise a potentially more mobile source of labor, and being a recent migrant to the current state where the respondent is working. One limitation of the NSSRN data is that we only observe job movements from the year immediately preceding the survey year; thus, we do not observe labor flows across all four intervening years between surveys. Despite this limitation, our measures can still provide useful insights into job mobility and the prevailing flexibility in the labor market. The data also provide information on job characteristics such as the hourly wage (calculated by dividing real pre-tax annual earnings expressed in real 2008 dollars by annual hours worked). Finally, we stratify our analytic samples by work experience to allow for any heterogeneous responses to changes in CRNA scope of practice laws.

4. Empirical Strategy

4.1. Difference-in-Differences for Medicare Utilization Data

[13] Although being able to precisely identify CRNAs is a clear benefit of the NSSRN, the data still have an unavoidable drawback in that CRNAs are very small share of the observed nurses—roughly 1% of observations in a given wave.

With our 20% Medicare claims data aggregated to the state-year-quarter level, we implement a generalized differences-in-differences (DD) analysis, with multiple treatment units and policy changes occurring at different times. Our most parsimonious estimating equation is:

$$Y_{st} = \alpha + \delta(Relax)_{st} + \lambda_s + \eta_t + \varepsilon_{st}$$

Y is one of our outcomes of interest, and Relax is our policy indicator for when a state opts-out of the MD supervision requirement for CRNAs. We also focus on states that removed the supervision requirement in 2003 and beyond (see Table 1) because we lacked sufficient pre-period data for states that implemented the policy in 2001 or 2002.[14] The only other additions to the model are vectors of state and year fixed effects. We then sequentially add state-specific time trends (times) and patient demographic covariates (*X*)—including patient CCI, indicators for being male, White, Black, and Hispanic, and five age group dummies—to Equation 1 to assess the sensitivity of our policy effect estimate.

$$Y_{st} = \alpha + \delta(Relax)_{st} + \lambda_s + \eta_t + \theta X_{st} + \xi time_s + \varepsilon_{st}$$

To reveal any anticipatory behavior or evolution in the treatment effect over time, we estimate an event study version of Equation 2. We create a set of half-year indicator variables (*T*) that span 2.5 years prior to and after a state's regulatory change. Two additional indicators (*Early* and *Late*) are equal to one for all time periods that extend beyond this five-year window around policy implementation.

$$Y_{st} = \alpha + \delta \sum_{i=-6}^{6} (Relax \times T_i)_{st} + \gamma Early_{st} + \psi Late_{st} + \lambda_s + \eta_t + \theta X_{st} + \xi time_s + \varepsilon_{st}$$

We also separately analyze all of our anesthesia care outcomes by the provider type that directly supplied the service (i.e., a physician anesthesiologist or CRNA). Doing so can reveal any provider substitution behavior or anesthesia workforce compositional changes after the CRNA regulations are removed. As mentioned in Section 3.1, we stratify the data by type of service—anesthesia care or other procedures—and focus on only the hospital setting.[15] We also perform a series of re-estimations for Equation 2 that restrict to treated states changing their

[14] We exclude Alaska and Colorado from our empirics for reasons previously described. Without the 6 states that opted out in 2001 to 2002, we are left with 42 states (10 treatment, 32 control).

[15] We focus on the hospital setting because the legislation targeted hospital employment only. We have considered other settings, and there are no significant changes in the ambulatory care or physician office settings. We have additionally repeated our analyses by urbanicity and find that our results are driven by urban areas; there no major changes in the rural areas. Results are available upon request.

CRNA policy in a particular year to observe if later opt-out states differ from early opt-out states. All standard errors are clustered at the state-level throughout.

4.2. Supplementary CRNA Labor Market Outcomes

To generate supporting evidence around the effects of lowering occupational barriers, we analyze states' opt-out decisions in a separate DD framework that focuses on the labor market outcomes for CRNAs. For this component of our empirics, we classify all US states (including the District of Columbia) as either a member of the treatment or control group based on the state's response to the 2001 federal opt-out policy change. By the conclusion of our workforce data (2008), 14 states have taken advantage of the opt-out provision and hence grant full practice independence to CRNAs working in the state (Downey 2010). All other states comprise the comparison (control) group. Our "post" period includes the 2004 and 2008 survey waves from the NSSRN, making 1992 to 2000 our pre-period.[16]

We estimate the simple two-groups, two-periods DD model for all CRNAs available in our data. The specification is as follows:

$$Y_{ist} = \alpha + \beta(Relax)_{is} + \gamma(Post)_{it} + \delta(Relax \times Post)_{ist} + \varepsilon_{ist}$$

Y is the labor market outcome of interest, *Relax* is equal to one for any individual (i) in state (s) that made the CRNA policy change (i.e., the treated states), and Post is equal to one for any individual (i) in year (t) that occurs after the 2000 NSSRN survey wave (i.e., 2004 and 2008). The delta parameter recovers are DD coefficient of interest. We additionally re-estimate Equation 1 with individual level covariates as a sensitivity check and cluster all standard errors at the state level (51 clusters in total). We also provide graphical displays of each labor market outcome to assess the validity of the pre-treatment parallel trends assumption (shown in the appendix results) and use the survey provided observational weights throughout our empirics.

We also re-estimate our core models on those with 5 years or less work experience as well as those with 15 years or more experience. By separately considering these specific subgroups of workers, we can determine which, if any, members of the nursing labor force appear most responsive to the law changes.

[16] We do note that two states (SD and WI) did not officially change their CRNA policies until the second part of the post-period in our data. However, for simplicity, we consider them treated in both the 2004 and 2008 survey years.

5. Results

5.1. CRNA Procedure Output and Supply

Table 2 provides summary measures of our key outcomes and patient populations within our Medicare data across the treatment and control states. Over the study period, opt-out states tend to have less physician (MD) anesthesiologists and CRNAs and a smaller supply of services linked to these providers, on average. The patient characteristics do not markedly differ by regulation type, though opt-out states tend to have less ethnically diverse Medicare populations.

In Table 3, we display our policy estimates from our primary outcomes of interest: claim volumes for MDs and CRNA (time-based) main anesthesia care and additional anesthesia procedures, respectively. Among hospital-based anesthesia care, the estimates in Panel A are negative for MD procedures (columns 1-3) with no consistent or statistically significant change among CRNA procedures (columns 4-6). Together, the results in Panel A suggest that hospitals may have responded by simply reducing MD supervision over approximately 7% of claims, without greater or lesser use of CRNAs in anesthesia care. Columns 1-3 in Panel B do not reveal and changes in terms of other stand-alone anesthesia procedures for MDs; however, there are some positive increases in these services delivered by CRNAs (columns 5-6, Panel B). The change is a roughly 20% increase for CRNA-linked procedures, but this is from a low base and sensitive to model specification. The estimate is only half as large in the most parsimonious DD specification (column 4, Panel B).

Figure 1 plots the coefficients from our event study models (Equation 3). Plot (a) shows the change in claims among MDs. There is a slight decrease in time-based anesthesia care claims shortly after the policy implementation, with some growth in the effect over the subsequent 2.5-year interval. The pre-policy trends are relatively flat. No similar pattern is observed for other anesthesia procedures delivered by MDs. There is an increase in these services even before the policy change occurs, and none of the post-period estimates is statistically distinguishable from the omitted time point of one-year prior to the regulatory change. The CRNA pattern in Figure 1(b) shows that there is no strong pattern for time-based anesthesia claims—though there is a downward trend in the post-period estimates, albeit lacking sufficient precision. However, the pre-period event study estimates in Figure 1(b) demonstrate some trending behavior as well, which cautions against drawing firm inferences from these results. There is a more compelling pattern for other procedures belonging to CRNAs in Figure 1(b). The pre-policy estimates are

not statistically different from each other, and the point estimates are near zero. Conversely, there is a level shift at the point of policy implementation, and the effect sizes are fairly stable during the first 2.5 years following the legislative change. This increase among CRNAs does not appear to be driven by idiosyncratic noise, as a null result is obtained when assigning the treatment states a random year-quarter in which to begin treatment (see Appendix Figure A1).

Figure 2 displays the results from an identical exercise estimating changes in the number of unique anesthesia providers in the state across our two anesthesia service domains. Similar to the prior figure, only the event study estimates for CRNAs performing stand-along anesthesia procedures (Figure 2b) demonstrates a pattern that aligns reasonably well with the regulatory change. Combining the results from Figures 1 and 2 suggests that hospitals expand their use of CRNAs beyond the common type of anesthesia activity (i.e., time-based anesthesia care), but do not obviously reduce their reliance on MD anesthesiologists.

Appendix Table A1 displays the policy effect estimates for our main outcomes when we limit the treatment group to those states changing in a particular year. Each column of Table A1 corresponds to a specific year of CRNA scope of practice changes, using states that never opted out between 2001-2013 as the control group throughout. For example, the "2009" model (column 5) only has California in the treatment group since no other state changed its CRNA regulations in that year. Panel A reveals that the reduction in anesthesia care among MDs is significant in most treatment years. Panel B indicates that the observed positive but imprecise increase in MD anesthesia procedures is predominantly driven by California. While there is heterogeneity across treatment years for CRNA anesthesia output (Panel C), our strongest estimate showing that CRNAs increase their provision of other procedures is again significant across most treatment years. In all years, the policy effects generally remain modest and plausible for all individual treatment groups. Appendix Table A2 investigates changes in Medicare payments for anesthesia care. There is no evidence of a strategic response by MDs to shift toward higher reimbursing services or deliver more intensive services to increase fee-for-service payments.

5.2. Task Matching, Quality of Care, and Frictions

Table 4 explores post-policy changes in the case types and clinical settings matched to a given anesthesia provider as well as rates of anesthesia complications.[17] In Panel A of Table 4, MD anesthesiologists seem to modestly reduce their involvement in the shortest cases (namely, 30 minutes or less) and redistribute that time to more extensive cases lasting more than an hour. Such a pattern is consistent with less of their labor being allocated to supervisory roles for relatively uncomplicated cases once state law no longer requires CRNA supervision. There is also suggestive evidence in Panel C that CRNAs deliver slightly more anesthesia services within hospital inpatient settings at the expense of outpatient settings; however, the estimates are only significant at the 10% level and reflect very small changes in terms of magnitude. The rates of complications are unaltered across anesthesia provider types as well as case and setting types (Panels B and D, Table 4).

Given that we find only weak evidence of changes in hospital hiring and staffing, we turn to evidence of market heterogeneity and evaluate the impact of possible frictions that restrain larger changes. Table 5 results are from a re-estimation of our core specifications for key outcomes (Equation 2) that includes a possible explanatory covariate and the interaction of that covariate with the post-treatment dummy. We first consider the impact of the surgeon preferences via the absolute number and share of surgeons in the hospital (Panels A and B). We then move to hospital margins and market landscape by using the share of Medicaid discharges as a financial position proxy (Panel C), market competition as measured by the log Herfindahl-Hirschmann Index (HHI) for a given area (Panel D), and physician malpractice risk (Panel E). As mentioned in Section 3.1, we focus our analysis in Panels A through D to be at the zip, quarter-year level. Because we limit our analysis to zip codes with only one distinct hospital, the analysis should be interpreted as heterogeneous responses across hospitals within a state over time. Panel E is constrained to be at the state, quarter-year level due to a lack of finer grain malpractice claims information.[18]

From the opposing signs between the main effect and the interacted coefficient in Panel A, the data suggest that when a hospital relies more on local surgeons, it is simultaneously more

[17] The specifications in Tables 4 and 5 rely on Equation 2 from Section 4.1.

[18] In light of a small first-order change among CRNAs and anesthesiologists, we assume that the deregulation did not induce downstream changes in second-order hospital or market characteristics. specific characteristics are unaffected by the policy change.

reluctant to increase the use of CRNAs after deregulation. It is also less likely to reallocate anesthesiologists from shorter procedures to longer procedures. Panel B provides weaker support for this pattern by demonstrating that the share of non-anesthesiology physicians who are surgeons will also restrain the re-allocation of anesthesiologists' labor. In Appendix Table A.3, we further examine the results when a hospital has a higher share of surgeons than the median hospital. We find stronger effects where hospitals with higher shares of surgeons are less likely to adjust their use of anesthesiologists and less likely to reallocate them across tasks. In total, these panels are consistent with the tempered response to the deregulation originating with surgeon preferences for complementary provider types (i.e., anesthesiologists).

Panel C considers the share of total hospital discharges that are from Medicaid-insured patients.[19] Hospital executives often cite financial challenges from Medicaid reimbursements to be the most pressing issue facing their organizations, and Medicaid is thought to pay hospitals less than the cost of delivering some types of care (Dietsche, 2016). We find that hospitals which have higher shares of Medicaid discharges and likely thinner margins (perhaps even operating at a loss) are more likely to respond to the policy change in a manner consistent with standard theory. As a corollary, hospitals with higher profit margins and better financial positions may have the luxury of being able to take-into account non-price constraints, as opposed to focusing solely on cost minimization.

Finally, the other possible frictions we consider—hospital competition and malpractice risk—do not appear to play a role in the muted responses to deregulation. For hospital competition, we consider a continuous measure of the log Herfindahl-Hirschmann Index (HHI).[20] For malpractice risk, we utilize the number of paid malpractice claims per 100 MDs among licensed physicians.[21] The resulting interaction terms are uniformly noisy and unrevealing. There are also no effects when examining heterogeneity among those with higher than median levels of competition or malpractice risk (in Appendix Table A.3).

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[19] Share of Medicaid discharges come from the HCRIS data. We prefer this measure to hospital margins (as calculated by operating revenues and expenses) because revenues can be influenced by changes in consumer choice that arise over preferences for provider type.

[20] HHI values were calculated using data from the American Health Association (AHA) annual survey. We use the firm's share of bed in their hospital referral region (i.e., local market).

[21] Data comes from the National Practitioner Data Bank (NPDB), commonly cited as the most representative national database of malpractice occurrences (Chandra et al., 2005).

5.3. CRNA Labor Market Outcomes

Moving to our supporting analyses for CRNA labor markets, Table 6 summarizes our CRNA subsample from 1992 through 2008, again with regulatory stratification. Across the two columns, CRNAs are on average middle-aged, white, and US-trained. Table 7 provides the DD estimates from the workforce data. Column 1 suggests a large regulatory impact on the migration margin. CRNAs in states that relaxed their scope of practice are roughly 6-percentage points more likely to have moved to the state within the last year, representing a more than doubling of the CRNA labor flow to those states. We can also see in column 3 that much of this is driven by CRNAs that are relatively new to the field—and hence have more limited work experience. The results for CRNAs with longer time durations since graduation are in the positive direction but smaller in magnitude and with less precision (columns 5 and 6). However, Appendix Figure B1 shows a divergent time path in this outcome for the two groups, which cautions against any strong inference.

Panel B of Table 7 indicates a decrease in the likelihood of working in a part-time job, but such an effect is only found among the more recent training graduates (columns 3 and 4). Consistent with the prior data patterns, Panel C reveals that CRNAs are much more likely to be unmarried and without children once states grant them full practice independence. Any policy impact is again concentrated among those newer to the CRNA labor market. The trends in outcomes (Appendix Figures B2 and B3) are also more closely aligned with the DD requirements, particularly for the unmarried and without children outcome. Taken together, the results in Table 7 are at least suggestive of recently trained CRNAs being attracted to new, more appealing job opportunities in states with more favorable regulatory environments, especially among the more mobile members of the workforce (i.e., those unmarried and without dependents). These supplementary results are also supportive of the general finding from our primary data that CRNAs and their employers respond to these law changes but not in an extensive way.22

[22] We also wish to reiterate the caveat highlighted in the earlier data description section: while we can cleanly identify CRNAs in the data, they are still relatively few in number. Thus, the NSSRN data are likely best suited for supportive, rather than definitive, evidence in this context.

There is no compelling change in average CRNA wages after states' opt-out decision (Appendix Figure B4)—though the 2008 survey year is consistent with a relative improvement. But no data beyond this year is available to determine if the observed wage differential persists. Also, the repeated cross-section data cannot inform us about changes in within-worker wage trajectories, which could vary by policy environment. For example, recent graduates may flock to these more favorable states not because the initial pay is better but because the expected wage growth and promotion opportunities are superior. Such longer-run considerations for a given CRNA cannot be captured with the available data.[23]

6. Discussion

Our collection of evidence demonstrates that the regulations are at most only weakly binding for hospital behavior. Removing regulatory barriers to CRNA independence seems to increase their procedure output and the number of different CRNAs delivering these procedures, but the laws have no influence over their primary anesthesia care duties. While there is suggestive evidence that early-career CRNAs are attracted to accompanying employment opportunities after the law changes, our findings in sum point to a limited impact for anesthesia labor markets. Importantly, none of our estimates indicate a disadvantage for MD anesthesia providers. Hospitals do not shed anesthesiologists in favor of CRNAs nor do they substantively reduce their use of anesthesiologists across a wide variety of caregiving tasks after a state's opt-out decision. If anything, the limited decreases in MD anesthesia billings are likely driven by fewer side payments for supervisory roles. While it could be argued that data on non-Medicare populations will help clarify hospital labor choices, the lack of large responses among the Medicare population suggests that there will be few, if any, changes among the non-Medicare population, especially because the scope of practice deregulation was a Medicare payment-based policy change.

Beyond the observed modest changes to procedural anesthesia care, we find that hospitals' lack of policy response likely reflects at least two competing hypotheses: physician preferences and hospitals' financial health. Surgeons and anesthesia providers are key complementary inputs for hospitals. Their combined efforts generate important revenue flows

[23] We also note that re-estimating the specifications from Table 7 with individual level covariates or the generalized DD setup with state and year fixed effects produces a nearly identical pattern of results (available upon request).

and profits to the hospital that may even cross-subsidize other loss-making service lines. Hospitals' choices of anesthesia providers may be consequently determined, at least in part, by the preferences of other physicians (employed as well as non-employed). With imperfect control over input choices, hospitals would have to settle for a mix of MD and CRNA anesthesia providers, irrespective of legal statutes. While hospitals with thinner margins are more likely to choose cost-minimizing labor inputs, those with higher margins can afford to maximize over non-price considerations.

Another interpretation consistent with these findings is that the policy change has the most bite early on in regards to how CRNAs are utilized within the potentially diverse care settings pertaining to a hospital. In other words, the blending and use of both provider types in their traditional roles of delivering anesthesia for surgical cases could have been optimized over the intervening years in a way that the presence or absence of the regulatory constraint makes little productivity (or cost) difference. Such subtle shifts in hospital behavior would not portend radical changes to health care delivery or performance in the short- to medium-term.

A common policy position is that the US can no longer afford to restrain providers' productive capacity, especially if projected shortages are correct. Scope of practice laws are often framed as instruments of quality control in an industry dominated by credence goods, but many suspect regulatory capture on the part of physicians. Accordingly, advocates argue that alleviating regulatory barriers for NPCs is one of few ways to accommodate short-run increases in demand (Dower et al. 2013; Ku et al. 2015; Xue et al. 2016) and to begin lowering the costs of care more broadly (Hooker and Muchow 2015). Restrictive scope of practice also seems to run counter to the growing trend in team-based medical care (Dower et al. 2013). And while a greater mix of staff can raise coordination costs (Dobson, Pinker, and Van Horn 2009; Richards et al. 2000), it can also allow for efficient labor substitution (Cooper and Aiken 2001; Jacobson, Parker, and Coulter 1998; Ku et al. 2015; Richards et al. 2000; Richardson et al. 1998; Thurston and Libby 2002; Zeckhauser and Eliastam 1974).

With respect to anesthesia care, however, it is far from clear that CRNA restrictions are distorting labor markets and constraining hospital efficiency. Hospitals are not strongly sensitive to their removal. While changing providers' scope of practice is notoriously difficult and contentious (Iglehart 2013), the political rhetoric concerning CRNAs appears out of balance with the laws' practical implications.

Evolving views of CRNA competencies and/or financial pressures on hospitals, such as bundled payments for surgical care, may encourage greater substitution activity down the road. In fact, the preservation of CRNA restrictions—and hence associated lobbying effort—may reflect anesthesiologists' concerns about future incomes as opposed to immediate changes in demand.24 If true, then these laws can still be counterproductive for health care delivery and social welfare when taking the long view. At a minimum, they add to the regulatory burden in an industry already awash with occupational laws and can needlessly stifle hospital innovation through more flexible provider allocations and duties as well as combinations of labor inputs. High-skilled nurses might also value practice independence for its own sake, which should not be ignored without evidence that patients' health is being put at greater risk.

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[24] If CRNA training programs outpace anesthesiology programs, this could further tilt the long-run outlook in CRNAs' favor. They would be cheaper, more plentiful, and capable of independent practice.

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Table 1: Treatment States Which Opted-Out

State	Year
Iowa	December 2001
Nebraska	February 2002
Idaho	March 2002
Minnesota	April 2002
New Hampshire	June 2002
New Mexico	November 2002
Kansas	March 2003
North Dakota	October 2003
Washington	October 2003
Alaska	October 2003
Oregon	December 2003
Montana	January 2004
South Dakota	March 2005
Wisconsin	June 2005
California	July 2009
Colorado	September 2010
Kentucky	April 2012

NOTE.– Because we lack pre-treatment data, we also drop from our analysis states which changed policies in 2001 and 2002. We additionally drop Alaska, due to asymmetric coding of CRNAs in the early years of data, and Colorado, which allowed for opt-outs only among Critical Access Hospitals and specified rural hospitals.

Table 2: Summary Statistics

	Opt-Out (Treated)		Non-Opt-Out (Control)	
	Mean	SD	Mean	SD
	(1)	(2)	(3)	(4)
Main Dependent Variables				
Anesthesia Care				
MD Claims	5189.68	7006.70	7368.72	6169.93
CRNA Claims	2122.21	1708.002	5196.11	4694.07
Number MDs	597.75	868.29	596.52	540.16
Number CRNAs	265.89	168.30	614.21	574.90
Other Procedures				
MD Claims	3359.32	3627.95	4463.51	3862.18
CRNA Claims	201.39	127.39	174.63	196.31
Number MDs	411.93	532.80	446.80	387.59
Number CRNAs	68.58	41.09	70.11	76.43
Average Patient Demographics				
CCI	2.631	0.298	2.581	0.325
Male	0.447	0.024	0.444	0.024
White	0.923	0.058	0.842	0.134
Black	0.027	0.023	0.108	0.102
Hispanic	0.01	0.018	0.01	0.015
Age$\leq$40	0.026	0.007	0.028	0.008
41$\leq$Age$\leq$50	0.041	0.011	0.045	0.012
51$\leq$Age$\leq$60	0.068	0.017	0.075	0.018
61$\leq$Age$\leq$70	0.266	0.029	0.271	0.035
71$\leq$Age$\leq$80	0.364	0.039	0.358	0.042
Observations	432		1632	

NOTE.–Medicare claims data at the state, year-quarter level. CRNA = Certified Registered Nurse Anesthetist; CCI = Charlson Comorbidity Index.

Table 3: Policy Impact on the Number of Claims

	MD Claims			CRNA Claims		
	(1)	(2)	(3)	(4)	(5)	(6)
	A. Anesthesia Care					
1(Relax)	-203.9	-519.2***	-559.1***	-552.9**	-135.2	-126.3
	(209.3)	(169.1)	(175.1)	(259.7)	(102.0)	(90.42)
Observations	2,064	2,064	2,064	2,064	2,064	2,064
R-squared	0.989	0.994	0.994	0.981	0.994	0.994
Dep. Var Mean		6912.64			4552.73	
	B. Other Procedures					
1(Relax)	554.1*	281.8	217.2	17.14	38.15***	38.17**
	(306.3)	(189.4)	(180.2)	(19.71)	(13.16)	(14.20)
Observations	2,064	2,064	2,064	2,064	2,064	2,064
R-squared	0.976	0.987	0.988	0.878	0.912	0.912
Dep. Var Mean		4136.15			176.01	
Yr-Qtr + State FE	Y	Y	Y	Y	Y	Y
State-Time Trend		Y	Y		Y	Y
Demographics			Y			Y

NOTE.–Each column and panel shows estimates from separate OLS regressions. The first three columns examine the number of MD procedures performed, and the last three columns consider the number of CRNA procedures performed. Robust standard errors, clustered by state, in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Distributional Changes in Surgical Anesthesia Within MDs and CRNAs

	By Time			By Place	
	Time≤30	30<Time≤60	Time>60	Inpatient	Outpatient
	(1)	(2)	(3)	(4)	(5)
	A. Share of Claims Across MD Distribution				
1(Relax)	-0.0296**	0.00551	0.0241**	0.00950	-0.00970
	(0.0112)	(0.00529)	(0.0109)	(0.0101)	(0.0104)
Obs	2,064	2,064	2,064	2,064	2,064
Dep. Var	0.55	0.19	0.26	0.48	0.56
	B. Complications per 1,000, MDs				
1(Relax)	-0.558*	-0.0561	0.245	-0.0622	0.241
	(0.284)	(0.198)	(0.380)	(0.255)	(0.184)
Obs	2,064	2,062	1,764	2,064	2,064
Dep. Var	2.29	0.38	0.30	1.47	1.28
	C. Share of Claims Across CRNA Distribution				
1(Relax)	-0.00223	-0.00275	0.00497	0.0133*	-0.0119*
	(0.0150)	(0.00639)	(0.0165)	(0.00713)	(0.00704)
Obs	2,064	2,064	2,064	2,064	2,064
Dep. Var	0.57	0.19	0.24	0.42	0.58
	D. Complications per 1,000, CRNAs				
1(Relax)	-0.896	0.637	0.262	0.182	-0.217
	(0.898)	(0.751)	(0.940)	(0.282)	(0.194)
Obs	2,064	1,998	1,679	2,064	2,064
Dep. Var	2.49	0.52	0.94	1.83	1.41

NOTE.– Each number comes from a separate regression with year-quarter and state fixed effects, state by year time trends, and patient demographics. Columns (1) through (3) focus on services that fell within the specified buckets of time. Columns (4) and (5) consider services performed in inpatient versus outpatient settings. Panels A and C consider the share of total claims that can be categorized by the column heading. Panels B and D consider the number of major and minor complications per 1,000 claims performed, calculated as (number of complications/claims performed)*1000. Robust standard errors, clustered by state, in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Differential Effects Across Hospitals

	CRNA Claims (1)	No. of CRNAs (2)	MD Claims (3)	No. of MDs (4)	Share Time≤30 (5)	Share Time>60 (6)
	A. Number of Surgeons, N=93,392					
1(Relax)	17.00***	2.248***	0.944	-1.151	-0.0228	0.0259
	(6.076)	(0.723)	(4.940)	(0.814)	(0.0231)	(0.0215)
1(Relax)x	-1.058***	-0.141***	-0.317	0.0691	0.000732***	-0.000925***
No. Surgeons	(0.322)	(0.0436)	(0.344)	(0.0429)	(0.000155)	(0.000272)
	B. Share of Surgeons, N=93,329, N=93,329					
1(Relax)	-4.372	-0.767	-11.40*	-1.285*	-0.0284	0.0278
	(4.456)	(0.550)	(5.959)	(0.733)	(0.0286)	(0.0288)
1(Relax)x	26.65	4.426	33.65	5.708	0.0981**	-0.103***
Share Surgeon	(23.51)	(3.436)	(50.62)	(5.131)	(0.0366)	(0.0328)
	C. Share Medicaid Discharges, N=60,861					
1(Relax)	-7.881*	-1.181**	-5.360	0.454	-0.00769	0.00134
	(4.295)	(0.494)	(8.444)	(0.654)	(0.0302)	(0.0306)
1(Relax)x	54.83**	8.011***	-2.266	-4.994*	0.00363	0.0313
Share Medicaid	(20.48)	(2.877)	(31.21)	(2.555)	(0.0470)	(0.0505)
	D. Log(HHI), N=93,225					
1(Relax)	29.51	1.908	79.23	6.953	-0.00814	0.0595
	(34.56)	(4.847)	(52.19)	(6.762)	(0.0549)	(0.0592)
1(Relax)x	-4.077	-0.264	-11.84	-1.008	1.51e-05	-0.00730
Log(HHI)	(4.818)	(0.674)	(7.413)	(0.961)	(0.00574)	(0.00704)
	E. Malpractice Claims per 100 MDs, N=2,064					
1(Relax)	-192.3	-3.851	-479.0	10.97	0.00589	-0.00721
	(183.6)	(11.61)	(308.6)	(13.80)	(0.0264)	(0.0252)
1(Relax)x	43.66	4.515	-20.52	-7.913	-0.0221	0.0195
Malpractice	(72.06)	(5.809)	(113.7)	(5.139)	(0.0166)	(0.0147)
Dep. Var Mean	58.61	7.75	88.99	8.32	0.537	0.253

NOTE.–For Panels A-D, data is at the zip, year-quarter level, and the sample is limited to zips with only one hospital. Panel E is at the state, year-quarter level. The number of surgeons and the share of procedures which are surgical come from the Medicare claims data. Share discharges from Medicaid come from the HCRIS. Market concentration, calculated by HRR and based on the number of hospital beds, comes from American Hospital Association. Malpractice claims per 100 MDs come from the National Practioner Data Bank. All regressions include year-quarter and state fixed effects, state by year time trends, and patient demographics. Robust standard errors, clustered by state, in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: NSSRN Summary Statistics

	Relaxed Regulations (1)	No Change (2)
Mean Age	46.4	46.2
White	98.7%	91.8%
Foreign Educated	0.3%	1.0%
Recent Migrant to State	5.5%	4.1%
Part-Time Position	16.2%	15.3%
Unmarried with No Children	6.9%	9.4%
Mean Annual Hours	2023.4	2054.8
Mean Hourly Wage	$65.00	$61.85
Rural Practice	36.4%	15.9%
No. Respondents	522	1337

SOURCE.–National Sample Survey of Registered Nurses (NSSRN) data, restricted to CRNA respondents and survey provided analytic weights used throughout.
NOTE.–Number of respondents reflects the total CRNA observations for each state grouping in the data; however, not all respondents have complete information on all variables. Relaxed Regulation States include: AK, IA, ID, KS, MN, MT, ND, NE, NH, NM, OR, SD, WA, WI. Wages are adjusted to 2008 US dollars using the Consumer Price Index. 'Rural' is defined as practicing in a non-MSA location.

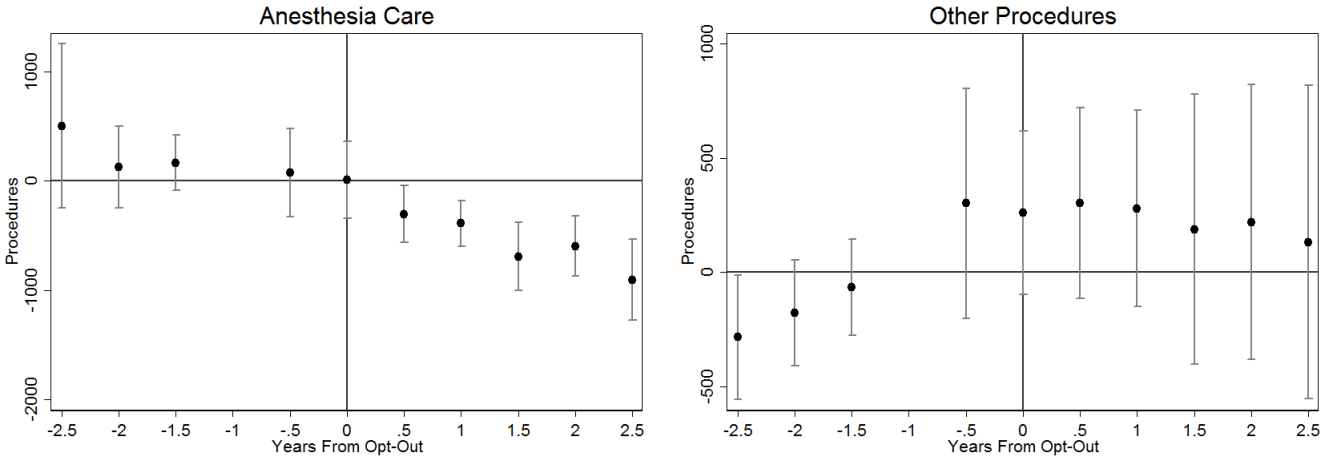
Table 7: Relaxed CRNA Regulation Effects on Worker Characteristics

	All	Women	5 Years or Less Experience	Women with 5 Years of Less	15 Year or More Experience	Women with 15 Years of More
	(1)	(2)	(3)	(4)	(5)	(6)
	A. Recent Migrant to State					
1(Relax)	0.059**	0.081*	0.207***	0.259	0.021	0.042
x 1(Post)	(0.024)	(0.045)	(0.066)	(0.166)	(0.014)	(0.031)
Observations	1809	1016	378	209	959	541
	B. Part Time Position					
1(Relax)	-0.02	0.014	-0.148***	-0.269***	-0.019	0.011
x 1(Post)	(0.069)	(0.108)	(0.051)	(0.073)	(0.082)	(0.108)
Observations	1859	1041	382	211	987	556
	C. Unmarried and Without Children					
1(Relax)	0.109***	0.194***	0.250**	0.473**	0.059	0.071
x 1(Post)	(0.035)	(0.054)	(0.108)	(0.197)	(0.041)	(0.057)
Observations	1833	1028	381	210	976	554

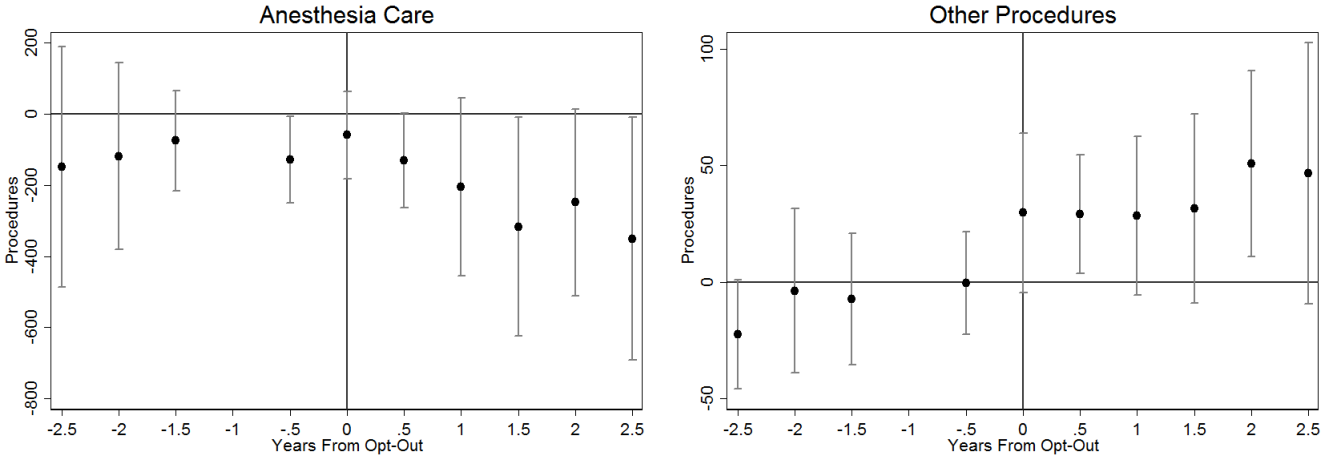
NOTE.–NSSRN analytic samples restricted to CRNA respondents and survey provided analytic weights used throughout. Robust standard errors clustered at state level. *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Number of Claims Over Time in Hospitals

(a) MD Claims



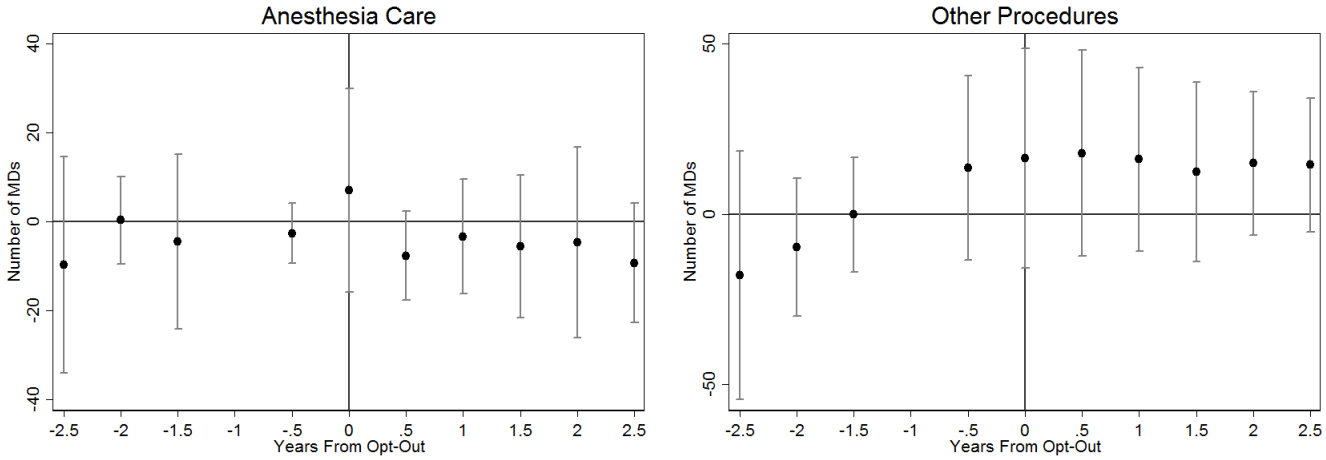
(b) CRNA Claims



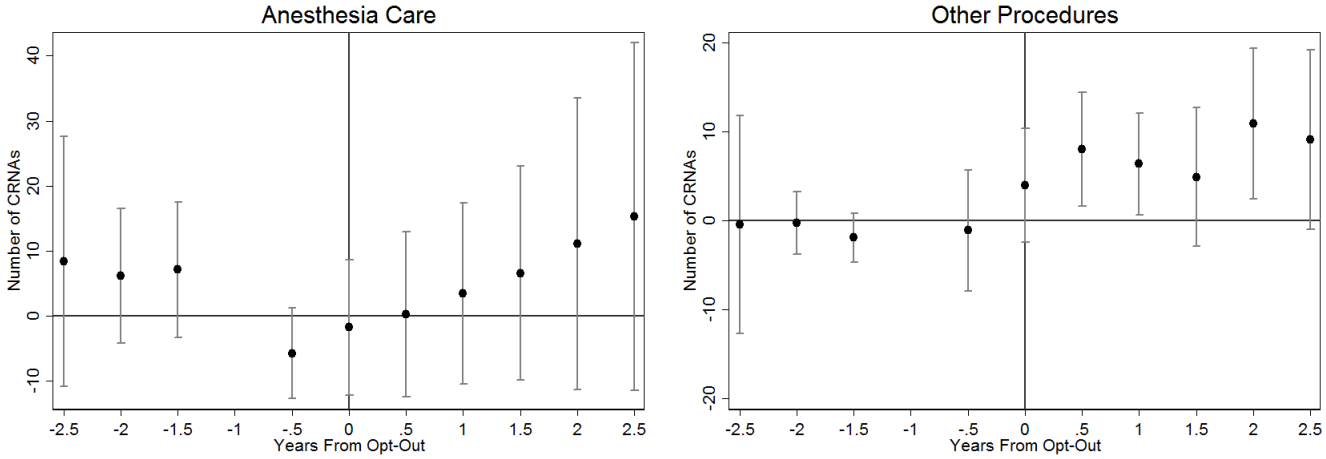
NOTE.–These plots show the OLS regression results from Equation (3), which controls for year-quarter and state fixed effects, state by year time trends, and patient demographics. The omitted reference point is one year prior to when the policy was implemented. 95% confidence intervals are shown.

Figure 2: Number of Providers Hired by the Hospital

(a) Number of MDs



(b) Number of CRNAs



NOTE.–These plots show the OLS regression results from Equation (3), which controls for year-quarter and state fixed effects, state by year time trends, and patient demographics. The omitted reference point is one year prior to when the policy was implemented. 95% confidence intervals are shown.

Online Appendix

A. Supplementary Table and Figures

Table A1: Main Results By Year of Treatment

	Treatment Group are States That Opted-Out In:					
	All	2003	2004	2005	2009	2012
	(1)	(2)	(3)	(4)	(5)	(6)
	A. Anesthesia Care Claims, MDs					
1(Post)	-559.1***	-529.7***	-523.4***	-690.9***	-1,406***	151.2
	(175.1)	(169.2)	(149.2)	(200.1)	(167.4)	(117.7)
Observations	2,064	1,824	1,680	1,728	1,680	1,680
	B. Other Procedure Claims, MDs					
1(Post)	217.2	-113.7	-139.4	382.9	1,348***	132.3
	(180.2)	(135.2)	(107.1)	(296.9)	(109.0)	(87.87)
Observations	2,064	1,824	1,680	1,728	1,680	1,680
	C. Anesthesia Care Claims, CRNAs					
1(Post)	-126.3	-142.2	-196.6**	-353.5***	472.9***	-277.1***
	(90.42)	(90.75)	(88.69)	(101.0)	(93.34)	(97.73)
Observations	2,064	1,824	1,680	1,728	1,680	1,680
	D. Other Procedure Claims, CRNAs					
1(Post)	38.17**	43.61	21.23	33.45*	33.21*	64.24***
	(14.20)	(31.10)	(13.74)	(19.71)	(19.34)	(12.63)
Observations	2,064	1,824	1,680	1,728	1,680	1,680

NOTE.– All regressions include year by quarter and state fixed effects and patient demographics. Robust standard errors, clustered by state, in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Each column includes the treated states in the specified year and control states that have never opted-out between 2001 and 2013.

Table A2: Policy Impact on Payments

	MD Procedures		CRNA Procedures	
	Log(Total Pay)	Pay per Claim	Log(Total Pay)	Pay per Claim
	(1)	(2)	(3)	(4)
	A. Anesthesia Care			
1(Relax)	-0.0378	3.890	-0.0540	-2.294
	(0.0329)	(2.870)	(0.0455)	(3.465)
Observations	2,064	2,064	2,064	2,064
Dep. Var Mean	13.37	160.42	12.65	133.52
	B. Other Procedures			
1(Relax)	0.0578	-3.723*	0.0609	0.312
	(0.0568)	(1.869)	(0.0555)	(2.945)
Observations	2,064	2,064	2,064	2,064
Dep. Var Mean	11.94	61.41	8.41	49.70

NOTE.– Each column and panel shows estimates from separate OLS regressions that include state and year fixed effects. Robust standard errors, clustered by state, in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

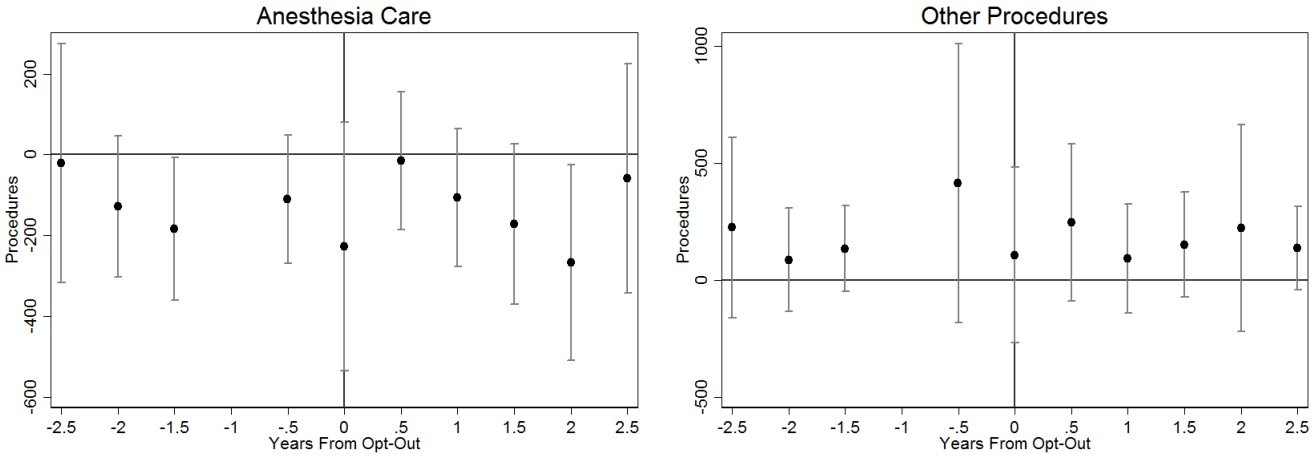
Table A3: Differential Effects Across Hospitals with Characteristics Above the Median

	CRNA Claims (1)	No. of CRNAs (2)	MD Claims (3)	No. of MDs (4)	Share Time≤30 (5)	Share Time>60 (6)
	A. Number of Surgeons>9.60), N=93,392					
1(Relax)	14.56**	1.866**	2.208	-0.822	-0.0379	0.0334
	(6.196)	(0.704)	(7.478)	(1.080)	(0.0229)	(0.0204)
1(Relax)x	-29.19***	-3.805**	-14.96	1.224	0.0459***	-0.0401***
1(Surgeons>p50)	(10.01)	(1.423)	(13.59)	(2.051)	(0.00791)	(0.0114)
	B. Share of Surgeons>0.172, N=93,329					
1(Relax)	-1.192	-0.441	-18.15***	-1.967**	-0.0167	0.0143
	(3.863)	(0.387)	(5.889)	(0.813)	(0.0268)	(0.0268)
1(Relax)x	2.690	0.836	23.37**	3.130**	0.0148*	-0.0120*
1(Share Surg.>p50)	(6.165)	(0.840)	(10.72)	(1.327)	(0.00820)	(0.00698)
	C. Share Medicaid Discharges>0.122, N=60,861					
1(Relax)	-4.773	-0.807	-11.88	-0.607	0.00519	-0.000923
	(3.872)	(0.521)	(10.79)	(1.057)	(0.0226)	(0.0257)
1(Relax)x	9.472*	1.515**	12.82	0.737	-0.0232***	0.0147**
1(Medicaid>p50)	(5.187)	(0.741)	(12.41)	(1.443)	(0.00812)	(0.00618)
	D. HHI>1960, N=93,225					
1(Relax)	0.560	0.0869	-6.745	-0.689	-0.0101	0.0140
	(3.708)	(0.419)	(6.948)	(0.674)	(0.0253)	(0.0259)
1(Relax)x	-0.342	-0.156	3.539	0.986	0.00447	-0.0145
1(HHI>p50)	(6.377)	(0.881)	(11.07)	(1.343)	(0.00848)	(0.00867)
	E. Malpractice Claims per 100 MDs>1.34), N=2,064					
1(Relax)	-90.80	4.439	-589.6***	5.494	-0.0206	0.0140
	(147.0)	(8.401)	(211.6)	(11.58)	(0.0139)	(0.0153)
1(Relax)x	-102.9	-2.635	163.2	-17.87	-0.0208	0.0234
1(Malprac>p50)	(143.5)	(11.51)	(252.6)	(12.47)	(0.0213)	(0.0190)
Dep. Var Mean	58.61	7.75	88.99	8.32	0.537	0.253

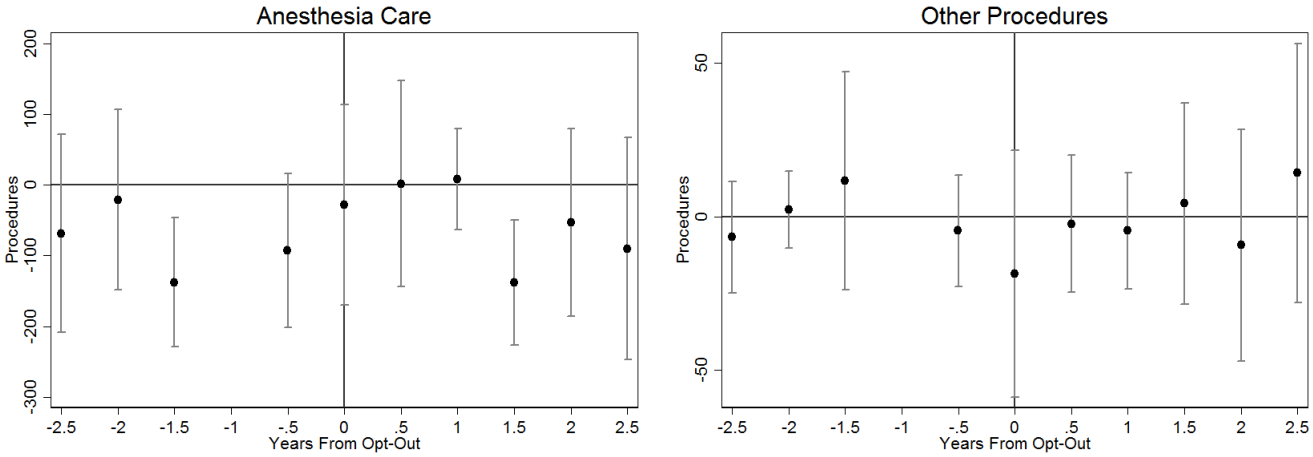
NOTE.–For Panels A-D, data is at the zip, year-quarter level, and the sample is limited to zips with only one hospital. Panel E is at the state, year-quarter level. See notes to Table 5. For each characteristic listed in the panel headings, we consider differential treatment effects when the characteristic is above the sample median. Robust standard errors, clustered by state, in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure A1: Number of Claims: Placebo Test with Randomly Assigned Treatment Date

(a) MD Claims



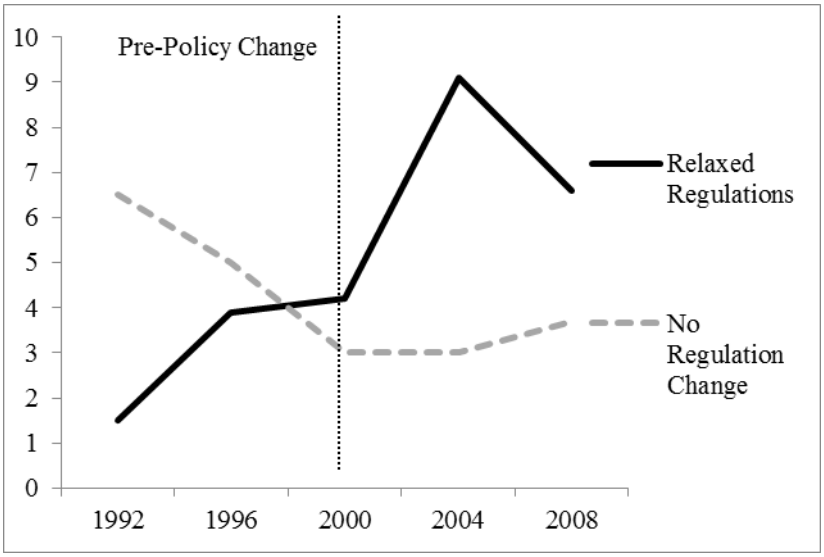
(b) CRNA Claims



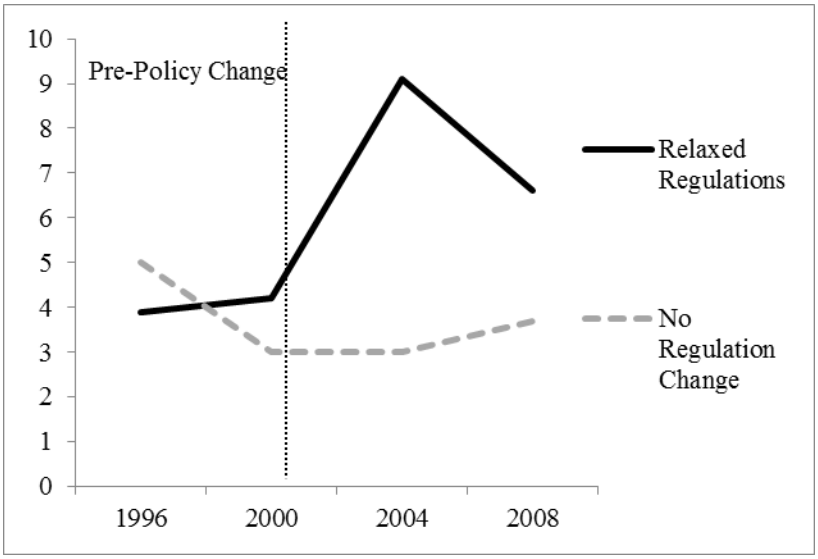
NOTE.–This figure is an analog of Figure 1 with the treatment states having randomly assigned dates of treatment, drawn from a uniform distribution.

Figure A2: Migration Outcome Over Time by Regulatory Grouping

(a) With 1992

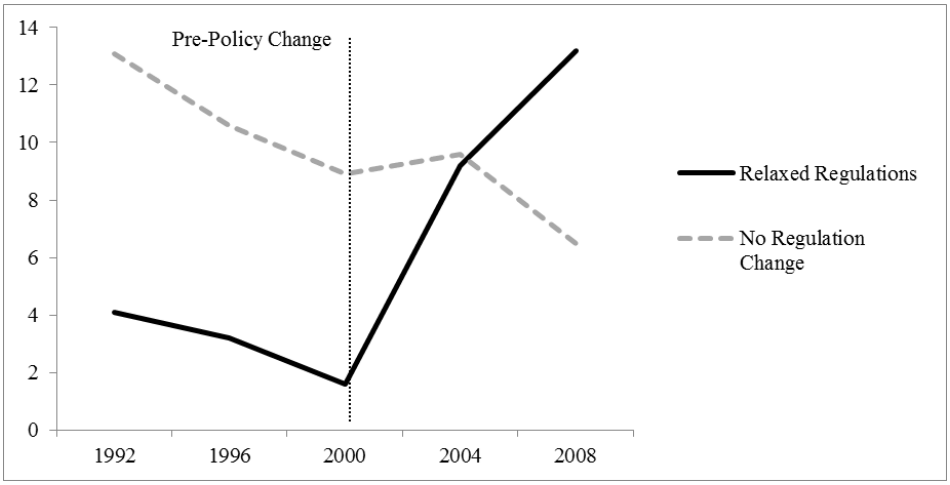


(b) Without 1992



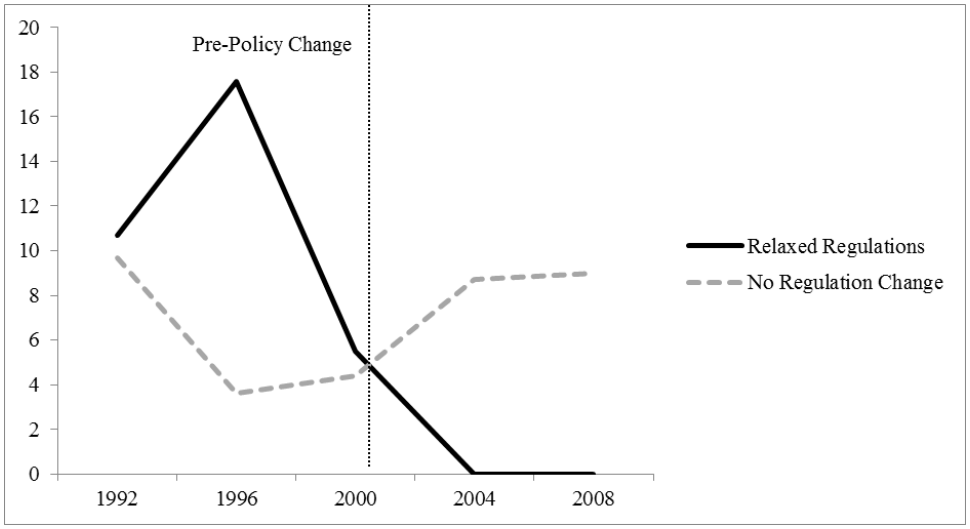
SOURCE.– NSSRN data.

Figure A3: Unmarried Without Children Outcome Over Time by Regulatory Grouping



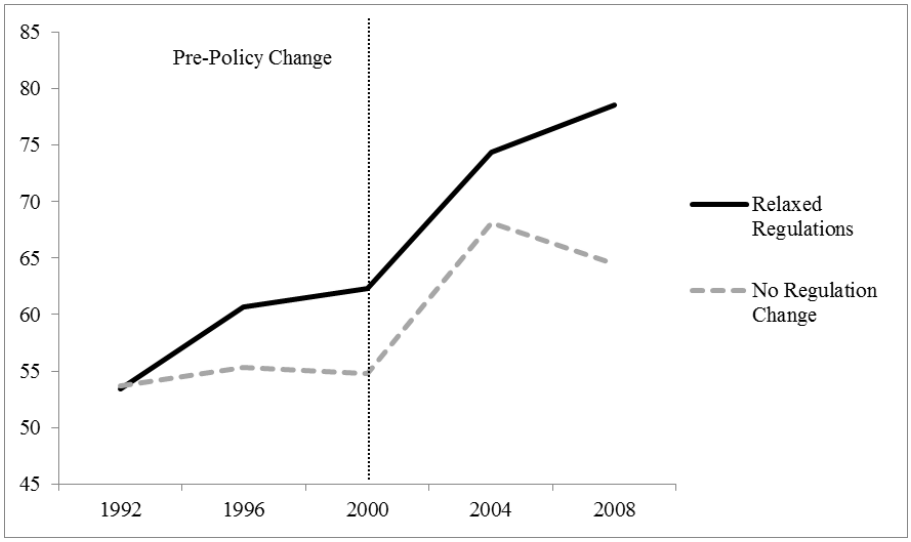
SOURCE.– NSSRN data.

Figure A4: Part-Time Position Outcome for Those With 5 Years Experience or Less Over Time by Regulatory Grouping



SOURCE.– NSSRN data.

Figure A5: Women CRNA Wage Trends Over Time by Regulatory Grouping



SOURCE.– NSSRN data.

Online Appendix

B. Anesthesia Coding

Shown in Table B.1, several different billing categories exist for anesthesia-related Medicare billing. In this paper, we focus on the change from MD performed, CRNA performed with medical supervision, or CRNA performed without supervision. Medical supervision is defined as the physician being involved in at least three of the following seven criteria: perform pre-anestheic exam and evaluation, prescribe anesthesia plan, participate in most demanding procedures, ensure performance of procedures by CRNA, monitors course of anesthesia, remains physically present, provides post-anesthesia care. When the physician provides all seven criteria, then the service can be categorized as "medical direction."

We also document the complications of anesthesia. Table B.2 shows the corresponding ICD-9 codes for complications listed by the American Society of Anesthesiologists. For general anesthesia, minor complications include nausea and vomiting, sore throat, muscle aches, itching, and hypothermia; major complications include cognitive dysfunction and malignant hyperthermia. For regional anesthesia, minor complications include headache with spinal fluid leak, minor back pain, difficulty urinating, and hematomas; major complications include pneumothorax and nerve damage causing pain. We search for corresponding ICD-9 codes that match these conditions, and we classify "minor" and "major" complications as ICD-9 codes where we can clearly identify some association with anesthesia.

Table B1: Anesthesia Service Billing

Billing Category	Physician Allowed	CRNA Allowed
MD performed	100%	N/A
Teaching	100%	N/A
Medical direction	50%	50%
Medical supervision	3 base + 1 time unit	50%
CRNA w/o supervision	N/A	100%

Table B2: Identifying Major and Minor Complications

ICD-9 Code	Description
Minor Complications	
787.0	Nausea and vomiting
339.3	Drug-induced headache, not elsewhere classified (medication overuse)
349.0	Headache following lumbar puncture
995.89	Hypothermia due to anesthesia
782.0	Disturbance of skin sensation (anesthesia of skin)
Major Complications	
995.22	Unspecified adverse event from anesthesia
995.86	Malignant hyperthermia/hyperprexia due to anesthesia
995.4	Shock due to anesthesia
968	Poisoning by other CNS depressants and anesthetics
668	Complications of the administration of anesthetic or other sedation
348.1	Anoxic brain damage
E873	Failure in dosage