Draft

Licensing Engineers in the Labor Market

Yoon Sun Hur, University of Minnesota, Twin Cities

Morris M. Kleiner, University of Minnesota and NBER

Yingchun Wang, University of Houston, Downtown

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“Shortages and surpluses of engineers are a recurrent labor market problem
in the United States, which have attracted considerable public and professional
attention."

Richard B. Freeman, “A Cobweb Model of the Supply and Starting Salary of New Engineers,” *Industrial and Labor Relations Review*, 1976.

Introduction

Many analysts of the labor market for engineers have documented the issue of recurring booms and busts in the engineering labor market (Hanson,1961 and Freeman,1976). One public policy solution has been to regulate the market for engineers, especially ones that require licenses to practice in the occupation. Besides the stated public policy rationale that labor market regulation improves the public health and safety, it may also serve to reduce the fluctuations in the market for engineers. Licensing may create a “Web of Rules” that may result in a more orderly functioning of the labor market for the occupation (Dunlop, 1958). Further, engineers are viewed as an occupation that contributes greatly to innovation and economic growth. Any analysis that sheds light on the functioning of these labor markets, may contribute to an understanding of how institutional factors influence engineering’s contribution to technological change. However, the influence of licensing for engineers may be similar to markets for other regulated occupations which would suggest that it may restrict the supply of labor and result in an increase in wages and reduce the utilization of engineers in the production process (Kleiner, and Kudrle 2000, Kleiner, and Todd, 2009).

The topic of occupational licensing is an important and growing issue in the U.S. labor market since it is among the fastest growing institutions in the U.S. economy. In the 1950s about 4.5 percent of the workforce was licensed by state government (Kleiner, 2006). By 2008 approximately 29 percent of the U.S. workforce was licensed by any level of government, and more than 800 occupations were licensed by at least one state in the 1990s (Brinegar, and Schmitt, 1992, Kleiner and Krueger, 2009, PDII, 2008). This statistic compared with about 12.4 percent of the workforce who said they were union members in the Current Population Survey (CPS) for the same year (Hirsch and Macpherson, 2011). Although we do not have information on the trends for the licensing of engineers, there has been a decline in their level of unionization. Figure 1 shows the decline in unionization for civil, electrical, and industrial engineers from 1983 to 2010, with the steepest dip for electrical engineers. These are the specialties on which we will focus our analysis for this occupation.

Since occupational regulation has many forms, it is worthwhile to describe its various types. The occupational regulation of engineers in the United States generally takes three forms. The least restrictive form is registration, in which individuals file their names, addresses, and qualifications with a government agency before practicing their occupation. The registration process may include posting a bond or filing a fee. In contrast, certification permits any person to perform the relevant tasks, but the government—or sometimes a private, nonprofit agency—administers an examination or other method to determine qualifications and certifies those who have achieved the level of skill and knowledge for certification. For example, travel agents and car mechanics are generally certified but not licensed. The toughest form of regulation is licensure; this form of regulation is often referred to as “the right to practice.” Under licensure laws, working in an occupation for compensation without first meeting government standards is illegal. Our analysis provides the first look at the role of occupational licensing rather than the other two forms of governmental regulation on the labor market for engineers in the U.S.

We examine the role for occupational licensing in the labor market for engineers from 2000 through 2009. Initially we present the evolution and anatomy of occupational licensing for engineers. Next we present a theory of licensing and show how this form of regulation can lead to optimal outcomes, when the rents from licensing are taxed by the state and redistributed. In the following section we show the data for the analysis and present a Box and Whisker chart of the growth of regulation. Next we present our empirical analysis for three specialties in engineering, civil, electrical and industrial engineering when occupational licensing is included. In the conclusions we summarize our results.

Our theoretical model shows that government can grant a license to protect the public that also leads to rents for the members of the occupation. The government can then tax those rents through fees and continuing education requirements, and redistribute those funds to society. Further, we find that occupational licensing raises the wages of licensed engineers over time using our panel data. Also, there are employment declines in states that have the most rigorous forms of occupational licensing. These results are consistent with a monopoly model of licensing that we present in the theory section. These results suggest that using licensing fees from engineering practitioners to distribute to the public has the potential to be an optimal solution.

The Evolution and Anatomy of Licensing for Engineers

Similar to other occupations that became licensed, the government regulation of engineers began in the early 1900s (Council of State Governments, 1952). The first state to pass a licensure law was Wyoming, in 1907. Wyoming engineers were at the time concerned with water speculators who lacked the qualifications or experience of trained engineers, but were nonetheless using the term "engineer." The law was passed so that "all the surveying and engineering pertaining to irrigation works should be properly done." The American Society of

Civil Engineers (ASCE) supported this piece of legislation, but otherwise resisted the notion of state-controlled licensing. After 1910, many civil engineering associations supported the concept of state licensing in order to control specific aspects of the practice which would be regulated. The ASCE promulgated a model law for licensure in 1910. This shift in policy also helped civil engineering stay in line with other professions such as medicine and law, which had already accepted licensure (Haber 1991; Pfatteicher 1996).

Around 1920 the National Council of State Boards of Engineering Examiners, was formed to work for licensure in every state, help enforce regulations, and ensure appropriate levels of experience and education for professional practice. As more states adopted regulations for professional practice these engineering associations also became involved in advocating for the standardization of engineering curricula in professional schools and Universities.

It took nearly 45 years for all 50 states to require licensure for the practice of civil engineering.

In contrast, chemical, electrical, mechanical and petroleum engineering recognized as title holders and were covered by licensing following World War II. In the 1960s industrial engineering was recognized as a title branch. Table 1 shows the percent licensed in the U.S. according the National Council of Examiners for Engineering and Surveying (NCEES) in 1995. Civil engineering is by far the branch of engineering that is the most regulated with more than 44 percent of those practicing being licensed and more than twice as regulated as the next most licensed, mechanical engineers. As Table 1 shows about nine percent of the more than 800,000 electrical engineers, the largest category of professional engineers, are licensed, and only eight percent of industrial engineers were licensed in the 1990s.

In order to measure the level of difficulty that each of states sets for becoming a professional engineer, we develop an index of restrictiveness for engineers. Not only has the level of licensing increased but the intensity of the process of becoming licensed has become more difficult. Based on conversations with key officials at the NCEES, as well as with focus groups comprised of engineers, architects, and interior designers, we have identified the following central items as important in becoming licensed: a general age/education requirement, experience requirements, a written exam, a practical performance exam, a specific engineering specialty exam, reciprocity requirements from other states, and a continuing education requirement. These elements are the basis of an index of the rigor of the licensing process, in addition to the type of licensing. Using this index we can trace through the evolution of the intensity of the licensing index from 2000 through 2009. This evolution is shown in Figure 2 using a box and whisker graph of the sum of the key elements of the licensing regulations for engineers. The results show an upward movement in the mean values and a narrower spread in the variance of the licensing provisions. Occupational licensing is growing among states and its provisions to enter and maintain good standing as a licensed professional engineer are becoming more stringent.

The Theory of Optimal Licensing with Governmental Objectives

In order to provide a theoretical context for our empirical work we first review a model of the influence of licensing on the supply of labor. In the following section we focus on the demand for labor and how government can be an important factor in a licensing model. The analysis of wage determination under licensing in engineering builds on work by Perloff (1980) on the influence of licensing laws on wage changes in the construction industry. The basic model posits that market forces are largely responsible for wage determination, and that the demand is highly cyclical. Perloff presents two cases. In the first, there are no costs to shifting across industries so that the labor supply is completely elastic at the opportunity wage. In this case the increase in the demand for work would have little effect on wages since workers would flow between varying industries. With a licensing law, it renders the supply of labor inelastic. Here, labor cannot flow between the sectors so that variations in demand would be reflected in the wage. In his empirical work, Perloff shows that for electricians, more so than for either laborers or plumbers, state regulations make the supply curve highly inelastic. Consequently, the ability of a state to limit entry or impose major costs on entry through licensing would enhance the occupation's ability to raise wages. We would expect that a similar approach would apply to the market for engineers with more inelastic supply curves for civil relative to electrical and industrial engineers.

Unlike the work that has been developed on the supply side, there has been relatively little analysis of the demand for labor with occupational licensing or for the role for government other than a passive participant. Our formal model focuses on the demand for labor, and we develop a general model that we will apply to the regulation of engineers. We initially develop a model of rent seeking behavior with licensing as follows:

Let $q = D(p)$ be the demand of the good in the market. Let $C(q)$ be the cost of producing q units of this good. Assume that the demand function has a constant elasticity: $q = D(p) = p^{-\varepsilon}$ where $\varepsilon > 1$ is the elasticity of demand. Where elasticity is lower than 1, the revenues, and thus the profits, are decreasing in quantity (i.e. increasing in price). Therefore, where $\varepsilon >= 1$, engineers will not adopt occupational licensing. Under these stylized assumptions there is assumed to be a relatively inelastic demand for engineering skills that cannot be substituted for by unregulated engineers or licensed architects or licensed interior designers. Marginal cost is constant and equal to c.

The total profits of the occupation, Π, is

$$\Pi = \max_{p}(p - c)p^{-\varepsilon}$$

(i) Before occupational licensing, the maximum is obtained through marginal cost pricing: p^c = $C'(q) = c$.

(ii) The total profits under occupational licensing corresponds to price $p^m = c/(1-1/\varepsilon)$, which yields

$$\Pi^m = (c/(1-1/\varepsilon) - c)p^{-\varepsilon}$$

(iii) The differences between the profits of competitive market and the monopoly market yields the economic rents of adopting occupational licensing

$$R = \Pi^m - \Pi^c = \frac{c^{1-\varepsilon}}{\varepsilon - 1}\left(\frac{\varepsilon}{\varepsilon - 1}\right)^{-\varepsilon}$$

Optimal licensing policy could exist where the state raises fees, *F*, to capture the rents of the monopolists which are the licensed workers in our case engineers, minus monitoring costs of the occupation, denoted as *m*, so that the workers are indifferent between licensing and remaining unregulated.

$$F = R = \frac{c^{1-\varepsilon}}{\varepsilon - 1}\left(\frac{\varepsilon}{\varepsilon - 1}\right)^{-\varepsilon}$$

The government will earn the following profits from the licensing, with *m(N)* being the monitoring cost, and *N* being the number of new workers allowed in. The monitoring costs will increase when more new workers are allowed in (i.e. *m'(N) > 0*), so for government to maximize government revenue *G*, the government will limit the number of new workers, and increase the continuing license fees to capture the rent of the occupation's incumbents (if the government can implement such policies without obstacles)[1].

$$G = R - m = \frac{c^{1-\varepsilon}}{\varepsilon - 1}\left(\frac{\varepsilon}{\varepsilon - 1}\right)^{-\varepsilon} - m(N)$$

Investigating the above equation, we find that $\frac{\partial F}{\partial c} = -c^{-\varepsilon}\left(\frac{\varepsilon}{\varepsilon - 1}\right)^{-\varepsilon} < 0$, which means that the higher the unit cost of the goods or service, the lower the occupational fees will be. Therefore, if the cost of becoming a licensed engineer increases the fees charged by government to work would go down.

Computations also show that the state fees are negatively associated with the demand elasticity, which means that the higher the demand elasticity, the lower the state fees will be.

$$\frac{\partial F}{\partial \varepsilon} = -\frac{\left(\frac{\varepsilon}{\varepsilon - 1}\right)^{1-\varepsilon} c^{1-\varepsilon}\left(\log\left(\frac{\varepsilon}{\varepsilon - 1}\right) + \log(c)\right)}{\varepsilon} < 0$$

To relax the assumption of the model presented above we state that if there are heterogeneous consumers (i.e. employers/clients who hire engineers in this context) with varying demand and the information is available to the occupation, the incumbents in the occupation could charge different prices according to the different demands (i.e. price discrimination). In such a case, the

[1] The government can either allow more workers into the occupation and grow revenue or raise fees. If too many are allowed into the occupation wages drop, and workers will stop entering the occupation or drop out of the occupation into an unregulated one where the government cannot collect fees.

monopolistic occupation could capture the entire consumer surplus, and the profits of the licensed occupation would become

$$\Pi_d^m = \int_0^{c^{-\varepsilon}} [q^{-1/\varepsilon} - c]dq$$

With some calculation, the profit is $\Pi_d^m = c^{1-\varepsilon} / (\varepsilon - 1)$, which is larger than the one with no price discrimination: $\Pi^m = \frac{c^{1-\varepsilon}}{\varepsilon - 1}\left(\frac{\varepsilon}{\varepsilon - 1}\right)^{-\varepsilon}$.

But usually, consumers will try to withhold the information about their demands to retain consumer surplus. If this is the case, profits will be the same as the one with no price discrimination. Therefore, consumers' ability to conceal demand information depends on different types of occupations. For example, engineers could have this type of information to some extent, and they could charge differently by client.

The implications of the model are that government can tax away rents from licensed occupations and redistribute them. The consequence can be a consumer surplus, if the rents are appropriately distributed and if the enhanced quality for persons receiving the service is greater than those not getting the regulated service. If individuals in the lower part of the distribution receive these rents, they can receive a higher quality service through licensing. In the empirical section we examine whether in the case of engineers there are rents that government could redistribute.

Data, Model, and Estimation

We now present the details of the information on the regulations facing engineers and the labor market conditions of the three types of engineers, civil, electrical and industrial. Table 2 displays the key elements (and their operational definition) of the licensing provisions in the statutes and administrative provisions that we plan to examine for each of the states in our sample for engineers. In the Appendix we present our survey of the various licensing statutes regulating the occupation over time by state. It tabulates only the changes in occupational regulations in state statutes. For example, engineers in Alaska were licensed at the state level and the key elements of the licensing provisions did not change between 1995 and 2009.

Table 3 gives the growth in the statutes by year over the period from 1995 through 2009. The results indicate that the occupation experienced growth in regulations governing the entry and training requirements. The level of the index or the number of items included in the measure grew from 5.69 to 6.16 or by more than 8 percent. This reflects the intensity of the growth of requirements to enter and maintain being an engineer. Further the standard deviation declined by almost 14 percent suggesting greater standardization of the requirements for licensing.

Finally in Table 4 we show the relative ranking of the states that have the highest and lowest values in the index. We also show values that were established through an expert systems approach, where an engineering and law student was given the data and asked to rank the states based on issues that were important to him as a professional in the field. In the Appendix we show which of the 25 states that changed their statutes on the licensing of engineers.

Economic Data

As a key part of our examination of the influence of regulation on the labor market for engineers, we use data from the American Community Survey (ACS) from 2000-2009. Table 5 presents the basic information that we used for our analysis. These variables include the standard variables from the ACS to include human capital variables such as gender, age, experience, education, and race. The means and standard deviations for the basic variables in the ACS are included in Table 5. They show that there are small differences in human capital characteristics such as age, experience, or education. However, a much higher percentage of civil engineers work for government and are self-employed than in the other two types of engineering. However, the hourly earnings of electrical engineers are the highest of the three categories. Generally the licensing requirements for civil engineers have been in force the longest and are the most detailed across states. For the employment level and change data we use the Occupational Employment Survey (OES). This is data gathered by the Bureau of Labor Statistics by state.

Wage Determination

Our empirical strategy is to first examine the three types of engineers, civil, electrical and industrial, that vary greatly in the type of regulation that influences their ability to find employment. Our basic model uses an earnings function and compares the three types of engineers with the least regulated one industrial engineers being the excluded category. Our basic model is of the following form:

1) $\ln(\text{Earnings}_{ist}) = \alpha + \beta T_{st} + \gamma X_{ist} + \delta_s + \theta_t + \varepsilon_{ist}$,

where $Earnings_{ist}$ is the hourly earnings of engineers i at state s in year t; T_{st} is the type of engineer (civil, electrical, or industrial) person i's state s in year t; $\boldsymbol{X}_{ist}$ is the vector that includes covariates measuring characteristics of each person; δ and η are state and year fixed effects, respectively; and ε_{ist} is the error term in our panel data.

The estimates in panel A of Table 6 show that electrical and civil engineers earn between approximately 7 and 18 percent more than the least regulated category of industrial engineers when human capital and state and year fixed effects characteristics are accounted for in our analysis. The analysis shows that electrical engineers, the specialty that is in middle group in terms of number regulated and length of the time since the occupation was first licensed has the highest hourly earnings.

Panel B shows the estimates of the Cobweb model of the labor market for these categories of engineers (Freeman, 1976). The model explicitly takes into account the lags in education time to fill positions in engineering. The estimates show that are the effects of being a in a more regulated branch of engineering raises wage between 7 to 13 percent using this model.

In a similar manner, we examine employment growth for each of the categories of engineers from 2000 to 2009. The basic model is of the following form

2) $Employment_{st} = \alpha + \beta T_{st} + \gamma X + \delta_s + \eta_t + \mu_{st},$

where $Employment_{st}$ is the employment growth of engineers at state s in time period t; T_{st} is the type of engineers at state s in time period t; the vector $\boldsymbol{X}_{st}$ includes covariates measuring economic and human capital characteristics within each state; δ_s and η_t are state and year fixed effects, respectively; and u_{st} is the error term.

In contrast to the estimates shown in Table 6 which uses the ACS, we estimate employment data for engineers gathered from the OES in the models estimated in Table 7. Our results show that in the model where state and year year fixed effects characteristics are accounted for in our analysis, the employment effects are modest, but with slower growth in those specialties where wages are higher. For example, the employment growth rate for electrical engineers is about 5 percent less than for industrial engineers, but there was no statistical difference in the employment growth rates between civil and industrial engineers.

Licensing Statutes

We next turn our attention to analyzing state specific regulations in the licensing of engineers. Initially we examine and estimate an earnings model with licensing regulations. The basic model is specified as follows:

3) $\ln(\text{Earnings}_{ist}) = \alpha + \beta R_{st} + \gamma X_{ist} + \delta_s + \theta_t + \varepsilon_{ist},$

where $Earnings_{ist}$ is the hourly earnings of engineers *i* at state *s* in year t; R_{st} is the licensing occupational regulations and components of the regulation in person *i*'s state s in year t; $\boldsymbol{X}_{ist}$ is the vector that includes covariates measuring characteristics of each person; δ and η are state and year fixed effects, respectively; and ε_{ist} is the error term in our panel data.

In Table 8 we show the estimates from the above model of the influence of licensing on wages for engineers. The results show that the licensing index variable matters in most of the specifications in the model. For example, the summated rating scale of licensing at the state level variable is statistically significant, and the coefficient is about 6 percent in the fully specified model. Various sensitivity tests showed similar results. [2]

The employment effects of variations in state statutes for engineers are shown in Table 9. The general employment equation can be stated as follows:

4) $Employment_{st} = \alpha + \beta R_{st} + \gamma X + \delta_s + \eta_t + \mu_{st},$

where $Employment_{st}$ is the employment growth of engineers at state *s* in time period *t*; R_{st} is the regulation measure and its components at state *s* in time period *t*; the vector $\boldsymbol{X}_{st}$ includes covariates measuring economic and human capital characteristics within each state; δ_s and η_t are state and year fixed effects, respectively; and u_{st} is the error term.

[2] We used our expert systems ranking and a Rasch measures, which is a nonlinear measure of the index and found similar results to those presented in Table 8. In addition, we estimated various falsification tests of the index and found results for engineers but not for the unregulated occupations.

The estimates in Table 9 using the OES show that the regulation index is associated with a reduction in employment growth for the engineers in our sample ranging between 11 and 16 percent. Further sensitivity tests using a Rasch measure and alternative weights to the index found consistent results, and are available from the authors. Overall our results show that the licensing index is associated with somewhat higher wages and slower employment growth for the engineers in our sample.

Conclusions

Our paper presents the first comprehensive analysis of the role of occupational licensing on the labor market for civil, electrical, and industrial engineers. These are the largest number of engineers which are covered by occupational licensing statutes in the U.S. We initially develop the historical evolution of licensing for engineers. Second, we develop a theoretical rationale for the role for government in the labor market for the occupation. The government can allow rents to occur if it can collect them through licensing fees and continuing education charges, and redistribute these rents to its citizens who are at the lower part of the income distribution. This has the potential to be an optimal solution for occupational licensing when certain conditions are met.

In the empirical section we show that licensing for these occupations has grown more rigorous from 1995 to 2009. We then estimate OLS and Cobweb models of the engineering labor market for the engineers in our sample. We find that the more generally regulated engineers earn higher wages and but have modestly lower employment growth in the models. In the subsequent section we find that using detailed measures of more restrictive licensing statutes are associated with higher wages for engineers but with slower employment growth. These estimates suggest that rents exist for the government to distribute these gains that was a key finding of the theoretical section.

Although the regulation of engineers may provide a consistent set of rules and potential rents for engineers that may reduce the variation in their numbers, this may come at the cost of higher wages and slower employment growth in the occupation. A consequence of the growth of regulation of the occupation may be to reduce access to engineers by their customers, and a slowing down of the ability of builders and manufacturers to use their vital services in the U.S. economy. Our study provides a first look at the issue. However, the potential issue of selection across engineering specialties, and more use of more detailed analysis such as the use of discontinuities when the passage of a law occurs, may provide more refined or precise estimates and examples of the role of regulation in the market for engineers.

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Figure 1: Percent Unionization for Civil, Electrical, and Industrial Engineers, 1983 and 2010

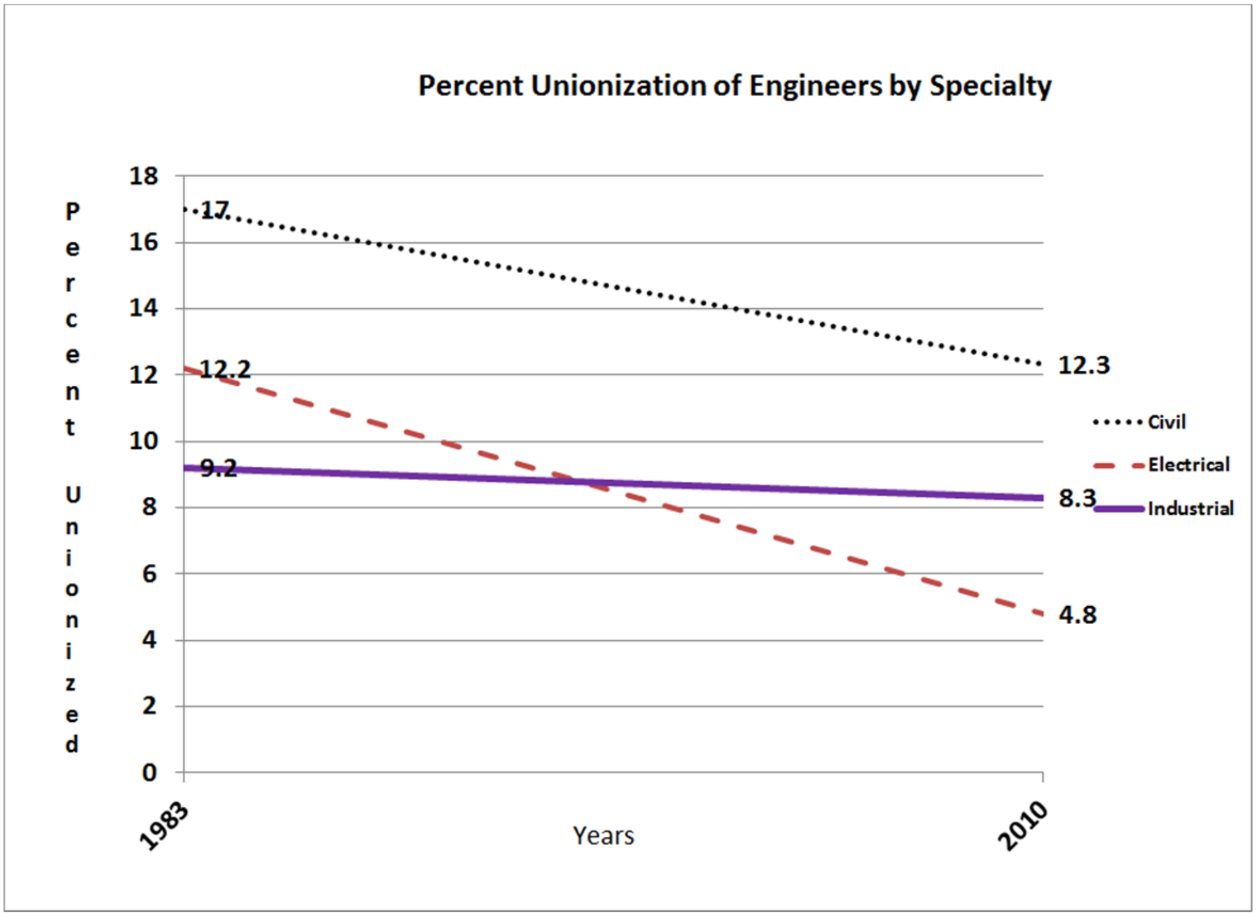

Figure 2: Box and Whisker Plot of the Growth of Licensing Provisions, 1995-2009

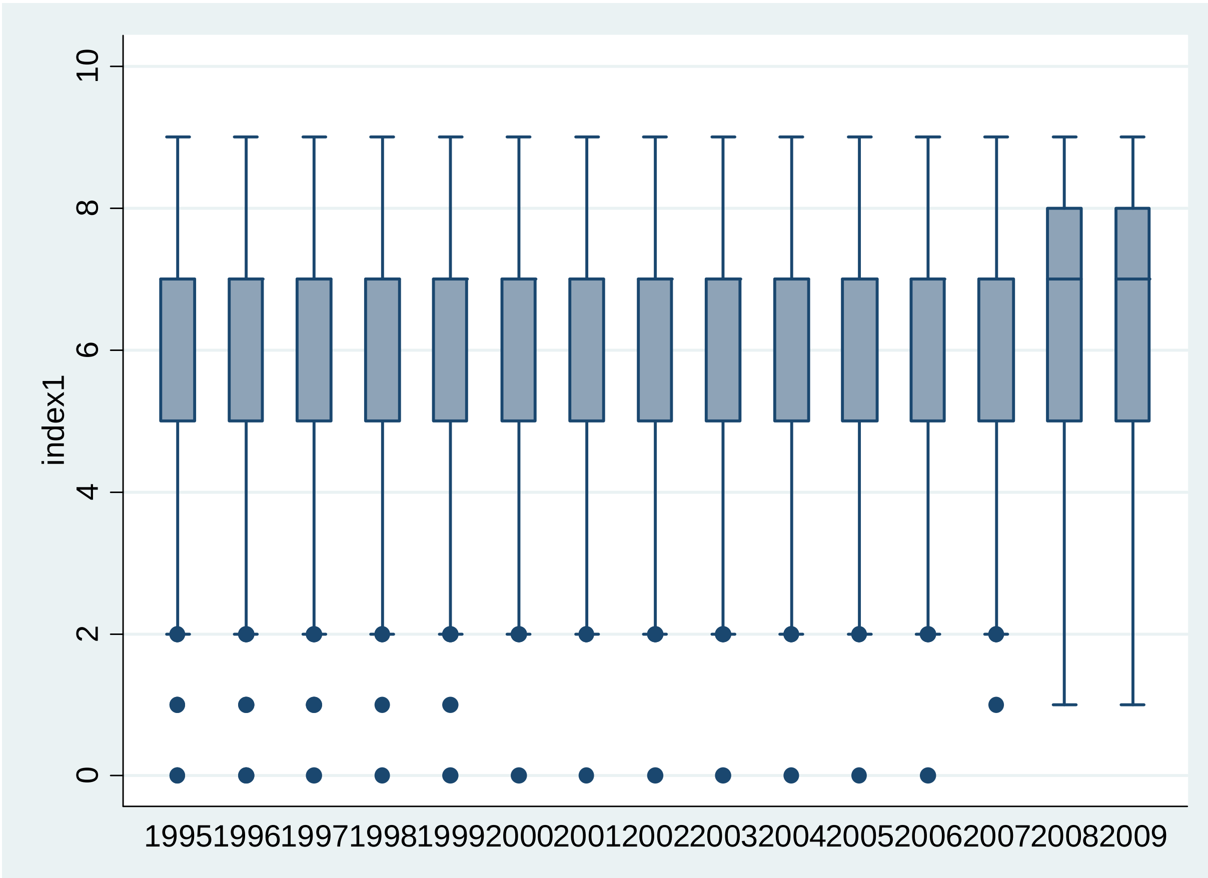

Table 1: Percent of Engineers who are licensed by Specialty:1995*

Engineering Discipline	**Approx. # Engineers**	**Approx. # Licensed**	**Percent Licensed**
Civil	360,000	160,000	44
Mechanical	395,000	91,000	23
Electrical	803,000	73,000	9
Chemical	180,000	15,000	8
Industrial	133,000	11,000	8
Agricultural	40,000	5,000	13
Mining/Metals	30,000	5,000	17
Other	259,000	40,000	15
Total	2,200,000	400,000	18

*Paul Taylor (NCEES Licensure Bulletin, December, 1995)

Table 2: Key variable in the development of the licensing index for engineers

Major components	Definition
Education requirement	3 if a minimum level of education is required to be licensed is bachelor degree; 2 if it is associates degrees; 1 if board decides; otherwise 0
Experience Requirement	3 if a minimum level of education is required to be licensed is 8 years; 2 if it is 4 years; 1 if it is 2 years; 0 if no requirement
Professional exam requirement	1 if Professional exam is required to be licensed; otherwise 0
Fundamental exam requirements	1 if Fundamental of engineering exam is required; otherwise 0
Interim exam requirement	1 if exam required for interim permit; otherwise 0
Continuing education requirement	1 if state has any requirement for continuing education; otherwise 0
Specific exam requirement	1 if specific additional exam is required for engineering discipline; otherwise 0

Table 3: Growth of Occupational licensing Intensity over Time

Year	# of state	Mean	Std. Dev.	Min	Max
1995	51	5.76	2.21	0.00	9.00
1996	51	5.80	2.25	0.00	9.00
1997	51	5.94	2.09	0.00	9.00
1998	51	6.04	1.95	0.00	9.00
1999	51	6.04	1.95	0.00	9.00
2000	51	6.06	1.86	0.00	9.00
2001	51	6.06	1.86	0.00	9.00
2002	51	6.08	1.87	0.00	9.00
2003	51	6.08	1.87	0.00	9.00
2004	51	6.12	1.91	0.00	9.00
2005	51	6.14	1.91	0.00	9.00
2006	51	6.14	1.91	0.00	9.00
2007	51	6.18	1.87	1.00	9.00
2008	51	6.22	1.90	1.00	9.00
2009	51	6.22	1.90	1.00	9.00

Table 4 State Regulation Rankings of the Top and Bottom States For the Restrictiveness of their Licensing in 2009

Top States		**Bottom States**	
States	Index	States	Index
Pennsylvania	9	Virginia	1
Texas	9	Alaska	2
Alabama	8	D.C	2
Colorado	8	Minnesota	2
Florida	8	South Dakota	3
Georgia	8	Connecticut	4
Idaho	8	Delaware	4
Kentucky	8		
Michigan	8		
North Dakota	8		
Ohio	8		
South Carolina	8		
Tennessee	8		

Table 5: Key variable in on Engineers in the ACS from 2001 to 2009

	Civil Engineers		Electrical Engineers		Industrial Engineers	
	Mean	S.D	Mean	S.D	Mean	S.D
Age	42.209	11.298	43.065	10.492	43.408	10.647
Schooling(in Year)	16.237	1.474	16.167	1.642	15.654	1.659
Gender(Male:1; Female:0)	0.876	0.330	0.913	0.282	0.816	0.387
Married (Married:1; Not Married:0)	0.740	0.439	0.758	0.428	0.746	0.435
Experience(in Year)	19.972	11.339	20.899	10.738	21.755	10.943
Experience-Squared	527.428	476.937	552.054	463.852	593.005	482.253
White(White:1; Others:0)	0.848	0.359	0.801	0.399	0.868	0.339
Black(Black:1;Others:0)	0.035	0.184	0.039	0.195	0.036	0.186
Citizen(U.S. Citizen:1; Others:0)	0.945	0.227	0.910	0.286	0.945	0.228
Work for For-Profit(Yes:1; No:0)	0.682	0.466	0.881	0.323	0.929	0.258
Work for Not-for-Profit(Yes:1;No:0)	0.011	0.106	0.019	0.138	0.012	0.107
Work for Government(Yes:1; No:0)	0.262	0.440	0.085	0.279	0.054	0.225
Self-employment(Yes:1; No:0)	0.045	0.206	0.014	0.118	0.006	0.079
Hourly Earnings(in 2009 dollars)	32.933	15.837	35.434	15.020	28.532	11.369

Table 6 Estimates of the Engineering Type (Civil, Electrical, and Industrial) on Wage Determination (ACS)

Panel A: OLS

VARIABLES	(1) log_h_wage	(2) log_h_wage	(3) log_h_wage	(4) log_h_wage	(5) log_h_wage	(6) log_h_wage
Civil Eng.	0.096***		0.085***	0.072***	0.085***	0.072***
	(0.005)		(0.005)	(0.006)	(0.005)	(0.006)
Elec. Eng.	0.181***		0.145***	0.140***	0.145***	0.140***
	(0.005)		(0.005)	(0.005)	(0.005)	(0.005)
Experience		0.037***	0.037***	0.037***	0.037***	0.037***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Experience squared		-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Schooling		0.088***	0.085***	0.084***	0.085***	0.084***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gender		0.096***	0.077***	0.078***	0.077***	0.078***
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Marriage		0.084***	0.084***	0.084***	0.084***	0.084***
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
White		0.016**	0.020***	0.020***	0.020***	0.020***
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Black		-0.051***	-0.050***	-0.050***	-0.050***	-0.050***
		(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Citizen		0.050***	0.052***	0.051***	0.052***	0.051***
		(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Work for profit		0.048***	0.053***	0.045***	0.053***	0.045***
		(0.005)	(0.005)	(0.006)	(0.005)	(0.006)
Work for non-profit		0.048***	0.041**	0.045***	0.041**	0.045***
		(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Self employed		-0.051***	-0.053***	-0.067***	-0.053***	-0.067***
		(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Constant	3.125***	1.146***	1.127***	1.155***	1.088***	1.118***
	(0.020)	(0.030)	(0.030)	(0.030)	(0.038)	(0.038)
Year fixed	YES	YES	YES	YES	YES	YES
State fixed	YES	YES	YES	YES	YES	YES
Industry Control	NO	NO	NO	YES	NO	YES
Region Control	NO	NO	NO	NO	YES	YES
Observations	46,493	46,493	46,493	46,493	46,493	46,493
R-squared	0.091	0.280	0.294	0.295	0.294	0.295

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Panel B: Cobweb Model Estimates on Wage Determination

VARIABLES	(1) ln_meanwage	(2) ln_meanwage	(3) ln_meanwage
Civil Eng.	0.108***		0.071***
	(0.014)		(0.016)
Elec. Eng.	0.169***		0.125***
	(0.013)		(0.013)
Experience		0.027***	0.026***
		(0.005)	(0.004)
Experience squared		-0.001***	-0.000***
		(0.000)	(0.000)
Schooling		0.113***	0.096***
		(0.008)	(0.008)
Gender		0.111***	-0.002
		(0.039)	(0.039)
Marriage		0.085***	0.094***
		(0.030)	(0.029)
White		-0.039	-0.011
		(0.056)	(0.054)
Black		0.085	0.075
		(0.090)	(0.086)
Citizen		-0.106	-0.045
		(0.070)	(0.067)
Work for profit		0.072**	0.079**
		(0.030)	(0.033)
Work for non-profit		0.215***	0.151*
		(0.082)	(0.080)
Self employed		0.314***	0.277***
		(0.086)	(0.083)
lag_wage1	-0.118***	-0.114***	-0.091***
	(0.030)	(0.027)	(0.027)
lag_wage2	-0.072**	-0.153***	-0.069***
	(0.029)	(0.026)	(0.026)
lag_wage3	0.041	0.150***	0.059**
	(0.029)	(0.026)	(0.026)
lag_wage4	0.006	-0.040	-0.012
	(0.029)	(0.026)	(0.026)
Constant	3.705***	1.693***	1.747***
	(0.213)	(0.261)	(0.253)
Year fixed	YES	YES	YES
State fixed	YES	YES	YES
Observations	1,160	1,160	1,160
R-squared	0.502	0.556	0.594

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7 Estimates of the Engineering Type (Civil, Electrical, and Industrial) on Employment Growth (OES)

VARIABLES	(1) log_emp	(2) log_emp	(3) log_emp	(4) log_emp	(5) log_emp	(6) log_emp
Civil Eng.	0.413***					0.001
	(0.026)					(0.014)
Elec. Eng.	-0.116***					-0.033**
	(0.026)					(0.017)
Hourly wage		-0.050***				0.004
		(0.005)				(0.004)
lag_empolyment1			0.961***		0.882***	0.876***
			(0.034)		(0.035)	(0.035)
lag_empolyment2			0.032		0.042	0.040
			(0.047)		(0.046)	(0.046)
lag_employment3			-0.227***		-0.213***	-0.217***
			(0.047)		(0.046)	(0.046)
lag_employment4			0.223***		0.227***	0.234***
			(0.034)		(0.035)	(0.036)
lag_wage1				0.078**	0.002	0.000
				(0.035)	(0.004)	(0.005)
lag_wage2				-0.004	-0.013**	-0.013**
				(0.046)	(0.006)	(0.006)
lag_wage3				-0.033	0.006	0.008
				(0.048)	(0.006)	(0.006)
lag_wage4				0.010	-0.007	-0.006
				(0.039)	(0.005)	(0.005)
Constant	7.727***	9.251***	0.111***	5.967***	0.907***	0.791***
	(0.084)	(0.175)	(0.035)	(0.439)	(0.151)	(0.162)
Year fixed	YES	YES	YES	YES	YES	YES
State fixed	YES	YES	YES	YES	YES	YES
Observations	1,360	1,360	726	752	726	726
R-squared	0.898	0.872	0.986	0.026	0.988	0.988

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8 Estimates of the Influence of Licensing Restrictiveness Index on Wage Determination for Civil, Electrical and Industrial Engineers, ACS

VARIABLES	(1) log_wage	(2) log_wage	(3) log_wage	(4) log_wage	(5) log_wage	(6) log_wage	(7) log_wage	(8) log_wage	(9) log_wage
Index	-0.01								0.06***
	(0.010)								(0.022)
Education		0.00							-0.06**
		(0.011)							(0.025)
Experience			-0.04**						-0.05*
			(0.015)						(0.030)
Prof.Exam				-0.09**					-0.09**
				(0.036)					(0.037)
Fund. Exam					0.15***				
					(0.032)				
Interim exam						0.07			0.01
						(0.047)			(0.052)
Cont.Ed.							-0.01		-0.07***
							(0.010)		(0.026)
Special exam								0.09**	
								(0.036)	
Constant	1.21***	1.13***	1.21***	1.22***	0.98***	1.14***	1.15***	1.13***	1.09***
	(0.086)	(0.037)	(0.036)	(0.047)	(0.038)	(0.031)	(0.032)	(0.031)	(0.029)
Basic control	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES	YES	YES	YES	YES	YES
State fixed	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	43,968	43,968	43,968	43,968	43,968	43,968	43,968	43,968	43,968
R-squared	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9 Estimates of the Influence of Licensing Restrictiveness Index on Employment Growth for Civil, Electrical and Industrial Engineers, OES

VARIABLES	(1) log_emp	(2) log_emp	(3) log_emp	(4) log_emp	(5) log_emp	(6) log_emp	(7) log_emp	(8) log_emp	(9) log_emp
Index	-0.11***								-0.16**
	(0.032)								(0.082)
Education		0.59***							0.59***
		(0.018)							(0.083)
Experience			0.88***						0.80***
			(0.027)						(0.061)
PE				-0.14					
				(0.124)					
FE					1.76***				-0.61***
					(0.054)				(0.144)
Interim exam						-0.16*			
						(0.082)			
Cont. edu.							-0.09***		0.07
							(0.034)		(0.087)
Spec. exam								0.14	0.13
								(0.124)	(0.122)
Constant	9.78***	7.18***	7.18***	9.08***	7.18***	8.94***	9.03***	8.94***	7.43***
	(0.256)	(0.042)	(0.042)	(0.128)	(0.042)	(0.042)	(0.052)	(0.042)	(0.097)
Year fixed	YES	YES	YES	YES	YES	YES	YES	YES	YES
State fixed	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	423	423	423	423	423	423	423	423	423
R-squared	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990	0.990

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix: States that Changed their Licensing Requirements between 1995 and 2009

Status changed between 1995-2009	**Status not changed between 1995 and 2009**
Alabama	Alaska
California	Arizona
Deleware	Arkansas
Florida	Colorado
Georgia	Connecticut
Idaho	District of Columbia
Kentucky	Hawaii
Louisiana	Illinois
Minnesota	Indiana
Mississippi	Iowa
Nebraska	Kansas
Nevada	Maine
New York	Maryland
North Carolina	Massachusetts
North Dakota	Michigan
Ohio	Missouri
Pennsylvania	Montana
Rhode Island	New Hampshire
South Carolina	New Jersey
South Dakota	New Mexico
Tennessee	Oklahoma
Texas	Oregon
Utah	Washington
Vermont	West Virginia
Virginia	Wisconsin
	Wyoming