

Competitive Occupational Licensure: Doctors Versus Chiropractors

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Abstract

This paper provides the first analysis of competitive occupational licensure, where substitute professions maintain separate licensing boards that set entry requirements strategically. I develop a model where professional organizations choose licensing stringency to maximize industry profits while accounting for competitive responses, as workers with heterogeneous abilities select occupations based on expected returns and consumers observe only average quality within each profession. Testing this theory using historical competition between medical doctors (MDs) and chiropractors (DCs) from 1907-1960, I exploit digitized American Medical Association records and state-by-year variation in chiropractic board adoption to show that medical boards responded strategically by increasing college requirements by 10 percentage points, mandating internships (10+ percentage points), and reducing pass rates by 5 percentage points. These regulatory changes generated substantial economic effects: doctors experienced 26% higher home values while their numbers declined by 17-40 practitioners per 100,000 population, and chiropractors saw 44% higher home values with increased market presence. The evidence demonstrates that licensing policy cannot be evaluated in isolation when competitive responses reshape entire markets.

Acknowledgements

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Any remaining errors are my own.

1 Introduction

The study of occupational licensure goes back to Adam Smith, but existing analyses tend to assume occupational licensing has only one board per broad occupation ([Leland, 1979](#); [Shapiro, 1986](#); [Plemmons and Timmons, 2023](#); [Shaked and Sutton, 1981](#); [Blair and Chung, 2021](#); [Kleiner and Soltas, 2023](#)). There are many examples of sets of near-substitute professions that have separate licensing boards, such as architects and structural engineers, social workers and psychologists, optometrists and ophthalmologists, among others. As occupational licensing becomes more common ([Carollo et al., 2022](#)), there will likely be an increase in such occurrences. Using reduced-form empirical analysis, I show that we should account for competition between occupational licensing boards.

I start by modeling worker and consumer behavior in professional licensing markets. Licensing stringency, set by professional organizations, acts as a barrier to entry and influences both labor quality and quantity. Consumers observe only average quality within each profession, creating a potential asymmetric information problem, as in [Akerlof \(1970\)](#), and allowing for an upward-sloping demand curve as in [Wilson \(1979\)](#). Workers, who differ in ability as in [Larsen et al. \(2022\)](#), decide whether to enter a profession based on expected

profit, entry costs, and personal preferences; both worker and consumer decisions are represented using a multinomial logit structure, which ensures non-zero, continuous supply and demand. Professional organizations choose licensing requirements strategically to maximize total profession-wide profit, taking into account competitive responses. The equilibrium entry costs chosen by the professional organizations regulate market access and shape the average quality of services provided.

I next simulate my model and show that allowing boards to compete can be welfare-increasing compared to having only one board. The competing professions may adopt a separating equilibrium. This equilibrium better ameliorates the asymmetric information problem by allowing consumers to choose between tiered options and by preventing monopolistic distortions.

To support my theoretical findings, I study the competition between doctors (MDs) and chiropractors (DCs) in the early 20th century. While some may not view chiropractors and doctors as close substitutes in the current context, it is much easier to argue that these professions were substitutes in the past. Both professions aimed to address all health issues during this period, and both campaigned against each other. At a minimum, these professions believed consumers might see them as substitutes.

To estimate the response from medical boards to chiropractic boards, I digitize records from the American Medical Association to measure the stringency of licensure. From 1907 to 1960, the American Medical Association released licensure statistics reports that include the years when state medical boards adopted more restrictive policies, such as requiring two years of medical school or requiring a doctor to complete an internship year. Additionally, I can identify the board passage rate of graduates from each medical school in each state for each year. This allows me to control for selection into medical schools, isolating shifts in the difficulty of board restrictions.

State medical boards increased barriers to entry around the same time as a chiropractic board was established. Using a stacked event study design ([Cengiz et al., 2019](#)), I show that state medical boards become more likely to require more years of college prior to medical

school. The probability of requiring two years of college increases by approximately 10 percentage points immediately following chiropractic board adoption. State medical boards are also more likely to require an internship year after medical school (with effects building gradually to just over 10 percentage points). Conditional on medical school quality, candidates seeking licensure failed more frequently, with passage rates declining by approximately 5 percentage points in treated states.

My findings suggest that the shift in medical board policy affected the selection and profitability of doctors. Using complete count census data ([Ruggles et al., 2024](#)), I show that following chiropractic board adoption, doctors experience a 26% increase in home values and a 4.4 percentage point increase in home ownership probability. Educational attainment among doctors increases by two years, while doctor prevalence declines by 17 practitioners per 100,000 population using fixed effects estimation and by 40 practitioners per 100,000 using instrumental variables estimation.

The establishment of a chiropractic board also impacted the selection and profitability of chiropractors. Chiropractors experience a 44% increase in home values and an 18.6 percentage point increase in home ownership probability. Educational attainment among chiropractors increases substantially by 0.6 years. Chiropractor prevalence increases by two practitioners per 100,000 using fixed effects estimation and by 12 per 100,000 using instrumental variables estimation.

To validate these findings, I examine similar non-health professions (Electrical Engineers, Civil Engineers, Librarians, Mechanical Engineers, and Government Officials) as a control group. These professions show markedly different responses: following chiropractic board adoption, they experience smaller increases in home values and home ownership, with no significant change in educational attainment and no evidence of supply effects.

I estimate the impact on chiropractic prevalence using a natural extension of the jackknife instrumental variable estimation strategy ([Angrist et al., 1999](#)) that should be usable in other contexts. I use the characteristics of other counties in a state as an instrument for the policy adopted within a specific county. To avoid spatial correlation violating the exclusion

restriction, I control for the characteristics of the counties that surround my county of interest. This strategy produces large F statistics (ranging from 338 to 699, well above conventional thresholds) and passes an over-identification test (Sargan test p-values of 1).

This paper is the first to consider competitive occupational licensure. Multiple papers examine what happens when scope of practice limits competition between professions ([Perry, 2009](#); [Kleiner et al., 2016](#); [Cai and Kleiner, 2020](#)). This research demonstrates that without these restrictions, there could be competition between professions. We need to understand what happens when they can compete.

The empirical context demonstrates the potential importance of competitive occupational licensure. The Flexner Report was a 1910 comprehensive evaluation of medical schools that led to widespread closures of low-quality institutions. Scholars traditionally view this report as an exogenous reform driven by scientific advancement and public interest. Recent work has demonstrated that changes associated with the Flexner Report led to substantial effects on mortality and other health outcomes ([Andrews, 2021](#); [Clay et al., 2025](#)), though these reforms also contributed to rural physician shortages ([Moehling et al., 2020](#)). The reforms occurred during a period when stricter physician licensing laws and improved medical education were contributing to broader mortality improvements ([Haines, 2001](#)).

However, my findings suggest these reforms may have been endogenous strategic responses to competitive threats from alternative practitioners like chiropractors. The timing of medical board policy changes around chiropractic licensing adoption indicates that established medical professionals used quality standardization as a competitive weapon rather than purely pursuing public welfare.

My evidence reframes the Flexner reforms not as exogenous shocks to medical markets, but as outcomes of the competitive dynamics between medical professions that my model predicts. Understanding these reforms as strategic responses rather than exogenous improvements has important implications for evaluating their welfare effects and understanding the political economy of professional regulation.

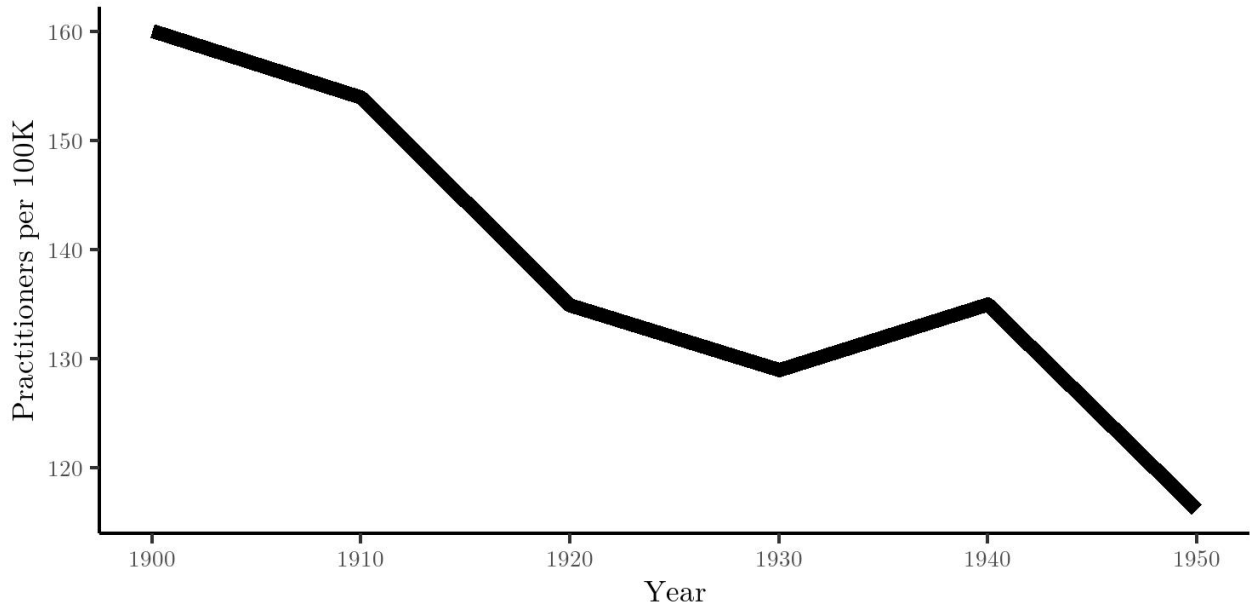
2 Context

2.1 The Medical Profession in the Early 20th Century

The medical profession in the early 20th century was undergoing a significant transformation, but remained underdeveloped by modern standards. Although germ theory was increasingly accepted by the late 19th century, medical training in the United States lagged behind global standards. The profession faced substantial changes following the landmark 1910 report by Abraham Flexner, which led to sharply rising education standards. Medical boards began requiring more extensive education and hands-on training through internships. This transformation was dramatic: the number of MD-granting institutions dropped from 160 in 1904 to 85 in 1920, and just 66 by 1935.

Despite these improvements, major medical breakthroughs such as the discovery of penicillin (1928), the structure of DNA (1953), and the introduction of the polio vaccine (1955) were still decades away. Nationally, the prevalence of physicians actually declined during the first half of the 20th century, with this long decline plateauing briefly but largely continuing throughout the period (Figure 1).

Figure 1: National Prevalence of Doctors Over Time



Data from IPUMS.

The high status of the medical profession is reflected in various socioeconomic indicators. Physicians consistently rank among the most prestigious occupations in American society, leading in educational attainment and maintaining substantial economic advantages over other healthcare professions. This elevated status would become a key factor in the medical establishment's resistance to alternative practitioners like chiropractors.

Table 1: Socioeconomic Status Indicators for Physicians and Chiropractors

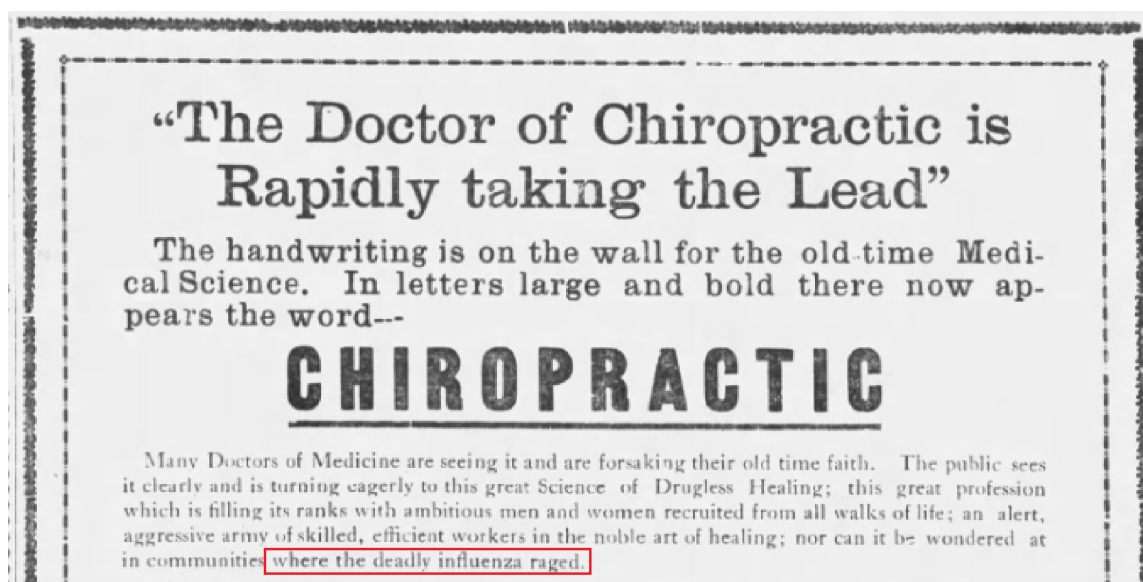
Occupation	Educational Attainment		Home Value		Home Ownership	
	Years	Rank	Value (\$)	Rank	Rate	Rank
Doctors	16.39	1/223	8,378	4/223	0.554	15/223
Chiropractors	13.63	21/223	4,728	54/223	0.509	35/223

Note: Data from IPUMS. Ranks are relative to other occupational codes. All data is from the 1940 complete count census.

2.2 The Chiropractic Profession and Its Development

Chiropractic emerged as a distinct profession in 1895, initially taking root in the Midwest before spreading across the United States. Chiropractors claimed the superiority of their philosophy and practice, asserting that their manual adjustments could address a wide range of ailments, including influenza (see Figure 2). Some chiropractic methods, particularly spinal manipulative therapy, do show evidence of benefit for lower back pain even by modern standards (Paige et al., 2017).

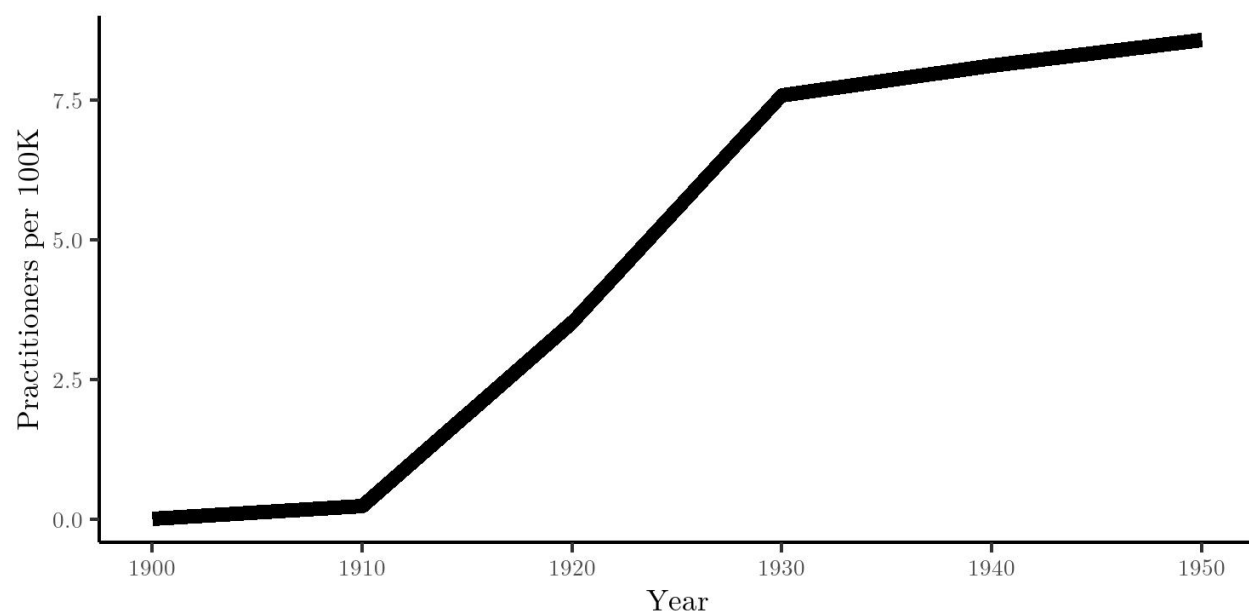
Figure 2: Chiropractors Claimed to Be Able to Heal a Broad Range of Ailments



Printed July 8, 1921 in The Lahoma Sun on page 6. Accessed via Newspapers.com

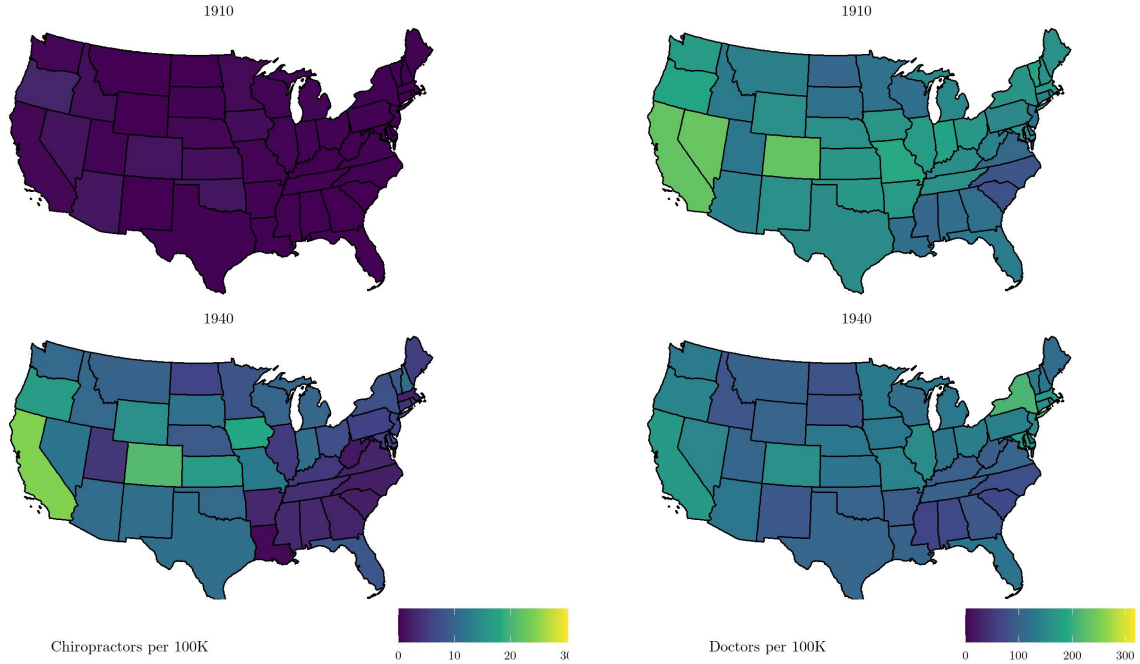
The profession expanded rapidly until around 1930, when it entered a prolonged plateau before resuming growth in the 1970s (Figure 3). Today, there are approximately 29 chiropractors per 100,000 people, according to the Federation of Chiropractic Licensing Boards. Geographically, while chiropractic eventually became well-represented on the West Coast, it struggled to gain widespread acceptance in the Northeast and South (Figure 4).

Figure 3: National Chiropractic Prevalence Over Time



Data from IPUMS.

Figure 4: Prevalence by State



Data from IPUMS. Scales are the same within a profession, but different across professions.

The professional status differences between chiropractors and physicians in the early 20th century are evident in their educational backgrounds and economic outcomes. Chiropractors consistently ranked below physicians across key socioeconomic indicators, but still bore similarities to other skilled professions. Analysis of Mahalanobis distances (Table 2) in average home-ownership, home values, and educational attainment reveals that chiropractors, share similar characteristics with other healthcare professionals and educators, while physicians share characteristics with elite professional occupations.

2.3 The Evolution of Occupational Licensing

By the end of the 19th century, medical licensing statutes had been enacted across nearly every U.S. state, with the main exceptions being Kansas (which established an examining board in 1901), Oklahoma (1903), and Alaska (1913). These laws often targeted alternative

Table 2: Mahalanobis Distance Rankings by Occupation Category

Average Distance			Chiropractor Distance			Doctor Distance		
Rank	Occupation	Distance	Rank	Occupation	Distance	Rank	Occupation	Distance
1	Osteopaths	2.343	1	Librarians	0.220	1	Lawyers and judges	0.518
2	Optometrists	2.373	2	Pharmacists	0.295	2	Engineers, mechanical	1.903
3	Dentists	2.428	3	Officials	1.121	3	Engineers, electrical	2.150
4	Engineers, electrical	2.449	4	Osteopaths	1.226	4	Dentists	2.476
5	Engineers, civil	2.786	5	Teachers	1.356	5	Engineers, chemical	2.616
6	Chemists	3.350	6	Bookkeepers	1.407	6	Optometrists	3.185
7	Librarians	3.420	7	Chemists	1.419	7	Engineers, industrial	3.393
8	Pharmacists	3.632	8	Draftsmen	1.422	8	Osteopaths	3.459
9	Engineers, mechanical	3.685	9	Optometrists	1.560	9	Engineers, civil	3.920
10	Officials	3.791	10	Apprentice electricians	1.649	10	Architects	4.026

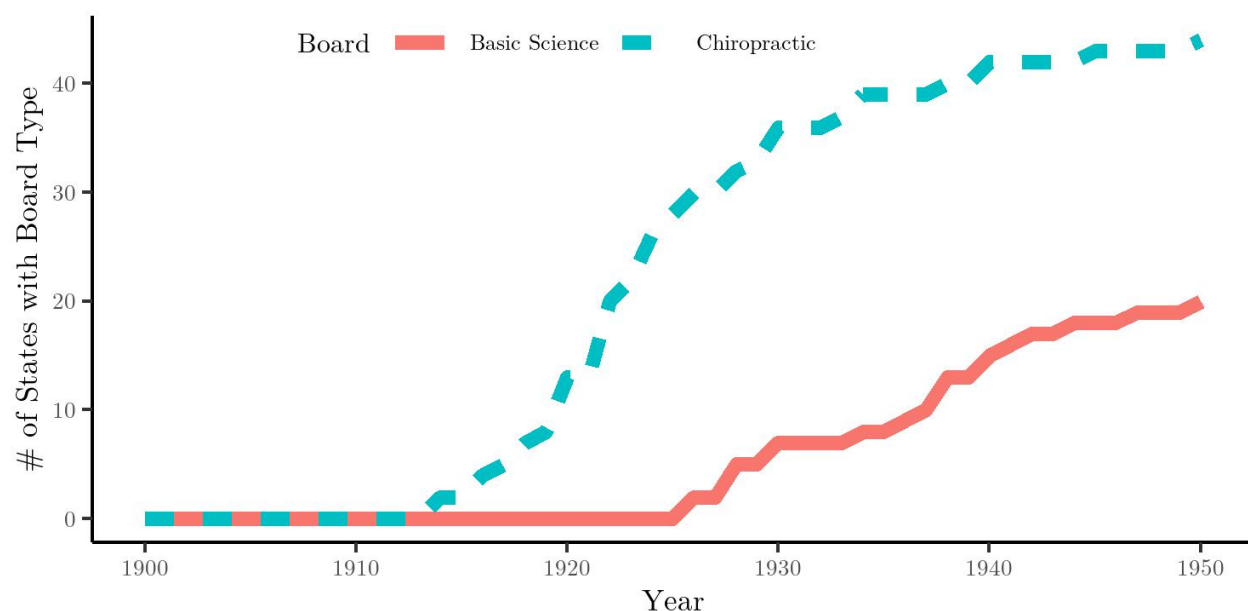
Note: Data from IPUMS. Distance is the Mahalanobis distance between the average values for the indicated profession and the profession of interest across home value, home ownership and years of education. All data is from the 1940 complete count census.

practitioners and gave the medical establishment significant regulatory power.

Early chiropractors were routinely prosecuted for practicing medicine without a license. D.D. Palmer, the founder of chiropractic, spent 23 days in jail in 1906 for such a charge. Ironically, these prosecutions may have helped the profession grow, as chiropractors often portrayed themselves as persecuted visionaries, using the legal system to build political support and public sympathy.

Kansas became the first state to establish a chiropractic licensing board in 1913. By 1929, 36 states had followed suit, and all 50 states had chiropractic licensing boards by 1973 (Figure 5).

Figure 5: Number of States with a Board Over Time



Chiropractic licensure data are from Keating et al., (2004). Medical board requirements are collected from annual licensure statistics reported in the Journal of the American Medical Association.

Concurrent with the development of chiropractic licensing boards was another important regulatory innovation: the basic science board. Beginning in 1925 with Connecticut and Wisconsin, these boards required candidates for both chiropractic and medical licensure to pass an additional exam in “basic scientific subjects”. These boards typically consisted of doctors, so the subjects more closely mirrored those taught in medical school. By 1959, a total of 24 states had implemented such boards, essentially giving physicians substantial influence over entry into the chiropractic profession.

The introduction of basic science boards is an important confounding factor in analyzing the impact of an independent licensing board. Chiropractors performed poorly on these basic science exams. In 1932, out of 23 chiropractors tested across seven states, only five passed, compared to 590 out of 657 MDs. By 1952, 195 chiropractors sat for basic science board exams across 21 states, but only 68 passed. In contrast, 2,870 out of 3,263 medical professionals passed that same year. These exams have been frequently cited as a key reason

for the stalled growth of the chiropractic profession between 1930 and 1970 ([Keating et al., 2004](#)).

2.4 The Relationship Between Medical Doctors and Chiropractors

In the early 20th century, competition between chiropractors and physicians was both direct and intense. Chiropractors were legally restricted from administering many of the treatments that doctors could offer. However, consumers may not have fully understood these limitations. Patients typically lacked both the information to choose the most effective provider and the ability to evaluate whether a treatment worked, since the counterfactual outcome was unobservable. Furthermore, the difference in treatment outcomes between doctors and chiropractors was likely narrower in the early 20th century than it is today, given the underdeveloped state of medical practice at the time.

Chiropractors briefly gained limited recognition from mainstream institutions. For example, chiropractic students were granted observing privileges at Cook County Hospital in Chicago. These privileges were later revoked after the students repeatedly disrupted surgeries by shouting, "Have you tried chiropractic?" to patients in the operating room ([Keating et al., 2004](#)).

Physicians, in turn, viewed chiropractors with deep skepticism and often outright hostility. At a meeting of the American Medical Association (AMA), Doyl Taylor declared, "Since the birth of chiropractic in 1895, the AMA has considered chiropractic an unscientific cult whose practitioners are not qualified to diagnose and treat human illness." He went on to say that chiropractic had not produced "a single shred of scientific proof" for its foundational hypothesis, that spinal subluxations cause human disease and can be cured through spinal adjustment ([Johnson and Green, 2021](#)).

As early as 1914, an article in the Journal of the American Medical Association declared chiropractic to be "the sheerest kind of quackery," practiced by individuals with little formal education and no understanding of basic science ([10., 1914](#)). Beyond disparaging chiropractic

publicly, the AMA took active steps to suppress its growth. The association barred its members from teaching at chiropractic colleges or attending chiropractic conferences. It also created a dedicated Committee on Quackery that lobbied against chiropractic practice. This committee even partnered with the syndicated advice column Ask Ann Landers to spread negative messages about chiropractors ([Johnson and Green, 2021](#)).

These efforts ultimately ran afoul of antitrust law. In the case *Wilk v. American Medical Association*, the courts ruled that the AMA had violated antitrust statutes by organizing a boycott against chiropractors and prohibiting its members from referring patients to them. Notably, the key evidence in the trial came from infiltrators associated with the Church of Scientology, which had also been targeted by the Committee on Quackery. These individuals leaked internal AMA documents to the Washington Post under the pseudonym "Sore Throat."

In recent years, the AMA has softened its stance. Today, it is possible, though not always easy, for a medical doctor to refer a patient to a chiropractor, in much the same way a referral might be made to a physical therapist.

3 Theoretical Model

It can be difficult to build an intuition about what to expect in competitive occupational licensure, so I develop a model to help understand the dynamics at play.

The model of competitive occupational licensing is a sequential game with three key features: (1) licensing serves as a barrier to entry, (2) it may benefit consumers, and (3) professional organizations have well-defined objectives. For simplicity, I refer to an *exterior game* where professional organizations set licensing requirements, followed by an *interior market* where workers and consumers make utility-maximizing choices among professions. I use this model to perform equilibrium analysis and structural estimation.

3.1 Timing

The game proceeds in five stages:

1. **Stage 1:** Professional organization 1 (doctors) sets entry cost s_1 .
2. **Stage 2:** Professional organization 2 (chiropractors) observes s_1 and sets entry cost s_2 .
3. **Stage 3:** A Walrasian auctioneer sets prices (P_1, P_2) to clear markets.
4. **Stage 4:** Workers observe (s_1, s_2) and prices (P_1, P_2) and choose professions and hours (h_1, h_2) .
5. **Stage 5:** Consumers observe prices (P_1, P_2) and choose services.

Stages 3-5 constitute the *interior economy*. I solve the game by backward induction, first characterizing the interior market equilibrium for any given (s_1, s_2) , then solving for the optimal licensing choices.

3.2 Interior Economy (Stages 3-5)

Consider a production economy with two types of agents and a single service market that clears via a Walrasian auctioneer. Within the market, there are two professional services indexed by $i \in \{1, 2\}$ and an outside option.

Agents

- **Consumers:** A continuum of consumers indexed by $c \in [0, m]$, where m is the market size. Each consumer has a unit demand for a professional service or the option to abstain. Heterogeneous tastes are modeled via profession-specific utility shocks.
- **Workers:** A continuum of workers indexed by $pr \in [0, l]$, where l is the labor force size. Each worker is endowed with labor and heterogeneous preferences over professions. Workers vary in ability q_{pr} and face profession-specific utility shocks. Each worker who enters profession i optimally chooses hours h_i to maximize profit.

Optimal Hours Choice Each practitioner in profession i chooses hours to maximize profit:

$$\max_{h_i} \pi_i = P_i h_i - \gamma h_i^2 \quad (1)$$

The first-order condition yields optimal hours:

$$h_i^* = \frac{P_i}{2\gamma} \quad (2)$$

and maximized profit:

$$\pi_i^* = \frac{P_i^2}{4\gamma} \quad (3)$$

Worker Payoffs A worker pr with ability q_{pr} derives utility from entering profession i as:

$$V_{i,pr} = a\pi_i^* - b\frac{s_i}{q_{pr}} - cq_{pr} + \mu_i + \varepsilon_{i,pr} \quad (4)$$

where π_i^* is the equilibrium profit, s_i is the entry cost, μ_i is the common profession-specific taste, and $\varepsilon_{i,pr} \sim \text{Extreme Value}$ is the idiosyncratic shock. This matches the intuition that workers want to earn a profit, while the cost imposed by the board is decreasing in ability, but the worker's outside option is also increasing in ability. μ_i reflects non-compensatory or regulatory features that may make a profession more or less appealing to workers. Because I have included the earnings from the outside option in the payoff from entering either profession, I assume the remaining utility from choosing the outside option is 0.

The choice probability is:

$$\mathbb{P}(\text{choose } i | q_{pr}) = \frac{e^{\bar{V}_i(q_{pr})}}{1 + e^{\bar{V}_1(q_{pr})} + e^{\bar{V}_2(q_{pr})}} \quad (5)$$

with $\bar{V}_i(q_{pr}) = a\pi_i - b\frac{s_i}{q_{pr}} - cq_{pr} + \mu_i$.

From this setup, labor quantity supplied and labor quality are determined by the equilibrium prices.

Consumer Preferences Consumer c receives utility from profession i :

$$U_{ic} = \alpha \bar{q}_i - \beta P_i + \psi_i + \epsilon_{ic} \quad (6)$$

where $\bar{q}_i$ is average quality, P_i the price, ψ_i is the average non-varying taste for a profession, and $\epsilon_{ic} \sim \text{Extreme Value}$ are idiosyncratic differences between consumer's tastes. This follows the logic that consumers want high-quality service, but dislike paying a high price. Consumers receive a utility of 0 when choosing the outside option.

Choice probabilities follow:

$$\mathbb{P}(\text{choose } i) = \frac{e^{\bar{U}_i}}{1 + e^{\bar{U}_1} + e^{\bar{U}_2}} \quad (7)$$

with $\bar{U}_i = \alpha \bar{q}_i - \beta P_i + \psi_i$.

Labor Supply The number of workers (n) entering profession i is:

$$n_i = l \int_0^\infty \frac{e^{\bar{V}_i(q_{pr})} f(q_{pr})}{1 + e^{\bar{V}_1(q_{pr})} + e^{\bar{V}_2(q_{pr})}} dq_{pr} \quad (8)$$

where $f(q_{pr})$ is the log-normal density.

Service Market Clearing Market clearing occurs when:

$$n_i h_i^* = m \frac{e^{\bar{U}_i}}{1 + e^{\bar{U}_1} + e^{\bar{U}_2}} \quad (9)$$

Substituting optimal hours:

$$n_i \frac{P_i}{2\gamma} = m \frac{e^{\bar{U}_i}}{1 + e^{\bar{U}_1} + e^{\bar{U}_2}} \quad (10)$$

with the left side as aggregate supply (number of workers times optimal hours worked per worker) and the right side as aggregate demand.

Quality Formation Average quality in profession i :

$$\bar{q}_i = \frac{l}{n_i} \int_0^\infty \frac{e^{\bar{V}_i(q_{pr})} f(q_{pr}) q_{pr}}{1 + e^{\bar{V}_1(q_{pr})} + e^{\bar{V}_2(q_{pr})}} dq_{pr} \quad (11)$$

When entry costs are higher, the average ability of workers generally increases, but if profit stays the same, fewer workers enter the profession. This creates a tradeoff between having more workers and having more capable workers in the profession.

Interior Market Equilibrium A *Walrasian equilibrium* is a collection of prices (P_1, P_2) , quantities (n_1, n_2) , hours (h_1^*, h_2^*) , and qualities $(\bar{q}_1, \bar{q}_2)$ such that:

1. Practitioners optimize hours given prices: $h_i^* = \frac{P_i}{2\gamma}$.
2. Workers optimize profession choice given prices and optimal profit.
3. Consumers optimize utility given prices.
4. The service market clears for both professions.
5. Qualities $\bar{q}_i$ are consistent with the selection mechanism implied by worker choice.

Result:

Proposition 1 (Interior Market Equilibrium). *Under the baseline model assumptions, there exists a Walrasian equilibrium for any given entry costs (s_1, s_2) . With specific parameter values, uniqueness can be verified by checking for a contraction mapping.*

For the formal existence proof, see Appendix [A](#).

3.3 Exterior Game (Stages 1-2)

Agents Each profession i has a representative organization that sets s_i to maximize total profession-wide profit. Profession 1 (the doctors) moves first in Stage 1; Profession 2 (the chiropractors) responds in Stage 2.

Payoffs It is unclear how to model the objective function of organizations that set licensing stringency. This parallels the classic Ross-Dunlop discussion regarding labor union decision-making (Kaufman, 2002). In my primary model, I adopt an "economic model" framework, assuming that licensing organizations seek to maximize total earnings within the profession. However, I will also examine alternative decision-making models to provide a more comprehensive analysis.

Organization i maximizes:

$$\text{Payoff}_i = n_i \pi_i \tag{12}$$

This reflects the idea that professional organizations derive revenue from serving practitioners.¹ I assume that the actual cost to practitioners associated with functioning of the professional organization is sufficiently small such that it does not impact the choice of profession for workers.²

Exterior Game Equilibrium I focus on subgame-perfect equilibria. A subgame-perfect equilibrium is a pair (s_1^*, s_2^*) such that neither organization wishes to change its entry cost, given the other's choice and the sequential nature of the game.

4 Simulations

Closed-form solutions to the model are analytically intractable due to the nonlinearity of the equilibrium conditions and the presence of multidimensional heterogeneity. To study the model's implications, I simulate equilibria under a range of parameter values. The goal is not to estimate structural primitives, but rather to generate comparative statics that clarify the theoretical mechanisms at play and motivate subsequent empirical analysis.

I calibrate the model to a stylized setting where two professions compete in a horizontally

¹A common suggestion is that a licensing board may be maximizing average profit, but in a one-generation model, this leads to unrealistic degenerate outcomes with infinitesimally small, high-quality professions.

²Alternatively, it could be considered part of the coefficient a .

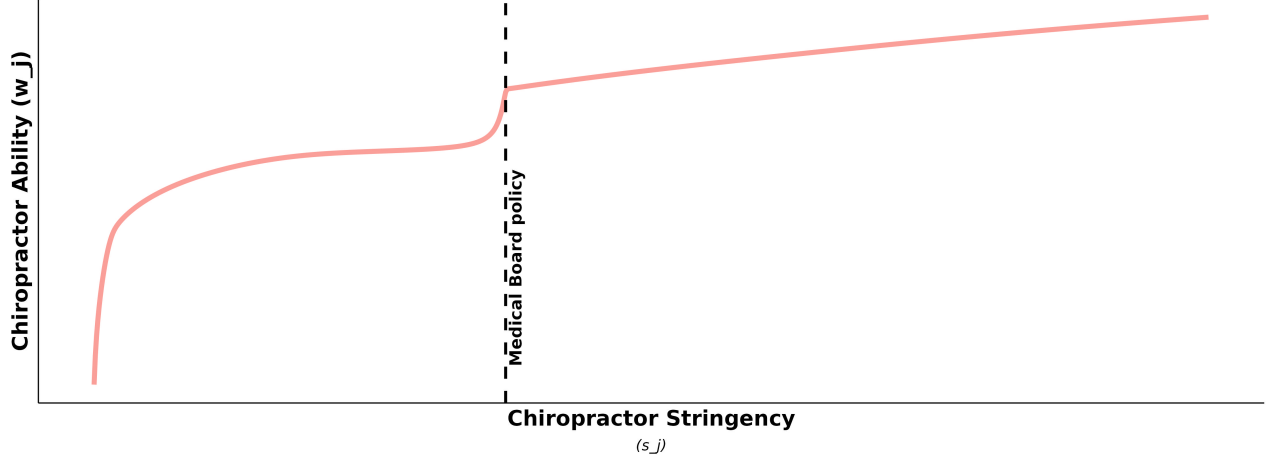
differentiated service market. The parameter values are chosen primarily to normalize the model and ensure that all relevant economic behavior can be clearly visualized in the simulation plots. I assume the practitioner hourly cost parameter $\gamma = 1$. I set price sensitivity (α) to 1.1. I normalize quality sensitivity (β), and practitioner productivity (a and b) to 1. Entry costs are fixed at $\psi_1 = \psi_2 = -10$, and nonpecuniary earnings shocks are set to zero ($\mu_1 = \mu_2 = 0$). Practitioner ability is drawn from a log-normal distribution, $q_{pr} \sim \text{LogNormal}(0, 1)$.

These parameter choices keep values close to unity wherever possible while ensuring that the full range of strategic interactions and equilibrium outcomes are observable in the simulations. The qualitative patterns and theoretical insights remain robust across different parameter specifications, so the particular numerical values do not materially affect the key takeaways from the analysis.

Each figure below shows how equilibrium outcomes change as one profession's licensing stringency increases, holding the other profession's stringency constant. The vertical line in each figure indicates the stringency level chosen by the doctor profession. The key insight is that licensing policy affects not only the size of the profession, but also its quality composition, price, entry dynamics, and spillover effects on competing professions.

Quality Sorting and Entry. Figure 6 shows how average chiropractic quality evolves as licensing requirements become more stringent. Higher stringency increases the cost of entry, thereby screening out lower-ability applicants. As a result, average quality rises. This is a standard selection effect: when entry becomes more difficult, only individuals with high enough expected returns will self-select into the profession. These are usually those with higher ability.

Figure 6: Quality Rises with Stringency; Acceleration As Surpassing Rival Board
Chiropractic Quality by Chiropractic Stringency

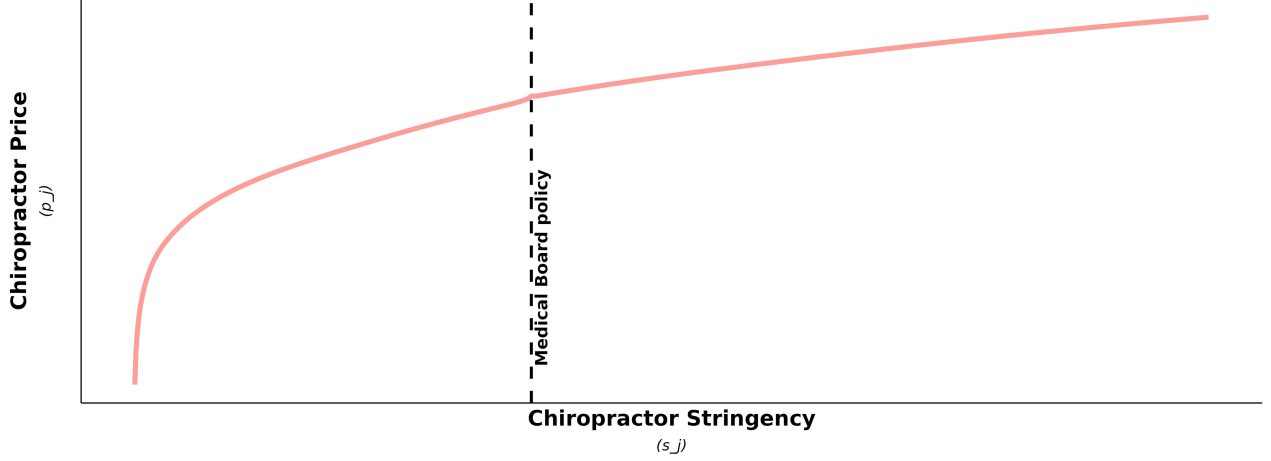


Medical board sets policy optimally under Stackelberg competition (vertical line). Parameters: $\alpha = 1.1, \beta = a = b = 1, \psi_i = \psi_j = -10, \mu_i = \mu_j = 0, \gamma = 1, q_{pr} \sim \text{LogNormal}(0, 1)$.

This quality improvement is not linear. As stringency increases beyond a certain point, the marginal increase in quality diminishes. At extreme levels, the cost of entry becomes so prohibitive that very few individuals enter, limiting further gains in average quality.

Price Effects. Because consumers value provider quality, increases in average ability translate into higher equilibrium prices. Figure 7 confirms that price increases with licensing stringency, consistent with a demand-side response to quality improvement. This effect is also amplified by the reduction in supply that accompanies more stringent entry standards.

Figure 7: Prices Rise with Stringency; Muted Response Near Rival's Policy
Equilibrium Price by Stringency of Own Board

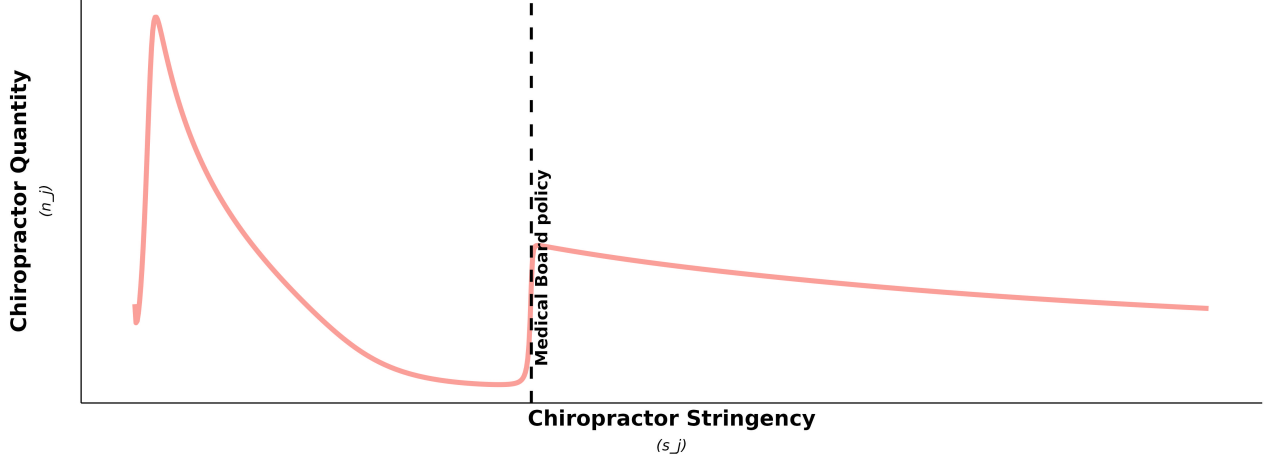


Medical board sets policy optimally under Stackelberg competition (vertical line). Parameters: $\alpha = 1.1, \beta = a = b = 1, \psi_i = \psi_j = -10, \mu_i = \mu_j = 0, \gamma = 1, q_{pr} \sim \text{LogNormal}(0, 1)$.

The nonlinearity in the price curve arises from two reinforcing effects. First, there is upward pressure from rising provider quality. Second, there is a contraction in the quantity supplied.

Quantity of Chiropractors Figure 8 illustrates the entry quantity response. Initially, entry falls as low-ability providers are excluded. At intermediate levels of stringency, entry stabilizes or even increases slightly, as higher quality supports higher prices and makes the profession attractive to high-ability individuals. Quantity declines as the competitive nature of the model comes into play, as workers generally prefer the higher ability profession if there is a reasonable choice. As stringency increases, lower-ability workers are driven out, but higher-ability workers still prefer the doctor profession until the chiropractic profession has higher standards. Once the rank of relative stringency flips, higher quality workers surge into the chiropractic profession. At very high stringency, however, entry declines again as only a small share of the ability distribution meets the entry threshold.

Figure 8: Entry Rises via Quality Premiums and Cream-Skimming
Chiropractic Quantity by Chiropractic Stringency



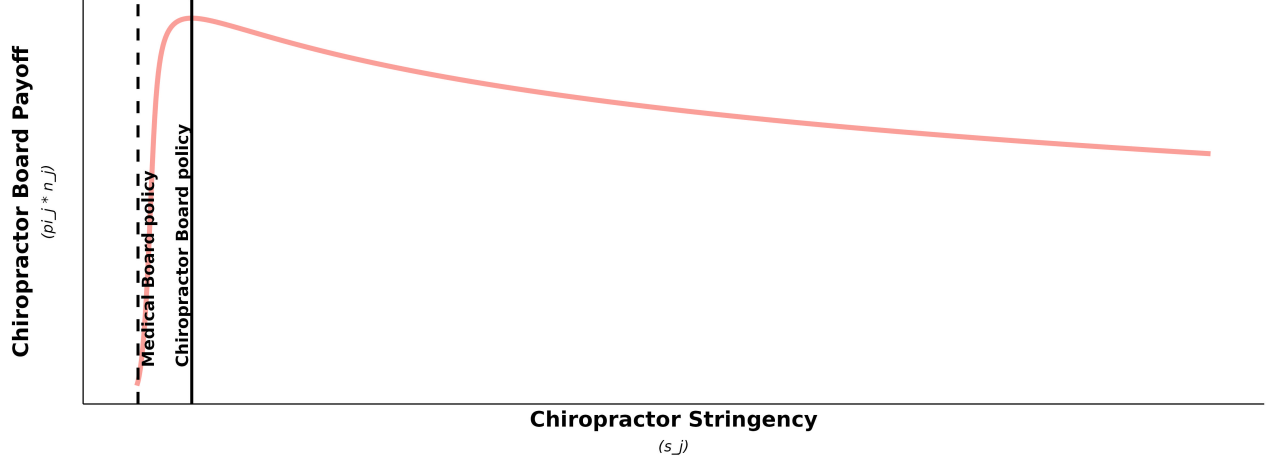
Medical board sets policy optimally under Stackelberg competition (vertical line). Parameters: $\alpha = 1.1, \beta = a = b = 1, \psi_i = \psi_j = -10, \mu_i = \mu_j = 0, \gamma = 1, q_{pr} \sim \text{LogNormal}(0, 1)$.

The result is a lopsided M-shaped pattern. This highlights a trade-off: while stringent licensing can improve provider quality, it may also create shortages or drive consumers toward substitute professions. Notably, the shape and magnitude of this pattern depend critically on the stringency level set by the competing profession's board, as indicated by the vertical line marking the medical board's policy choice.

Chiropractic Profits Figures 9, 10, and 11 plot the total profits earned by the chiropractic board as stringency increases under different competitive scenarios. The pattern is non-monotonic and highly dependent on the medical board's policy stance. When facing a minimally restrictive medical board policy (Figure 9), the chiropractic board can largely ignore the other profession and set policy based primarily on its own profit considerations. However, when the medical board acts as if they are the only board (Figure 10), the chiropractic board's optimal response is to be slightly more restrictive. In effect, they engage in cream-skimming. This attracts high-quality practitioners away from the doctor profession. Conversely, if the medical board sets a much more restrictive policy, then the chiropractic

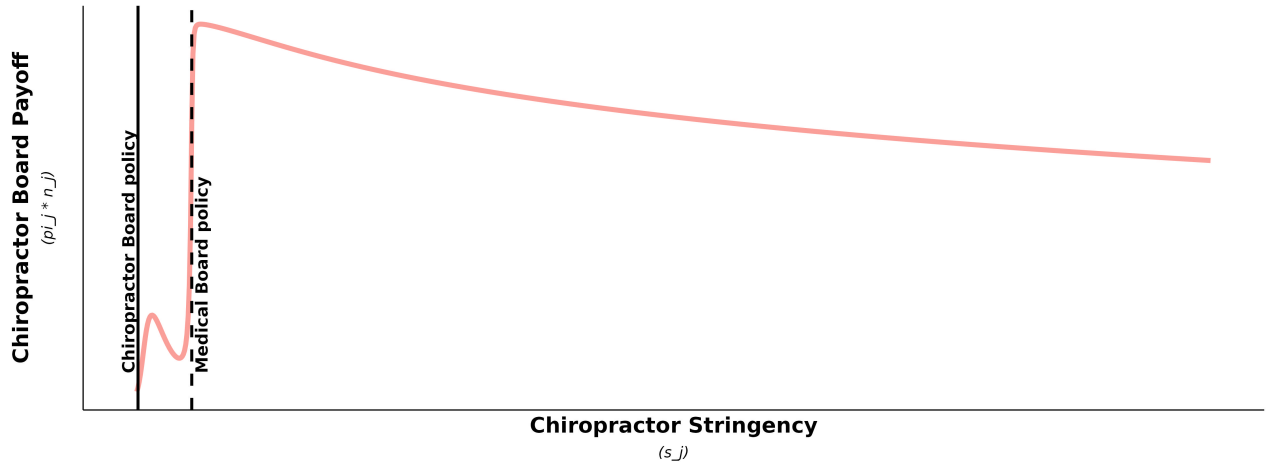
board prefers to set a much lower stringency level because the medical board's policy is too restrictive to make cream-skimming worthwhile.

Figure 9: Moderate Stringency Optimal Without Competitive Pressure
Total Chiropractic Profit by Chiropractic Stringency



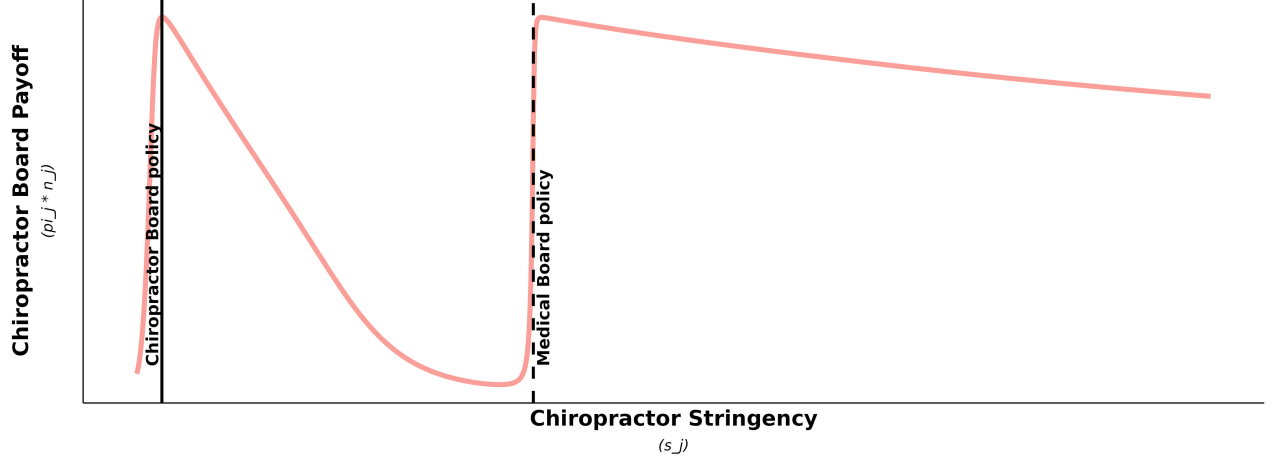
Chiropractic board maximizes profit (solid vertical line); medical board restricted from optimal strategy (dashed vertical line). Solid vertical line shows chiropractic board's optimal policy. Parameters: $\alpha = 1.1, \beta = a = b = 1, \psi_i = \psi_j = -10, \mu_i = \mu_j = 0, \gamma = 1, q_{pr} \sim \text{LogNormal}(0, 1)$.

Figure 10: Cream-Skimming Strategy Maximizes Profits Against Moderate Rival
Total Chiropractic Profit by Chiropractic Stringency With Competition



Medical board maximizes profit (dashed vertical line); chiropractic board restricted to suboptimally low stringency (solid vertical line). Solid vertical line shows chiropractic board's restricted policy. Parameters: $\alpha = 1.1, \beta = a = b = 1, \psi_i = \psi_j = -10, \mu_i = \mu_j = 0, \gamma = 1, q_{pr} \sim \text{LogNormal}(0, 1)$.

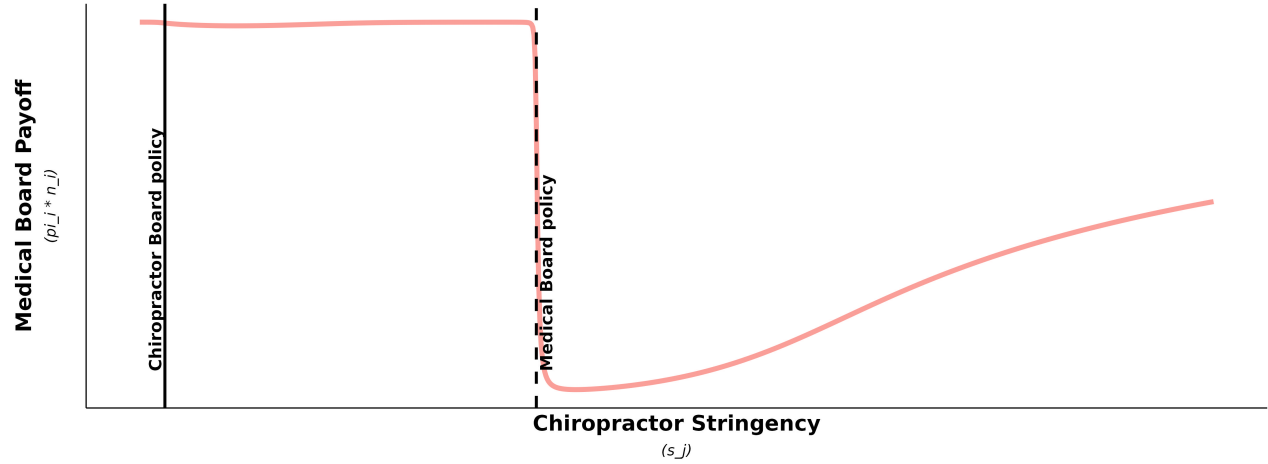
Figure 11: High Stringency Deters Rival Cream-Skimming Through Entry Costs
Total Chiropractic Profit by Chiropractic Stringency In Stackelberg Equilibrium



Both boards set policies optimally under Stackelberg competition. Dashed vertical line is medical board's optimal policy; solid vertical line is chiropractic board's optimal policy. Parameters: $\alpha = 1.1, \beta = a = b = 1, \psi_i = \psi_j = -10, \mu_i = \mu_j = 0, \gamma = 1, q_{pr} \sim \text{LogNormal}(0, 1)$.

Strategic Interaction and Spillovers Figure 12 shows doctor profession profits as a function of the chiropractic's stringency level. When the chiropractic profession is unregulated, the doctors face little competitive pressure and prefer relatively low stringency. If the chiropractic board increases its entry standards above the medical board standards, the medical board suffers from cream-skimming as high-ability doctors shift to the rival. This incentivizes the medical board to raise its own stringency in order to avoid being cream-skimmed.

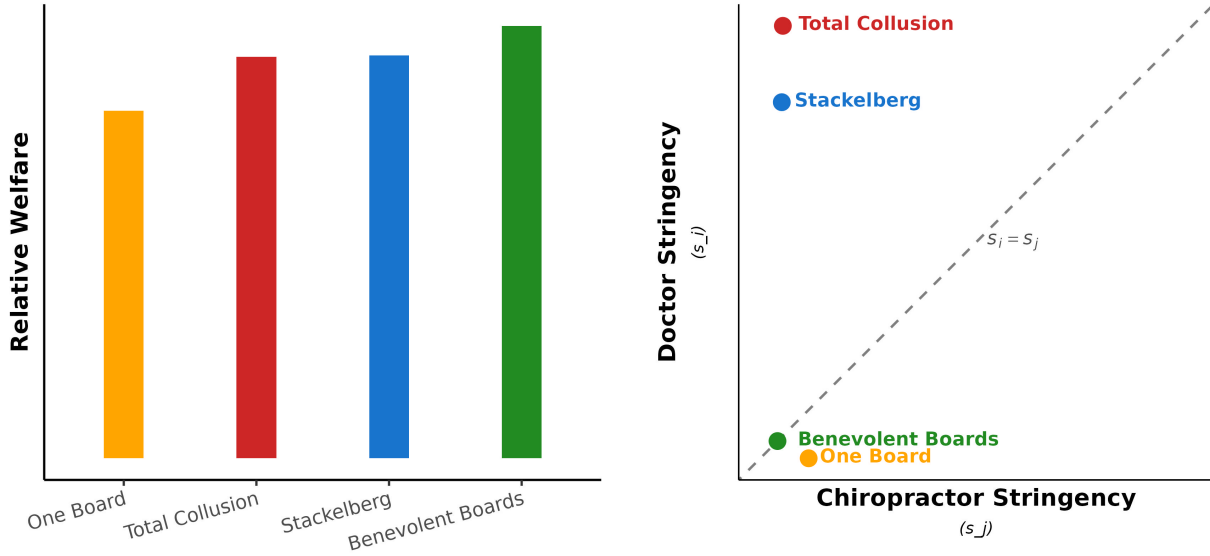
Figure 12: Cream-Skimming Costly; Higher-Status Board Prefers Keeping Lead
Total Medical Board Profit by Chiropractic Stringency



Both boards set policies optimally under Stackelberg competition. Dashed vertical line is medical board's optimal policy; solid vertical line is chiropractic board's optimal policy. Parameters: $\alpha = 1.1, \beta = a = b = 1, \psi_i = \psi_j = -10, \mu_i = \mu_j = 0, \gamma = 1, q_{pr} \sim \text{LogNormal}(0, 1)$.

Welfare Effects Finally, Figure 13 plots total welfare (including consumer surplus and provider surplus) as a function of the chiropractic board's stringency under different regulatory scenarios. The highest welfare is achieved when both boards act benevolently, coordinating to set relatively unrestrictive barriers to entry that maximize social welfare. The next best outcome occurs under Stackelberg competition, closely followed by total collusion between the boards, where both adopt staggered policies with one board setting more restrictive standards than the other. The lowest welfare occurs when only one board is allowed to set policy. In this case, the monopolistic board chooses a more restrictive policy than the social optimum, though still less restrictive than the higher-stringency board in the collusion and Stackelberg scenarios.

Figure 13: Competition Outperforms Collusion; Both Beat Single-Board Dominance
Total Welfare by Regulatory Scenario and Board Policy Combinations



Left panel shows relative total welfare across regulatory scenarios. Right panel shows policy combinations under different scenarios. Parameters: $\alpha = 1.1, \beta = a = b = 1, \psi_i = \psi_j = -10, \mu_i = \mu_j = 0, \gamma = 1, q_{pr} \sim \text{LogNormal}(0, 1)$.

This result highlights the importance of regulatory structure and coordination. When boards act benevolently with full coordination, they can maximize social welfare by setting optimal entry barriers. However, this benevolent outcome may not be achievable in practice due to regulatory capture, where licensing boards prioritize their professions' interests over broader social welfare. In more realistic scenarios where boards act in their professions' interests, strategic interaction leads to suboptimal outcomes. The welfare ranking (benevolent coordination $>$ strategic competition $>$ collusion $>$ monopoly) demonstrates that when benevolent coordination is not feasible, competition between boards produces higher welfare than either collusion or monopolistic control.

Summary These simulations highlight the dual function of licensing: as a barrier to entry and as a potential signal of quality. The trade-offs involved are nontrivial and

context-dependent. Policymakers must balance quality improvements against access and supply constraints, and should consider strategic spillovers across professions. In empirical work that follows, I examine how these dynamics play out in the chiropractic and medical professions across U.S. states, where variation in licensing regimes allows me to test the model's predictions.

5 Do Medical Boards React to Chiropractic Boards?

To test whether professional organizations strategically respond to competitive threats, I examine whether medical licensing boards tightened entry requirements following the establishment of chiropractic licensing boards in their states. This analysis exploits variation in the timing of chiropractic board adoption across states and over time, using newly digitized data on medical licensing requirements from 1907-1960.

Medical Licensure Statistics for 1960

Fifty-Ninth Annual Presentation of Licensure Statistics by the Council
on Medical Education and Hospitals of the American Medical Association

The data in the following annual report on Medical Licensure Statistics have been compiled by the staff under the supervision of Mrs. Anne Tipner, Assistant to the Secretary of the Council on Medical Education and Hospitals

WALTER S. WIGGINS, M.D., Secretary
Council on Medical Education and Hospitals

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AMA published these reports from 1907-1960 documenting medical licensing requirements across states.

The identification strategy leverages the staggered adoption of chiropractic licensing boards across states as a shock to the competitive environment faced by medical boards. The key insight is that if medical boards view chiropractors as substitute providers, they should respond to legitimization of the chiropractic profession through state licensing by raising barriers to medical practice.

State Examining Board of	One Year of College Work		Two Years of College Work		A Hospital Internship	
	Affects Students Matriculating	Affects All Graduates	Affects Students Matriculating	Affects All Graduates	Affects Students Matriculating	Affects All Applicants
Alabama.....	.....	....	1915-16	1919	.....	....
Alaska.....	1914-15	1918	1918-19	1922	1912-13	1917
Arizona.....	1914-15	1918	1918-19	1922	.....	....
Arkansas.....	1915-16	1919	1918-19	1922	.....	....
California.....	1920-21	1924	.....	....	.....	....
Colorado.....	1908-09	1912	1910-11	1914	.....	....
Connecticut.....	1915-16	1919	.....	....	.....	....
Delaware*.....	.....	....	.....	....	1919-20	1924
Dist. of Columbia.	.....	....	1925-26	1929	1924-25	1929
Florida.....	1914-15	1918	1918-19	1922	.....	....
Georgia.....	.....	....	1918-19	1922	.....	....
Idaho.....	.....	....	1915-16	1919	.....	....
Illinois.....	1915-16	1919	1919-20	1923	1918-19	1923

AMA reports documented when state medical boards adopted specific policies including education requirements and internship mandates, providing the data foundation for tracking policy changes over time.

The empirical analysis focuses on three key dimensions of medical licensing stringency: passage rates on medical board examinations, requirements for two years of pre-medical college education, and mandatory internship requirements.

		Marginal Numbers																											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23					
Marginal Numbers	Name of School	Alabama	Alaska	Arizona	Arkansas	California	Colorado	Connecticut	Delaware	District of Columbia	Florida	Georgia	Hawaii	Idaho	Illinois	Indiana	Iowa	Kansas	Kentucky	Louisiana	Maine	Maryland	Massachusetts	Michigan					
		P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F				
Ala.	1 Medical Coll. of Alabama.....	64	0								6	1	1	0															
Ark.	2 University of Arkansas.....				84	5					4	1								1	0								
Calif.	3 Coll. of Med. Evan.....		1	0		32	0				8	1	3	0		2	0	1	0		1	0		6	1	1	0	2	0
	4 Univ. of California, Los Angeles				1	0		49	0		1	0		1	0														
	5 University of Southern Cal....					42	0				0	1																	
	6 Stanford University.....					33	0													3	0								
	7 Univ. of Calif., San Francisco..					78	0							2	0														

Example data showing number of applicants from a medical school who passed or failed state medical board examinations in a given year, illustrating the granular nature of the data used to calculate passage rates by state, school, and year.

I implement a stacked event study design following [Cengiz et al. \(2019\)](#), which addresses potential bias from heterogeneous treatment effects across states and time periods. Each event d represents a subset of observations where states either adopted a chiropractic board in a given year or did not adopt a chiropractic board until the end of the subpanel. This design ensures identification comes only from comparisons between just-treated and never-treated states within each event window. The estimating equation is:

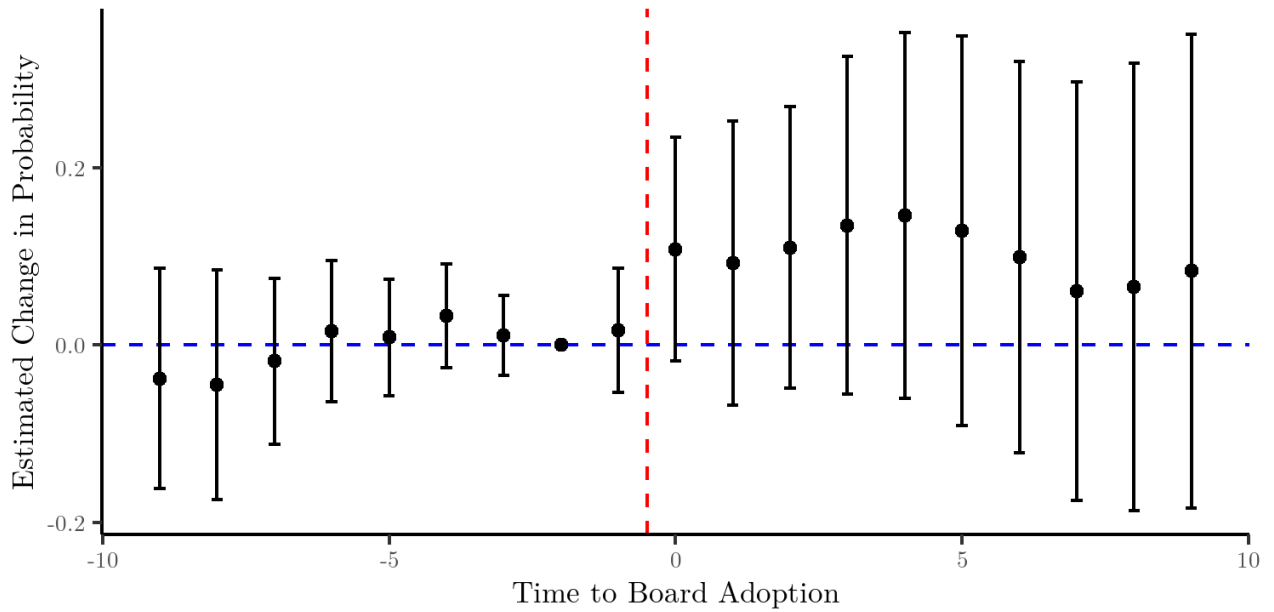
$$Y_{scyd} = \alpha \text{NewBoard}_{syd} + \beta X_{syd} + \gamma_{scd} + \phi_{cyd} + \varepsilon_{csyd} \quad (13)$$

where Y_{scyd} represents the outcome of interest (passage rate, education requirement, or internship requirement) for state s , school c , and year y relative to treatment timing (event) d . The treatment indicator NewBoard_{syd} captures the adoption of chiropractic boards or basic science boards, allowing me to separately identify the effect of direct competitive pressure versus general regulatory changes. State-level controls X_{syd} include alternative medical practice restrictions and other licensing board adoptions to isolate the chiropractic-specific effect.

The specification for the passage rate of individual students includes event-school-state

fixed effects γ_{scd} and event-school-year fixed effects ϕ_{cyd} , which control for time-invariant unobservables at the state-college level and common temporal shocks within each college, respectively. For the state-level regressions the fixed effects are simply at the event-year (yd) and state-event (sd) level. This two-way fixed effects structure ensures identification comes from within-state variation in the timing of chiropractic board adoption, comparing medical board stringency before and after the competitive shock.

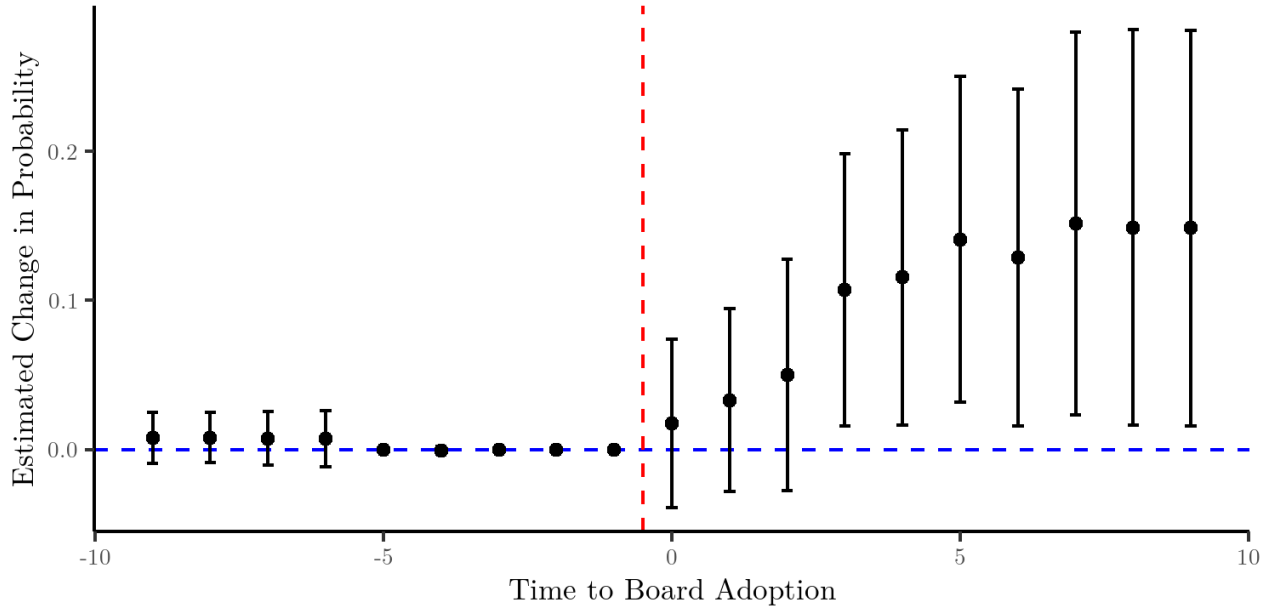
Figure 14: Requiring Two Years of College by Time to Chiropractic Board



Event study plot using stacked event study methodology. Outcome variable is the probability of requiring two years of college prior to medical school. Plot shows coefficients relative to two years prior to chiropractic board adoption (time -2), with 95% confidence intervals. Identification comes from within-state variation in timing of chiropractic board establishment.

The event study results reveal a clear pattern of strategic response by medical boards. Figure 14 shows that medical boards significantly increased the probability of requiring two years of pre-medical college education following chiropractic board establishment. The effect is immediate and persistent, with a sudden jump of approximately 10 percentage points that remains stable in subsequent years.

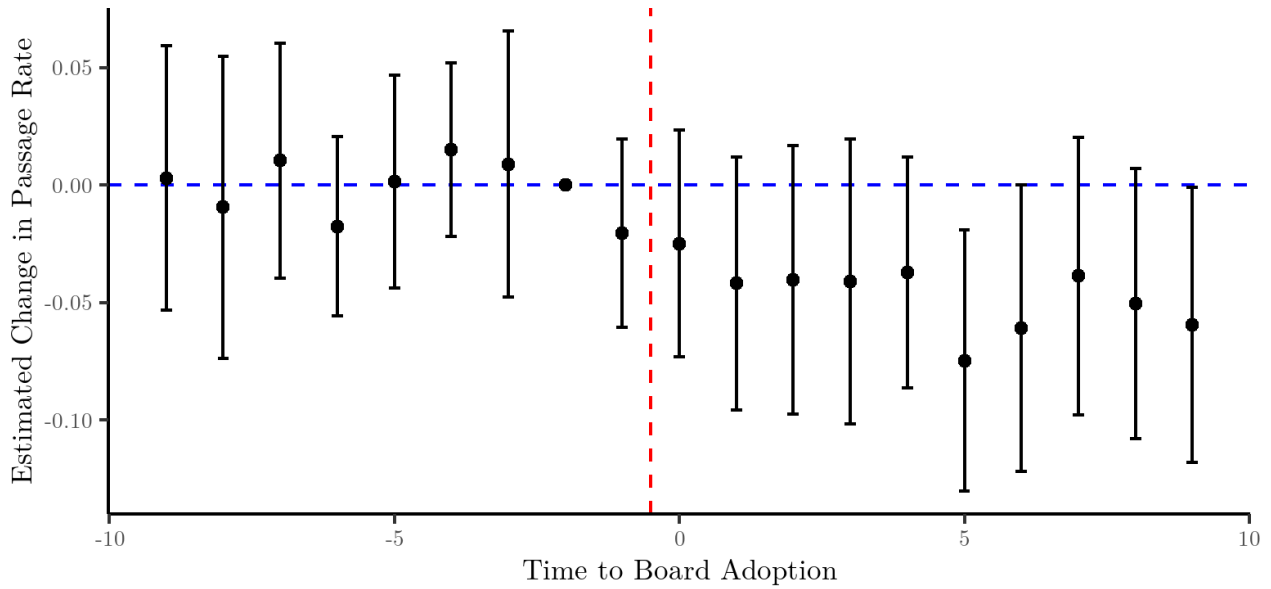
Figure 15: Requiring an Internship by Time to Chiropractic Board



Event study plot using stacked event study methodology. Outcome variable is the probability of a state requiring doctors to complete an internship year following medical school. Plot shows coefficients relative to two years prior to chiropractic board adoption (time -2), with 95% confidence intervals. The specification includes state-event and event-year fixed effects. Small confidence intervals in the pre-period are a result of limited movement in covariates.

Similarly, Figure 15 demonstrates that medical boards increased internship requirements in response to chiropractic legitimization. Unlike the college requirement, this effect builds more gradually over time, growing to just over 10 percentage points in treated states relative to control states. This pattern suggests that internship requirements may have required more coordination or legislative processes to implement.

Figure 16: Medical Board Passage Rate by Time to Chiropractic Board



Event study plot using stacked event study methodology. Outcome variable is the passage rate of state medical boards conditional on medical school quality. Plot shows coefficients relative to two years prior to chiropractic board adoption (time -2), with 95% confidence intervals. Methodology controls for medical school quality to isolate changes in board examination difficulty.

The results for examination passage rates, shown in Figure 16, provide additional evidence of strategic tightening. Medical boards appear to have made their examinations more difficult following chiropractic board adoption, with passage rates declining by approximately 5 percentage points in treated states. Notably, this decline may begin the year prior to chiropractic board establishment, potentially demonstrating anticipatory behavior by medical boards who could foresee the competitive threat and adjust examination difficulty more quickly than formal regulatory requirements.

Collectively, these findings provide strong empirical support for strategic interaction between professional licensing boards. The consistency of results across multiple dimensions of licensing stringency suggests that medical boards systematically responded to competitive threats by raising barriers to entry into their own profession. This behavior is consistent with the theoretical prediction that medical professional organizations will use regulatory tools to

maintain market power when faced with substitute providers.

6 How Does This Affect Doctors?

Given that doctors seem to think it matters to them if chiropractors are licensed, I need to examine how this regulatory change impacts the medical profession across multiple dimensions. The analysis focuses on three key measures of professional well-being: profitability as measured by home values from census data spanning 1930-1940, quality of the profession as indicated by educational attainment from the 1940-1950 census records, and supply dynamics reflected in the prevalence of medical professionals from census data covering 1900-1950.

6.1 Methodology and Empirical Strategy

The primary analytical approach employs a difference-in-differences framework to isolate the causal effects of chiropractic board adoption. The baseline specification takes the form:

$$Y_{icy} = \alpha ChiroBoard_{cy} + \delta BasicScience_{cy} + \beta Age_{icy} + \gamma_c + \phi_y + \varepsilon_{icy} \quad (14)$$

In this model, Y_{icy} represents the outcome variables of interest, including the logarithm of home values and home ownership rates for individual i in county c during year y . The key treatment variables $ChiroBoard_{cy}$ and $BasicScience_{cy}$ capture the adoption of either chiropractic boards or basic science boards in county c during year y . Age_{icy} controls for general differences by age, while the specification incorporates county fixed effects γ_c and year fixed effects ϕ_y to control for time-invariant county characteristics and common temporal shocks.

6.2 Control Group: Similar Non-Health Professions

To provide context and test whether licensing effects are specific to health professions, I examine outcomes for similar non-health professions as a control group. I selected five professions—Electrical Engineers, Civil Engineers, Librarians, Mechanical Engineers, and Government Officials—to minimize the Mahalanobis distance between their average log home values, educational attainment, and home ownership rates relative to both chiropractors and doctors. This control group analysis helps validate that the observed effects are specific to health professions rather than reflecting broader economic trends affecting all skilled professions.

6.3 Impact on Doctor Economic Outcomes

The empirical results reveal striking patterns in how licensing reforms impact the economic well-being of medical professionals compared to the control group. When examining home ownership patterns among doctors, the adoption of chiropractic boards generates a positive effect on home values, with a coefficient of 0.228 (approximately a 26% increase in home values) for doctors following the establishment of chiropractic licensing boards. This is unlikely to be driven by selection given that, home ownership itself increases by about four percentage points.

In contrast, the results for similar non-health professions present a markedly different picture. Chiropractic board adoption shows much smaller effects on these placebo professions' home values, with a coefficient of 0.060. The probability of home ownership for similar non-health professions also increases by a smaller magnitude of 0.021.

The adoption of basic science boards shows a negative effect on doctor home values, with a coefficient of -0.137 (a 12.8% decrease). The probability of home ownership shows virtually no change. For similar non-health professions, basic science board adoption shows a smaller negative effect on home values (-0.053) and a positive effect on home ownership probability (0.037). Fully interacted regressions demonstrate that in most cases, the effects on doctors

Table 3: Difference-in-Differences on Doctor Home Ownership versus Similar Non-Health Professions

Event Type	Doctor		Placebo Professions		Doctor & Placebo	
	log(Home Value)	Pr(Own Home)	log(Home Value)	Pr(Own Home)	log(Home Value)	Pr(Own Home)
Adopt Chiropractic Board	0.228*** (0.031)	0.044*** (0.013)	0.060* (0.026)	0.021 [†] (0.012)	0.060* (0.026)	0.021 [†] (0.012)
Adopt Basic Science Board	-0.137*** (0.034)	0.003 (0.014)	-0.053 [†] (0.029)	0.037** (0.012)	-0.053 [†] (0.029)	0.037** (0.012)
Adopt Chiropractic Board × Doctor					0.168*** (0.041)	0.024 (0.017)
Adopt Basic Science Board × Doctor					-0.084 [†] (0.046)	-0.034 [†] (0.019)
Observations	80,436	151,030	141,808	301,782	222,244	301,782

Note: [†] $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Difference-in-differences estimation with county and year fixed effects. Wild cluster bootstrap standard errors clustered by state in parentheses. Sample includes doctors from 1930-1940 Census and similar non-health professions (Electrical Engineers, Civil Engineers, Librarians, Mechanical Engineers, and Government Officials).

differ significantly from the effects on placebo professions, as shown by the interaction terms.

6.4 Educational Quality Analysis

The analysis extends beyond economic outcomes to examine how licensing reforms affect the quality of medical professionals, as proxied by educational attainment. Using a selection-on-observables approach, the specification becomes:

$$Y_{icy} = \alpha \text{ChiroBoard}_{cy} + \delta \text{BasicScience}_{cy} + \beta X_{icy} + \phi_y + \varepsilon_{icy} \quad (15)$$

Here, the outcome Y_{icy} represents years of educational attainment, while the control variables X_{icy} include individual age and the average educational attainment of non-health professionals in the county to account for local educational trends.

The results show that chiropractic board adoption is associated with increased educational attainment among doctors. The most robust specification, which includes both age fixed effects and controls for local educational trends, yields a coefficient of 0.2 years of additional education.

The parallel analysis of similar non-health profession educational attainment provides additional validation for the identification strategy. Chiropractic board adoption produces

negligible effects on placebo profession education in the most comprehensive specification, which includes age fixed effects and controls for local educational trends.

Table 4: Board Adoption on Doctor Educational Attainment versus Similar Non-Health Professions

	Doctor Attainment			Placebo Attainment			Doctor & Placebo
	(1)	(2)	(3)	(1)	(2)	(3)	(4)
Adopted Chiropractic Board	0.138 (0.091)	0.186* (0.089)	0.175 [†] (0.093)	0.040 (0.119)	0.038 (0.120)	-0.031 (0.096)	-0.031 (0.096)
Adopted Basic Science Board	-0.042 (0.108)	-0.040 (0.096)	-0.059 (0.086)	-0.042 (0.154)	-0.022 (0.159)	-0.071 (0.106)	-0.071 (0.106)
Average Educational Attainment			0.120** (0.035)			0.486*** (0.053)	0.486*** (0.053)
Adopted Chiropractic Board × Doctor							0.206* (0.089)
Adopted Basic Science Board × Doctor							0.012 (0.122)
Average Educational Attainment × Doctor							-0.366*** (0.046)
Observations	200,442	200,442	200,442	516,829	516,829	516,829	717,271
Age FEs		✓	✓		✓	✓	✓

Note: [†] $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Selection-on-observables approach with year fixed effects and individual controls. Standard errors clustered by state in parentheses. Sample includes doctors and similar non-health professions from 1940-1950 Census.

Basic science board adoption shows consistently negative but statistically insignificant effects on doctor educational attainment across all specifications, with coefficients ranging from -0.040 to -0.059. For similar non-health professions, the effects are also generally negative and insignificant. Fully interacted regressions show that the estimated effect on doctors is significantly different from the effect on placebo professions.

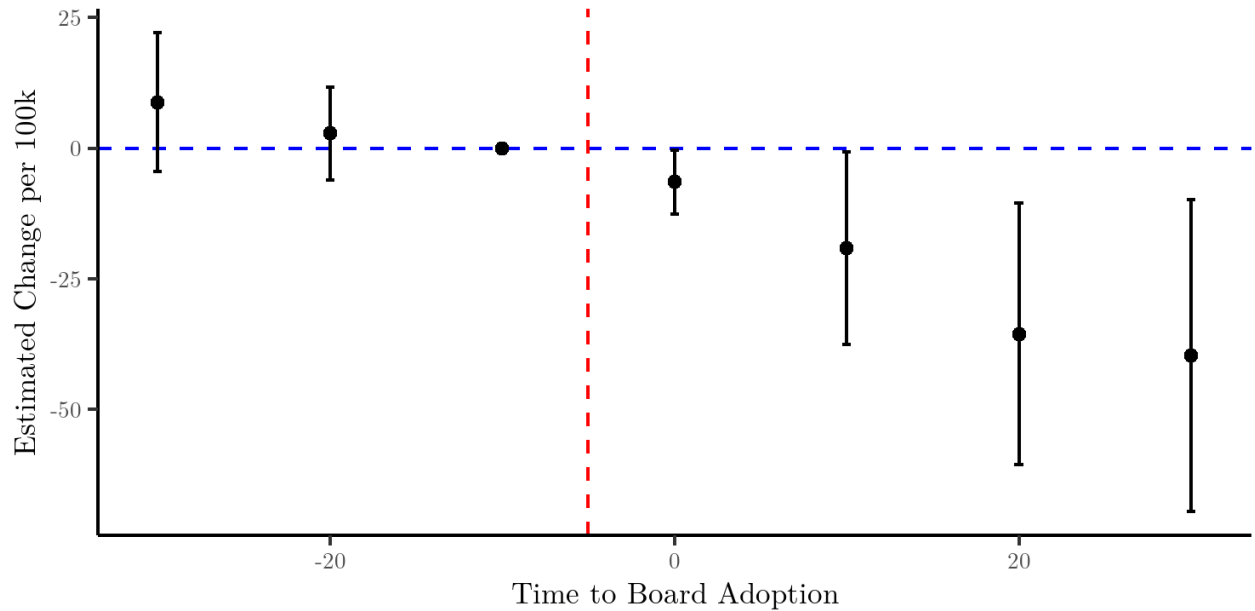
6.5 Supply Effects and Market Dynamics

To examine how licensing affects the supply of medical professionals, I employ the same stacked event study approach I used in the earlier analysis of medical board responses to chiropractic licensing. I follow the methodology of [Cengiz et al. \(2019\)](#). This specification addresses potential concerns about treatment effect heterogeneity and timing of adoption:

$$Y_{cjd} = \alpha NewBoard_{cjd} + \beta X_{cjd} + \gamma_{cd} + \phi_{jd} + \varepsilon_{cjd} \quad (16)$$

Each event d represents a subset of observations where states either adopted a chiropractic board in a given year or did not adopt a chiropractic board until the end of the subpanel. The outcome variable Y_{cjd} measures the number of practitioners per 100,000 population in county c , year y , for event d . The treatment variable $NewBoard_{cjd}$ indicates the adoption of licensing boards. Controls X_{cjd} include the adoption of alternative board types and urban-rural classification. The specification incorporates event-county fixed effects γ_{cd} and event-year fixed effects ϕ_{jd} . These provide more flexible control for confounding factors.

Figure 17: Event Study on Prevalence of Doctors at Adoption of Chiropractic Board



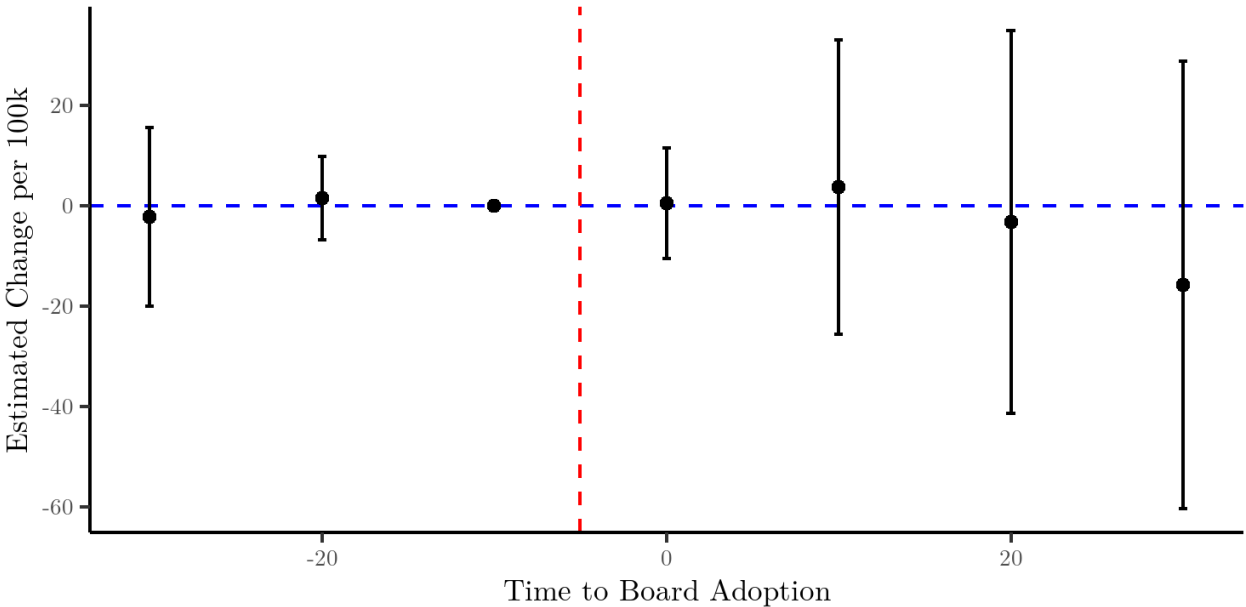
This figure shows the dynamic effects of chiropractic board adoption on the number of doctors per 100,000 population using a stacked event study methodology comparing treated states to untreated states. The x-axis represents years relative to chiropractic board adoption, and the y-axis shows the estimated treatment effects with 95% confidence intervals.

Following the adoption of chiropractic licensing boards, the prevalence of doctors in treated states exhibits a persistent decline (Figure 17). Notably, no significant deviation occurs in the years preceding adoption, suggesting the policy change itself drives this trend. The magnitude of this decline parallels the national drop in doctor prevalence commonly

attributed to the Flexner Report (Figure 1).

In contrast, the analysis of similar non-health profession supply using the same stacked difference-in-differences approach reveals patterns distinct from those observed for doctors. As Figure 18 shows, the event study analysis provides no evidence of a shift in the prevalence of similar non-health professions following chiropractic board introduction. The coefficients remain close to zero across all periods, both before and after board adoption, with confidence intervals that consistently include zero.

Figure 18: Event Study on Prevalence of Similar Non-Health Professions at Adoption of Chiropractic Board



This figure shows the dynamic effects of chiropractic board adoption on the number of similar non-health professionals per 100,000 population using a stacked event study methodology comparing treated states to untreated states. The x-axis represents years relative to chiropractic board adoption, and the y-axis shows the estimated treatment effects with 95% confidence intervals. Similar non-health professions include Electrical Engineers, Civil Engineers, Librarians, Mechanical Engineers, and Government Officials.

This stark contrast between the supply effects on doctors versus similar non-health professions provides additional validation that the observed patterns reflect profession-specific responses to healthcare regulation rather than broader economic trends

affecting all skilled professions.

7 How Does This Affect Chiropractors?

Having established the spillover effects of chiropractic licensing on the medical profession, I now examine how these regulatory changes directly impact chiropractors themselves. This analysis examines the primary intended beneficiaries of licensing reform and provides insight into how professional regulation shapes market outcomes for the regulated profession.

7.1 Economic Impact on Chiropractors

The economic effects of licensing on chiropractors show patterns that differ from those observed for doctors and are even more distinct from the control group of similar non-health professions. Using the same difference-in-differences framework applied to doctors, the adoption of chiropractic boards generates a positive effect on chiropractor home values, with a coefficient of 0.364 (approximately a 44% increase in home values). The effect on home ownership probability is also positive, with an increase of about 19 percentage points.

These effects are substantially larger than those observed for similar non-health professions, which show coefficients of 0.060 for home values and 0.021 for home ownership probability following chiropractic board adoption.

7.2 Educational Quality Effects

The adoption of chiropractic licensing boards substantially increases educational attainment among chiropractors. Using the most comprehensive specification, which includes age fixed effects and controls for local educational trends, the policy change is associated with 0.6 additional years of education.

This effect is consistent across specifications, with coefficients ranging from 0.520 to 0.565, all statistically significant at the 1% or 0.1% level. This contrasts sharply with the effects on

Table 5: Difference-in-Differences on Chiropractor Home Ownership versus Similar Non-Health Professions

Event Type	Chiropractor		Placebo Professions		Chiro & Placebo	
	log(Home Value)	Pr(Own Home)	log(Home Value)	Pr(Own Home)	log(Home Value)	Pr(Own Home)
Adopt Chiropractic Board	0.364*	0.186*	0.060*	0.021 [†]	0.060*	0.021 [†]
	(0.172)	(0.078)	(0.026)	(0.012)	(0.026)	(0.012)
Adopt Basic Science Board	-0.277	-0.096	-0.053 [†]	0.037**	-0.053 [†]	0.037**
	(0.184)	(0.083)	(0.029)	(0.012)	(0.029)	(0.012)
Adopt Chiropractic Board × Chiropractor					0.304 [†]	0.165*
					(0.173)	(0.079)
Adopt Basic Science Board × Chiropractor					-0.224	-0.133
					(0.185)	(0.084)
Observations	3,152	6,855	141,808	301,782	144,960	308,637

Note: [†] $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Difference-in-differences estimation with county and year fixed effects. Wild cluster bootstrap standard errors clustered by state in parentheses. Sample includes chiropractors from 1930-1940 Census and similar non-health professions.

similar non-health professions, where chiropractic board adoption produces negative effects on education in the most comprehensive specification, with a statistically insignificant coefficient of -0.031.

Table 6: Board Adoption on Chiropractor Educational Attainment versus Similar Non-Health Professions

	Chiropractor Attainment			Placebo Attainment			Chiro & Placebo
	(1)	(2)	(3)	(1)	(2)	(3)	(4)
Adopted Chiropractic Board	0.520**	0.540***	0.565***	0.040	0.038	-0.031	-0.031
	(0.158)	(0.152)	(0.161)	(0.119)	(0.120)	(0.096)	(0.096)
Adopted Basic Science Board	-0.082	-0.067	-0.074	-0.042	-0.022	-0.071	-0.071
	(0.133)	(0.122)	(0.127)	(0.154)	(0.159)	(0.106)	(0.106)
Average Educational Attainment			-0.054			0.486***	0.486***
			(0.061)			(0.053)	(0.053)
Adopted Chiropractic Board × Chiropractor							0.596***
							(0.136)
Adopted Basic Science Board × Chiropractor							-0.004
							(0.129)
Average Educational Attainment × Chiropractor							-0.540***
							(0.074)
Observations	12,641	12,641	12,641	516,829	516,829	516,829	529,470
Age FEs		✓	✓		✓	✓	✓

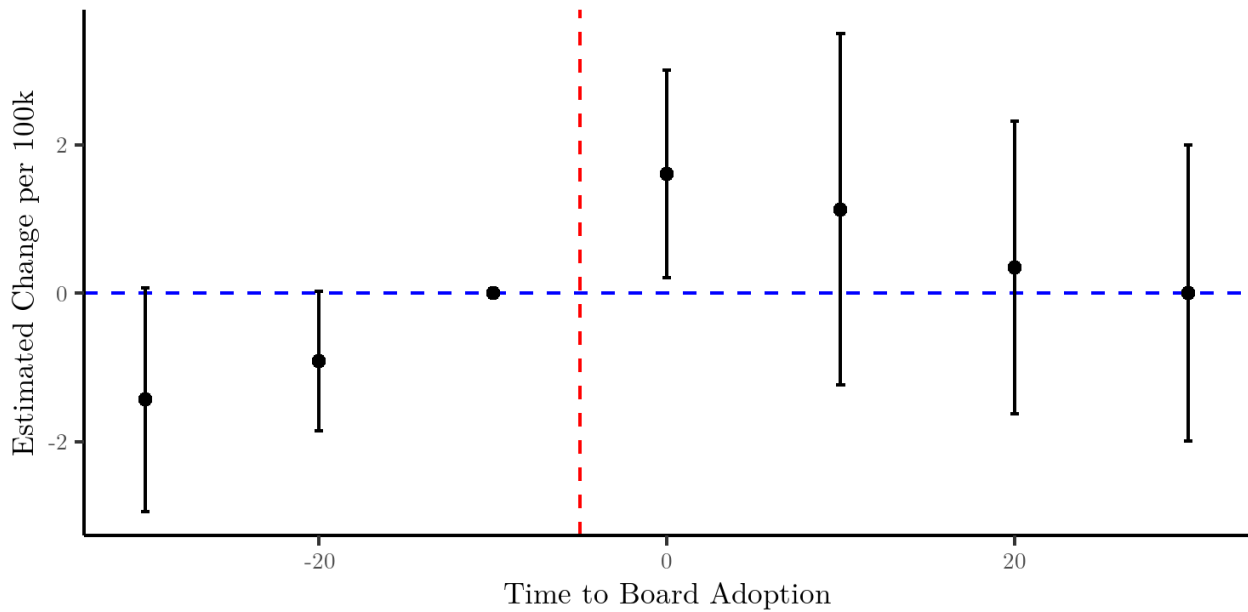
Note: [†] $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Selection-on-observables approach with year fixed effects and individual controls. Standard errors clustered by state in parentheses. Sample includes chiropractors and similar non-health professions from 1940-1950 Census.

The fully interacted regression shows that the effect on chiropractors is significantly different and much larger than the effect on placebo professions, with an interaction coefficient of 0.596.

7.3 Supply Dynamics and Market Entry

A simple stacked event study (Figure 19) on the prevalence of chiropractors suggests that the prevalence of chiropractors increased after the adoption of a chiropractic board. The periods before adoption, however, show a concerning upward trajectory, complicating causal interpretation.

Figure 19: Event Study on Prevalence of Chiropractors at Adoption of Chiropractic Board



This figure presents the event study analysis of chiropractic board adoption effects on chiropractor prevalence per 100,000 population. The analysis uses a two-way fixed effects specification with event-time relative to board adoption on the x-axis and estimated coefficients with confidence intervals on the y-axis.

In contrast to both chiropractors and doctors, similar non-health professions show no evidence of supply effects following chiropractic board adoption, as demonstrated in Figure 18, providing additional validation that the observed patterns are specific to health professions.

7.4 Methodological Challenges and Solutions

The analysis of chiropractor supply effects confronts two primary identification challenges that threaten the validity of standard difference-in-differences approaches. First, higher prevalence of chiropractors may increase their political lobbying power, leading to endogenous adoption of licensing boards [Law and Kim \(2005\)](#). This reverse causality problem means that jurisdictions with more chiropractors may be more likely to adopt licensing, confounding the ability to identify the causal effect of licensing on prevalence.

Second, the prevalence of chiropractors exhibits strong persistence over time, meaning that a higher current prevalence leads to a higher future prevalence, as workers often remain in the profession they previously chose. This creates a serial correlation problem that can bias estimates of treatment effects.

To address these challenges, I implement an instrumental variables approach combined with dynamic panel methods. The strategy involves two key innovations: first, instrumenting for the existence of a licensing board using the prevalence of health professions in non-bordering counties within the state, combined with the lagged urbanicity of the state. Second, including a lagged dependent variable and higher-order polynomial controls for prior profession prevalence to address persistence issues.

7.5 Instrumental Variables Strategy

The first stage of the instrumental variables approach takes the form:

$$NewBoard_{pcyd} = \sum^P \gamma_{cdpi} (Y_{dp,-10,-c}) * 1[T] + vX_{pcyd} + \varepsilon_{pcyd} \quad (17)$$

where $NewBoard_{pcyd}$ is a binary indicator for chiropractic board adoption in profession p , county c , year y , event d . This specification instruments for board adoption using $Y_{dp,-10,-c}$, the prevalence of various health professions in non-bordering counties within the same state ten years prior to adoption, interacted with time period indicators $1[T]$. The coefficients γ_{cdpi}

capture the relationship between distant professional prevalence and local licensing decisions, while X_{pcyd} represents control variables with coefficients v . The identifying assumption is that state-level political and regulatory environments influence licensing decisions, while the specific prevalence in non-bordering counties remains uncorrelated with local economic shocks directly affecting chiropractor outcomes in the focal county.

The second stage incorporates the predicted board adoption variable with flexible persistence controls:

$$Y_{cyp} = \alpha New\hat{Board}_{pcyd} + \beta X_{pcyd} + \sum_{i=1}^P \sum_{j=1}^3 \delta_{cdpi} f(Y_{cdp,y-1}^i) + \phi_{pyd} + \varepsilon_{pcyd} \quad (18)$$

where Y_{cyp} is the outcome variable, α is the coefficient of interest on predicted board adoption $New\hat{Board}_{pcyd}$, and β represents coefficients on control variables X_{pcyd} . The specification includes $f(Y_{cdp,y-1}^i)$, a cubic polynomial ($i=1,2,3$) in lagged profession prevalence with coefficients δ_{cdpi} to flexibly control for persistence effects, and ϕ_{pyd} representing event-specific year fixed effects to absorb common temporal shocks.

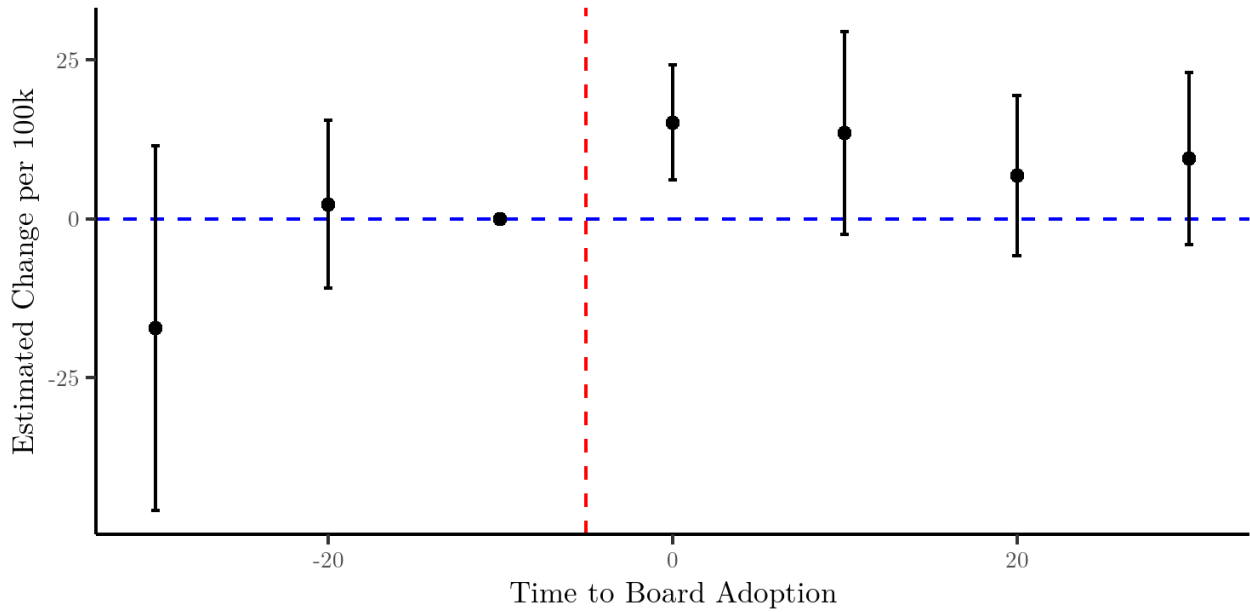
The key insight underlying this identification strategy is that policy decisions are determined by characteristics of the entire state, which can be isolated from local economic shocks that might directly affect professional outcomes. The prevalence of health professions in distant parts of the state reflects broader political economy factors that influence regulatory decisions without being directly correlated with local market conditions.

The primary threat to the exclusion restriction is spatial correlation in economic conditions across counties within a state. However, the extensive controls for neighboring county characteristics and flexible time trends should address this concern. Additionally, the use of non-bordering counties helps minimize direct spillover effects while maintaining the relevance of state-level political determinants.

7.6 Instrumental Variables Results

This instrumental variables approach continues to show an increase in chiropractor prevalence, but with a less concerning pre-trend. Figure 20 requires a different interpretation than prior event studies due to the lagged dependent variable specification, but yields similar conclusions. Following chiropractic board adoption, the growth in chiropractor prevalence increases by approximately 11 practitioners per 100,000 people, compared to relatively flat growth rates before adoption. To contextualize this magnitude, an 11-practitioner increase in prevalence exceeds the total national increase observed over the study period (Figure 3). However, the concurrent growth in basic science board prevalence would partially offset this increase.

Figure 20: Event Study on Growth of Chiropractors at Adoption of Chiropractic Board



Notes: This figure shows event study coefficients from the instrumental variables specification described in equation (2). The dependent variable is the growth in chiropractor prevalence (practitioners per 100,000 population). The specification includes cubic polynomials in lagged profession prevalence and event-specific year fixed effects. Confidence intervals are shown at the 95% level. The interpretation differs from standard event studies due to the lagged dependent variable specification, but demonstrates relatively flat pre-trends followed by sustained growth in chiropractor prevalence after board adoption.

The results comparing fixed effects and instrumental variables approaches across different professions show distinct patterns. For chiropractors, the instrumental variables estimate of chiropractic board adoption shows a coefficient of 11.733 chiropractors per 100,000 population, compared to the fixed effects estimate of 1.825. For similar non-health professions, the coefficients are much smaller and generally insignificant, providing additional validation for the health profession-specific effects.

Table 7: Estimated Effects of Board Adoption on Prevalence

Event Type	Chiropractors/100K		Doctors/100K		Similar Non-Health Professions/100K	
	Chiropractic Board	Basic Science Board	Chiropractic Board	Basic Science Board	Chiropractic Board	Basic Science Board
Fixed Effects Regressions						
Adopted Board	1.825 [†] (0.931)	0.258 (0.973)	-17.177* (8.243)	12.642 [†] (6.543)	-0.132 (0.706)	-1.086 (1.183)
Observations	141,695	141,190	141,695	141,190	141,695	141,190
IV Lagged DV Regressions						
Adopted Board	11.733* (4.559)	-23.009 [†] (13.263)	-39.605 [†] (21.829)	32.509 (23.829)	3.279 (3.115)	-6.132 (9.789)
Observations	111,152	116,428	111,152	116,428	111,152	116,428
Instrument Strength and Validity Tests						
Cragg-Donald F statistic						
Treated	381.806	338.886	381.806	338.886	430.026	341.598
Chiropractic Board		699.318		699.318		634.419
Basic Science Board	455.011		455.011		488.752	
Sargan test p-value	1.000	1.000	1.000	1.000	1.000	1.000

Note: [†] $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Fixed effects models use stacked event study methodology comparing treated states to untreated states with event-county and event-year fixed effects. IV models instrument for licensing using non-bordering county health profession prevalence, with lagged dependent variables and cubic polynomial controls. Standard errors clustered by state in parentheses. Similar non-health professions include Electrical Engineers, Civil Engineers, Librarians, Mechanical Engineers, and Government Officials.

The instrumental variables results also show effects on other professions. The adoption of chiropractic boards shows a coefficient of -39.605 per 100,000 population for doctor prevalence (with large standard errors). For similar non-health professions, the chiropractic board coefficient is not significant, providing further evidence that the licensing effects are specific to health professions. The Cragg-Donald F-statistics range from 338 to 699, well above conventional thresholds for instrument relevance. The Sargan test p-values of 1 indicate that the null hypothesis of instrument exogeneity cannot be rejected.

The stark contrast in results between health professions (doctors and chiropractors) and similar non-health professions across all outcome measures—economic outcomes, educational attainment, and supply effects—provides strong validation that the observed patterns reflect profession-specific responses to healthcare regulation rather than broader economic trends affecting all skilled professions.

8 Conclusion

This paper establishes that occupational licensing boards respond strategically to competitive threats from substitute professions. The theoretical model demonstrates that when professional organizations can set licensing requirements independently, they engage in strategic interactions that affect market structure, professional quality, and consumer welfare. Simulations reveal that competition between boards can improve welfare relative to monopolistic regulation by creating a separating equilibrium that partially addresses information asymmetries in professional service markets.

The empirical analysis of medical and chiropractic licensing from 1907-1960 provides strong evidence for these strategic dynamics. Medical boards systematically tightened entry requirements following the establishment of chiropractic licensing boards in their states, increasing college requirements by 10 percentage points, mandating internships at rates exceeding 10 percentage points, and reducing passage rates by approximately 5 percentage points. These regulatory responses generated substantial economic consequences: doctors

experienced 26% increases in home values and gained 0.2 years of educational attainment, while their prevalence declined by 17-40 per 100,000 population. Chiropractors saw even larger gains, with 44% increases in home values, 0.6 additional years of education, and increased market presence.

The instrumental variables strategy, which exploits variation in non-bordering county characteristics within states, addresses endogeneity concerns arising from persistence in professional prevalence and potential reverse causality in board adoption. The absence of comparable effects for similar non-health professions validates that the observed patterns reflect profession-specific responses to healthcare regulation rather than broader economic trends. These findings have important implications for regulatory policy. First, analyses of occupational licensing that ignore competitive dynamics between professions may substantially mischaracterize welfare effects. Second, the strategic use of licensing to limit competition suggests that professional organizations may not act as benevolent regulators maximizing social welfare. Third, the welfare improvements from board competition relative to monopolistic regulation indicate that policy interventions preventing collusion between professional boards may yield social benefits.

Future research should extend this framework to contemporary licensing contexts where multiple professions compete, such as nurse practitioners and physicians, or mental health counselors and psychologists. Additionally, structural estimation of the model parameters would enable quantification of the welfare trade-offs between quality improvements and access restrictions under different regulatory regimes. As occupational licensing continues to expand across industries and professions, understanding these competitive dynamics becomes increasingly critical for effective regulatory design.

References

(1914). Current Comment. *Journal of the American Medical Association*, LXII(15):1176–1178.

- Akerlof, G. A. (1970). The market for “lemons”: Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics*, 84(3):488–500.
- Andrews, B. P. (2021). Reporting versus reputation: Physician quality and the flexner report of 1910. Technical report, Working Paper. Version: 11 December.
- Angrist, J. D., Imbens, G. W., and Krueger, A. B. (1999). Jackknife instrumental variables estimation. *Journal of Applied Econometrics*, 14(1):57–67.
- Blair, P. Q. and Chung, B. W. (2021). A model of occupational licensing and statistical discrimination. In *AEA papers and proceedings*, volume 111, pages 201–205. American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203.
- Cai, J. and Kleiner, M. M. (2020). The labor market consequences of regulating similar occupations: the licensing of occupational and physical therapists. *Journal of Labor Research*, 41:352–381.
- Carollo, N. A., Hicks, J. F., Karch, A., and Kleiner, M. M. (2022). The origins and evolution of occupational licensing in the united states. *Work Pap.*
- Cengiz, D., Dube, A., Lindner, A., and Zipperer, B. (2019). The effect of minimum wages on low-wage jobs. *The Quarterly Journal of Economics*, 134(3):1405–1454.
- Clay, K., Miller, G., Portnykh, M., and Schmick, E. J. (2025). Medical school closures, market adjustment, and mortality in the flexner report era. Technical report, National Bureau of Economic Research.
- Haines, M. R. (2001). The urban mortality transition in the united states, 1800-1940. In *Annales de démographie historique*, volume 101, pages 33–64. Belin.
- Johnson, C. D. and Green, B. N. (2021). Looking back at the lawsuit that transformed the chiropractic profession part 4: Committee on quackery. *Journal of Chiropractic Education*, 35(S1):55–73.

- Kaufman, B. E. (2002). Models of union wage determination: What have we learned since dunlop and ross? *Industrial Relations: A Journal of Economy and Society*, 41(1):110–158.
- Keating, J. C., Cleveland, C. S., and Menke, M. (2004). *Chiropractic History: A Primer*. Association for the History of Chiropractic Davenport, IA.
- Kleiner, M. M., Marier, A., Park, K. W., and Wing, C. (2016). Relaxing occupational licensing requirements: Analyzing wages and prices for a medical service. *The Journal of Law and Economics*, 59(2):261–291.
- Kleiner, M. M. and Soltas, E. J. (2023). A welfare analysis of occupational licensing in us states. *Review of Economic Studies*, 90(5):2481–2516.
- Larsen, B. J., Ju, Z., Kapor, A., and Yu, C. (2022). The effects of occupational licensing stringency on the market for public school teachers. Technical report, Technical report.
- Law, M. T. and Kim, S. (2005). Specialization and regulation: The rise of professionals and the emergence of occupational licensing regulation. *The Journal of Economic History*, 65(3):723–756.
- Leland, H. E. (1979). Quacks, lemons, and licensing: A theory of minimum quality standards. *Journal of Political Economy*, 87(6):1328–1346.
- Moehling, C. M., Niemesh, G. T., Thomasson, M. A., and Treber, J. (2020). Medical education reforms and the origins of the rural physician shortage. *Cliometrica*, 14(2):181–225.
- Paige, N. M., Miake-Lye, I. M., Booth, M. S., Beroes, J. M., Mardian, A. S., Dougherty, P., Branson, R., Tang, B., Morton, S. C., and Shekelle, P. G. (2017). Association of Spinal Manipulative Therapy With Clinical Benefit and Harm for Acute Low Back Pain: Systematic Review and Meta-analysis. *JAMA*, 317(14):1451–1460.
- Perry, J. J. (2009). The rise and impact of nurse practitioners and physician assistants on their own and cross-occupation incomes. *Contemporary Economic Policy*, 27(4):491–511.

- Plemmons, A. and Timmons, E. (2023). Occupational licensing: A barrier to opportunity and prosperity. *The Center for Growth and Opportunity*.
- Ruggles, S., Nelson, M. A., Sobek, M., Fitch, C. A., Goeken, R., Hacker, J. D., Roberts, E., and Warren, J. R. (2024). Ipums ancestry full count data: Version 4.0 [dataset]. minneapolis, mn: Ipums.
- Shaked, A. and Sutton, J. (1981). Heterogeneous consumers and product differentiation in a market for professional services. *European Economic Review*, 15(2):159–177.
- Shapiro, C. (1986). Investment, moral hazard, and occupational licensing. *The Review of Economic Studies*, 53(5):843–862.
- Wilson, C. A. (1979). Equilibrium and adverse selection. *The American Economic Review*, 69(2):313–317.

A Equilibrium Existence

This appendix provides a formal proof that a Walrasian equilibrium exists in the interior economy for any given entry costs (s_1, s_2) .

A.1 Setup and Definitions

For fixed entry costs (s_1, s_2) , define the excess demand functions:

$$Z_i(P_1, P_2) = D_i(P_1, P_2) - S_i(P_1, P_2), \quad i \in \{1, 2\}, \quad (19)$$

where

$$D_i(P_1, P_2) = m \cdot \frac{e^{\bar{U}_i}}{1 + e^{\bar{U}_1} + e^{\bar{U}_2}}, \quad (20)$$

$$S_i(P_1, P_2) = n_i(P_1, P_2) \cdot \frac{P_i}{2\gamma}, \quad (21)$$

with $\bar{U}_i = \alpha \bar{q}_i - \beta P_i + \psi_i$ and $n_i(P_1, P_2)$ given in the main text.

Standing Assumptions. Throughout the proof we assume:

1. $\beta > 0$ and $\gamma > 0$.
2. The worker ability distribution is log-normal with finite mean and variance; in particular, it admits a density $f(a)$ on $(0, \infty)$ with $\int_0^\infty f(a) da = 1$.
3. For each ability level a , the multinomial logit choice probabilities $\pi_i(a; P_1, P_2)$ are continuous in (P_1, P_2) and satisfy $0 \leq \pi_i \leq 1$.
4. Total worker mass m is finite.

These assumptions guarantee bounded demand and well-defined supply.

A.2 Price Domain

Define the compact price domain $S \subset \mathbb{R}_+^2$ as:

$$S = [P_{\min}, P_{\max}]^2. \quad (22)$$

Here $P_{\min} > 0$ is chosen such that $Z_i(P_{\min}, P_j) > 0$ for all $P_j \in [P_{\min}, P_{\max}]$ and $i, j \in \{1, 2\}$, while $P_{\max}$ is chosen such that $Z_i(P_{\max}, P_j) < 0$ for all $P_j \in [P_{\min}, P_{\max}]$.

Existence of such bounds follows from standard comparative statics: as $P_i \rightarrow 0^+$, demand from (20) remains strictly positive while supply from (21) tends to zero, so $Z_i \rightarrow +\infty$; as $P_i \rightarrow +\infty$, demand vanishes (since $\beta > 0$) while supply is positive, so $Z_i \rightarrow -\infty$.

A.3 Excess Demand Correspondence

For small $\alpha > 0$, define the correspondence $\Phi : S \rightrightarrows S$ by

$$\Phi(P_1, P_2) = \text{Proj}_S \left[(P_1, P_2) + \alpha (Z_1(P_1, P_2), Z_2(P_1, P_2)) \right], \quad (23)$$

where Proj_S denotes the orthogonal projection onto the convex set S . By construction this projection is unique, so Φ is in fact single-valued.

A.4 Verification of Kakutani Conditions

Lemma 1 (Domain Properties). *The set S is non-empty, compact, and convex.*

Proof. S in (22) is a closed, bounded rectangle in $\mathbb{R}^2$, hence compact. It is convex as the Cartesian product of convex intervals. Non-emptiness follows since $P_{\min} < P_{\max}$. $\square$

Lemma 2 (Continuity of Excess Demand). *The functions $Z_i(P_1, P_2)$ defined in (19) are continuous on S .*

Proof. Demand D_i in (20) is a composition of continuous functions. Supply depends on $n_i(P_1, P_2) = \int \pi_i(a; P_1, P_2) f(a) da$. The integrand is continuous in (P_1, P_2) and dominated by

$f(a)$, which is integrable. By the Dominated Convergence Theorem, n_i is continuous.

Therefore S_i in (21) and hence Z_i are continuous. $\square$

Lemma 3 (Convex Values). *For each $(P_1, P_2) \in S$, the set $\Phi(P_1, P_2)$ defined in (23) is non-empty and convex.*

Proof. Since projection is unique, $\Phi(P_1, P_2)$ is a singleton. Singletons are trivially non-empty and convex. $\square$

Lemma 4 (Closed Graph). *The correspondence Φ defined in (23) has a closed graph.*

Proof. Φ is single-valued and continuous, being the composition of continuous maps (addition and projection). A continuous function has a closed graph. $\square$

A.5 Existence Result

Theorem 1 (Interior Market Equilibrium Existence). *For any given entry costs (s_1, s_2) , there exists a Walrasian equilibrium in the interior economy.*

Proof. By Lemmas 1–4, the correspondence $\Phi : S \rightrightarrows S$ satisfies the conditions of Kakutani's Fixed Point Theorem. Hence there exists $(P_1^*, P_2^*) \in S$ such that

$$(P_1^*, P_2^*) \in \Phi(P_1^*, P_2^*). \quad (24)$$

By (23) and (24),

$$(P_1^*, P_2^*) = \text{Proj}_S \left[(P_1^*, P_2^*) + \alpha (Z_1(P_1^*, P_2^*), Z_2(P_1^*, P_2^*)) \right]. \quad (25)$$

If $(Z_1, Z_2) \neq (0, 0)$ at (P_1^*, P_2^*) , then the update $(P_1^*, P_2^*) + \alpha(Z_1, Z_2)$ points strictly into the interior of S , so the projection would differ from (P_1^*, P_2^*) , contradicting (24). Therefore we must have

$$(Z_1(P_1^*, P_2^*), Z_2(P_1^*, P_2^*)) = (0, 0).$$

Both markets clear, establishing equilibrium existence.

Equilibrium worker allocations (n_1^*, n_2^*) and average qualities $(\bar{q}_1^*, \bar{q}_2^*)$ then follow from the definitions in the main text. □