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THE LABOR MARKET EFFECTS OF OCCUPATIONAL LICENSING IN THE PUBLIC SECTOR

Morris M. Kleiner
Wenchen Wang

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ABSTRACT

In the U.S., occupational licensing is more prevalent in the public sector than in the private sector, but the influence of occupational regulation for public sector workers has not been analyzed in detail. Our study initially examines the probability of a licensed worker selecting into the public sector. Using the probability as a control for these individuals' risk aversion, we next examine how licensing impacts key labor market outcomes, such as wages, hours worked, and employment in the public sector. Our results show that having an occupational license increases the likelihood of working in the public sector. After adjusting for the selection bias of choosing into the public sector, we find that being in a licensed occupation in the public sector raises wages by about 6% and increases hours worked, but reduces employment, even when controlling for other labor market institutions that also are more prevalent in the public sector such as unionization. Overall, our estimates suggest that the social welfare effects of licensing in the public sector are like those for the whole sample, and they generally result in a welfare loss in the public sector.

Morris M. Kleiner
University of Minnesota
Humphrey School of Public Affairs
260 Humphrey Center
301 19th Street South
Minneapolis, MN 55455
and NBER
kleiner@umn.edu

Wenchen Wang
University of Minnesota
820 Emerald Street SE
Humphrey School of Public Affairs
Saint Paul, MN 55114
wang6054@umn.edu

1. Introduction

Occupational licensing has become one of the most important labor market institutions influencing wages and employment in the U.S. The proportion of workers in the U.S. who have attained an occupational license from the government in order to work for pay has grown from less than 10% of the workforce in the 1970s to approximately 25% (Kleiner and Krueger, 2010, Cunningham, 2019). The influence of occupational licensing in the public sector may be different from that in the private sector for several reasons. First, the percentage of workers who are licensed in the public sector is twice as high as the percentage of licensed workers in the private sector (Cunningham, 2019). Second, there are often differences in the methods of wage and hours setting, as well as employment, in the public and private sectors (Freeman and Valletta, 1988). Third, job stability and duration of employment are higher in the public sector than in the private sector, resulting in differing worker characteristics. In this study, we provide the first in-depth analysis of this issue and develop models of the role of individuals' choice to work in the public or private sector by their regulatory status. We also examine how occupational licensing influences key labor market outcome variables in the public sector and the private sector. Finally, we provide estimates of the welfare effects of occupational licensing in the public sector and compare them with results for the whole sample.

As background, there are differences in the process and outcomes of wage and employment determination in the public and private sectors.[2] One reason for potential wage gaps is that

[2] For example, first, employment in the public sector is much smaller than that in the private sector. The Bureau of Labor Statistics (BLS) shows that in September 2020, total employment in the U.S. was around 141.87 million jobs, with the public sector accounting for 15.4% (21.86 million jobs), while the total private sector accounted for 84.6% (120.01 million jobs) (BLS Report, 2020 *[this source seems to be missing from the references*]). Second, average wages for public sector workers were $22.55 at the state government level and $22.33 at the local government level, compared with $21.55 in the private sector (Gittleman and Pierce, 2011).

decision making on government employment and wages takes place partially in a political setting, but private sector outcomes are more likely to occur in a market environment. More specifically, in the public sector, the decision makers for the employment relationship are politicians and bureaucrats; in the private sector, they are the owners of capital (Gregory and Borland, 1999). Given these differences in the methods of wage setting in the sectors, the role of occupational licensing also may have differential effects. Public sector wage and employment setting may respond differently to the regulatory constraints imposed by occupational licensing.

The academic literature has examined both the demand and supply implications of the labor market effects of licensing (Bryson and Kleiner, 2020). Kleiner and Krueger (2010) find that licensing generates around a 15% wage premium while not significantly reducing wage dispersion for licensed workers; they further demonstrate even bigger wage effects of 23% when interacted with union effects (Kleiner and Krueger, 2010). Gittleman et al. (2018) find a wage premium of around 5% using Survey of Income and Program Participation (SIPP) data which uses somewhat different questions than the ones asked in other surveys, and they also conclude that licensing is associated with higher probabilities of being employed and receiving health insurance from employers. Blair and Chung (2022) show that licensing reduces equilibrium labor supply by an average of 17% to 27% by estimating market share ratios; and Kleiner and Soltas (2023) find that licensing raises wages and hours but reduces employment by similar percentages. Johnson and Kleiner (2020) show that occupational licensing reduces interstate migration, while Kleiner and Xu (2020) show that licensed workers have lower cross occupational mobility. Han and Kleiner (2021) demonstrate that the duration of the licensing statute and grandfathering of previously unregulated workers into occupational licensing are positively associated with wage growth but in a nonlinear manner.

In the reduced form estimates between the public and private workers, the literature generally finds that public sector employees have a wage premium. However, the wage effect is larger at the federal level but is smaller or even negative at the state and local level (Krueger and Summers, 1988; Belman and Heywood, 1989; Venti and Smith, 2008). When comparing both the wages and benefits between workers in the public and private sectors, public sector workers have higher compensation than private-sector ones. Heywood (1991) finds that working in the public sector increases the probability of an employee's having pension plan, life insurance, sick leave, and vacation leave in their compensation; and Gittleman and Pierce (2011) finds ambiguous wage only effects of being in the public sector, but positive overall compensation effects of working in the public sector. The comparisons of earning distributions between the two sectors finds a pattern of higher earning dispersion for private sector employees (Katz and Krueger, 1991; Poterba and Rueben, 1994), while the effects on employment are inconclusive (Gregory and Borland, 1999).

When describing the labor market institution of licensing and its effect on the labor market, it is useful to compare it to the other major labor market institution of unionization. Unions have organized almost 40 percent of the public sector but only 6 percent of the private sector (Hirsch and Macpherson 2003). Like licensing, union workers are paid more than non-union workers and they could restrict labor supply and can negotiate for higher wages through collective bargaining process. Lewis (1986) finds a union wage premium of 20% in 1976. Hirsch and Macpherson (2003) examine the union wage advantage in the public sector and finds that the hourly pay of unionized government workers is 8% higher than that of nonunionized government workers. This union wage advantage for private-sector workers is 9 percentage points higher than the wage advantage for union workers in the public sector (Hirsch, 2013). Union workers

also enjoy a greater variety and higher overall level of fringe benefits. Budd and McCall (2004) found that union members are 31 percentage points and 25 percentage points more likely than their nonunion counterparts to have pension and health insurance coverage. More recent work by Knepper (2020) found that newly certified unions increase pension contributions more than wages. Like licensing, unions are associated with generally higher pay and benefits, but the differential is greater in the private sector relative to the public sector.

The contribution of this paper is that we are the first to analyze occupational licensing in the public sector. We do this by first analyzing licensing's effects on workers' choice of sectors and then analyzing licensing's effects on labor market outcomes while controlling for their selection into the sectors. Second, we develop a comprehensive sample from the Current Population Survey (CPS) covering 2015 to 2021. During this period, the CPS added three new questions on occupational licensing. In addition, we use the licensing indicator and labor market outcomes using the imputation strategy developed in Kleiner and Xu (2020).[3] The analysis provides new evidence of the labor market effects of licensing and their differences in the public and private sectors.

Initially, we use propensity score matching (PSM) to link individuals by a series of observable characteristics and find that licensing is positively associated with the probability of choosing to work in the public sector in our preferred specification. More specifically, licensed workers are about 3.9% more likely to select into the public sector. In order to correct for the selection into different sectors, we adopt a two-stage estimation procedure and find that for the whole sample, licensing has a positive wage effect, and licensed workers have a wage premium

[3] Although our imputation methods are not to be faulted, we followed the descriptions in the appendix of Kleiner and Xu (2020) to construct our own cleaning codes. We are responsible for any possible imputation errors that might occur.

of around 6.5%. Further, occupational licensing increases total weekly hours for workers by 4.3% and reduces employment by around 31.5%. This is consistent with Blair and Chung (2022) and Kleiner and Soltas (2023). Using sub-sample analysis, we find that licensing in the public sector increases wages by 6.4% and raises weekly hours worked by 5% but reduces employment by 23%. The sub-sample results not only serve as a robustness check for our whole sample but also can provide insights into licensing's effects in the public sector. We also use other methods to test the robustness of our results, including an instrumental variable approach (Kleiner and Soltas 2023), as well as using different datasets from the SIPP.

Our paper proceeds as follows. Section 2 presents the theoretical model of sector choice, as well as a welfare effects model of licensing on labor market outcomes, which we use as foundations for our empirical analysis. Section 3 explains the datasets used in the analysis. Section 4 outlines the empirical methodology adopted in analyzing different effects. Section 5 describes the baseline results. Section 6 breaks down licensing's effects in the public sector by federal, state, and local level, the heterogeneous effects of licensing across different occupational groups, and union effects. Section 7 presents the robustness checks of our results. In Section 8, we summarize, conclude, and present some of the limitations and further research directions of this study.

2. Theoretical Framework

2.1. Probability of Public Sector Choice

We develop a model that posits public sector workers choose to work in that sector because its level of employment risk is lower than that of the private sector (Lang and Palacios, 2018). We specify a simple dynamic model of discrete occupational choice to demonstrate how

licensing would affect workers' choice between public and private sector occupations. On one hand, the insurance mechanism of the public sector has made job security in this sector higher than its private counterpart (Rodrik 1997). Therefore, public sector workers are assumed to be more risk averse than private sector workers, and if other factors are held constant, individuals with higher degrees of risk aversion will have a higher tendency of selecting into the public sector. The probit analysis in Bellante and Link (1981) has provided supporting evidence for this hypothesis. On the other hand, because of the "barrier to entry" occupational licensing creates, it can be hypothesized that people who are more risk averse will select into licensing because workers in licensed occupations enjoy job security and economic rents due to tougher entry requirements that restrict the supply of labor (Kleiner, 2006). Support for this hypothesis has been found by Gittleman et al. (2018), who provide evidence that licensed individuals have a higher probability of being employed. Therefore, assuming workers prefer employment to unemployment, risk aversion could be proxied by licensing status.

Our model takes the form of the occupational choice approach in Lang and Palacios (2018). The difference between our model and theirs lies in the risk aversion parameter. Lang and Palacios (2018) use three constructed questions to measure the level of risk aversion of people who are in the sample, while we will use licensing as an indicator for risk averse individuals. Also, Lang and Palacios (2018) allow for transitions between sectors, but we do not relax our assumptions in the model.

We further assume workers decide each year between working in the public sector or working in the private sector to maximize their expected lifetime discounted utility. We expect that risk averse individuals will sort into the public sector, since compensation in the private sector is more often based on performance pay or pay at risk, and the public sector has less

variable pay and more job security. We also use licensing as a proxy for the measure of the risk aversion parameter on the assumption that individuals who choose licensed occupations do so because their risk is lower than that of unlicensed ones (Gittleman et al., 2018)

We assume that individual i in period t has different utility functions in different sectors d, and the utility functions take the general form below:

$$V_t^d = \left(U_{it}^d, \delta, E[V_{t+1}]\right),$$

where V_t^d is the utility function for workers, U_{it}^d is the individual's utility function in different sectors, and δ is the discount factor. Since we assume individuals are forward looking, we will consider the effects of their sector choices on their future earnings.

We let the one-period utility function take a quadratic function in earnings:

$$u(w) = aw - Lw^2,$$

where $a > 2Lw$. If we assume the distribution of the taste shock for earnings has a normal distribution with variance of σ_ξ^2, the expected utility becomes

$$E(u) = aE[w] - L(E[w])^2 - L\sigma_\xi^2.$$

The equation shows that the utility is increasing at a decreasing rate with the expected earnings and decreases with the variance, which meets the concavity definition of risk aversion. Here, L is our measure of licensing, and it can capture whether the worker is risk averse.[4]

[4] Although it does not correspond to a standard coefficient of absolute or relative risk aversion.

For U_{it}^{d}, we add socio-demographic controls that do not allow for transitions between sectors. Consequently, the utility function in each sector d depends on the sector variables $s_{it} = \{\bar{Z}_{it}^{d}, \xi_{it}^{d}\}$, as described below:

$$U_{\mathrm{it}}^{d}(s_{it}) = u\left(d, \bar{Z}_{it}^{d}\right) + \xi_{it}^{d}.$$

If we use the one-period utility function as defined above, the utility function in each sector d becomes

$$U_{\mathrm{it}}^{d}(s_{it}) = \beta_{u1} E\left[w_{it}^{d}\right] + \beta_{u2}^{d}\left(E\left[w_{it}^{d}\right]\right)^{2} + \beta_{u3}^{d} z_{it} + \xi_{it}^{d},$$

where $E\left[w_{it}^{d}\right]$ is the expected earnings and z_{it} is the worker's choice characteristics. We do not consider the utility of non-employment.

The time periods in this model are finite, starting from time t (normally at age 16) through the retirement age of T (normally at age 64). If we take the time periods into consideration, the choice-specific value function is

$$V_{t}^{d}(s_{it}) = \begin{cases} U_{it}^{d} + \delta E\left[V_{t+1}\left(s_{i,t+1}\right) \middle| s_{it}, d_{it} = d\right] & if\ t < T \\ U_{it}^{d} & if\ t = T \end{cases}.$$

We assume that the distribution of ξ_{it}^{d} follows an extreme value type I, using backward induction calculation the probability of choosing occupation d in period t takes a logit form:

$$P(d_{it} = d | \bar{Z}_{it}, \beta_{u}) = \frac{\exp(v_{it}^{d})}{\sum_{d} \exp(v_{it}^{d})},$$

where v_{it}^{d} is the expected choice-specific value.

Although solving this discrete choice dynamic programming model in general equilibrium is outside the scope of this paper, the implication from this model is that the

probability of choosing private sector jobs for licensed workers is associated with larger positive shocks than that of choosing public sector jobs. The theoretical implications raised in this model will be evaluated empirically in the rest of this paper.

2.2 Economic Model for Occupational Licensing

Bryson and Kleiner (2019) use an adapted licensing model in the context of a labor demand and supply side approach adapted from Kleiner and Soltas (2023), which is also shown in Figure 1. Occupational licensing influences economic welfare through its impact on the supply of workers and demand for the services of certain occupations. In Figure 1, the supply curve is shifting to the left from S to S', and the quantity of services supplied changes from q to q' because of licensing. This shift means that occupational licensing is restricting supply in the labor market by establishing the "barrier to entry" discussed above, and only individuals who can meet the licensing requirements from the government can work in the occupation in question. Therefore, non-qualified workers are blocked out of the labor market, resulting in the reduction in the labor supply curve and the supply side deadweight loss marked in the blue shaded section. On the demand side, occupational licensing shifts the demand curve to the right from D to D'; consequently, the price of services increases from p to p'. In the model, this is a result of the perceived quality of services that results from licensing (Chetty, 2009). Therefore, practitioners' increased inputs into occupational licensing are transformed into higher prices for the services (higher wages for the practitioners), resulting in a market surplus, shown in the red shaded area. The supply side reduction in the quantity of services is a welfare loss, while the demand side increase in the prices is regarded as a welfare benefit. The total welfare effects of licensing depend on the magnitude of the deadweight loss caused by the supply side shift and the market

surplus caused by the demand side shift. We do not derive the general equilibrium parameters for the models, and we mainly use them as a guide for our empirical analysis.

3 Data

In this section, we describe the datasets used in our empirical analysis and the data cleaning and sample selection criteria. One of the biggest challenges in analyzing the effects of labor market institutions such as occupational licensing has been the lack of a comprehensive and consistent national dataset (Gittleman et al., 2018). New questions that address important aspects of licensing have recently been added to the Current Population Survey, which is the primary dataset for our analysis.

The Current Population Survey (CPS) is a monthly representative dataset in the U.S. that interviews households following a 4-8-4 pattern (Flood and Pacas, 2017).[5] The licensing questions were first asked in January 2015, and the responses help form the licensing indicator in our sample. Detailed income questions are asked in the sample in months 4 and 8 in the outgoing rotation group (ORG), and this information helps us construct data on labor market outcomes in the sample. The three questions asked about occupational licensing in the CPS are as follows:

1. Do you have a currently active professional certification or a state or industry license?
2. Were any of your certifications or licenses issued by the federal, state, or local government?

3. Is your certification or license required for your job?

[5] In the 4-8-4 pattern, a household will first be interviewed for 4 months, then it will rotate out of the interviewing sample for 8 months, and finally it comes back for another 4 months of interviews. There is a distinction between sample month (mish) and interview month (month). For example, in the CPS, "month 5" refers to the calendar month when the household is interviewed, while "mish 5" refers to the fifth month the household is in the sample, which may not necessarily be the same as the calendar month of the interview.

In 2015, the questions were asked in every month, but from 2016 onward, they have been asked only in sample months 1 and 5. Also, the third question was added in 2016 but was not asked in 2015. To develop our licensing indicator, we say that an individual is licensed if he/she answers "yes" to both of the first two questions, following the convention in the literature.[6] We use the measure of licensing attainment rather than coverage by a licensing statute.[7]

The sample covers employed workers ages 16–64 in the period from 2015 to 2021. It excludes self-employed workers, members of the armed forces, and individuals who are unpaid family workers. To develop consistent measures in the CPS, we adopt the imputation methods described in Kleiner and Xu (2020) and construct two CPS datasets with different sample month observations. First, we keep worker observations from mish 4 and 8, since these two months have the most accurate measure of wages and hours.[8] We then impute some of the inaccurate licensing status using licensing indicator information from mish 1 and 5. Conversely, we keep workers in mish 1 and 5 with the most accurate licensing indicator and use the wage and hours information in mish 4 and 8 to match with individuals in mish 1 and 5. We use mish 4 and 8

[6] Another way to form the licensing indicator is to consider an individual licensed if he/she answers "yes" to all three of the questions. But this might be too strict of a standard. Also, since the third question has been asked only since 2016, using this criterion would reduce our sample size as well. This indicator is used as a robustness check, the results of which are included in the Appendix B1.

[7] Gittleman and Kleiner (2016) use the indicator of licensing coverage to estimate wage effects by mapping the six-digit SOC codes to their corresponding 2000 Census codes in a given state's licensing requirements. Han and Kleiner (2021) also use licensing coverage as their main treatment variable.

[8] "Mish" is CPS survey sample month rather than calendar month. It indicates the number of times (from 1 to 8) occupants of a housing unit have been interviewed for the CPS. Household members are interviewed for four consecutive months, excluded for eight months, and then included for four more consecutive months. On first interview, a household has a value of 1 for MISH. Households returning to the sample after an 8-month hiatus have a value of 5, and those which have completed their last interview have a value of 8. Persons with codes of 4 or 8 in MISH are said to be in "outgoing rotation groups," because they will not be interviewed during the following month.

sample to deliver our baseline results.[9] For top-coding issues relating to wage and hours, we follow Autor et. Al. (2008) to winsorize top-coded earnings and usual weekly hours above 100.[10]

Our baseline sample contains 807,918 observations of 382,970 unique individuals in 442 occupations based on 2010 Census categories. Table 1 shows that the licensing rate in the sample is around 15% and the mean of the real hourly wage of the sample is around $27. These findings are consistent with the literature (Kleiner and Krueger, 2013; Blair and Chung, 2022 Kleiner and Soltas, 2023).

4 Empirical Identification Strategy

4.1 Probability of Sector Choice

One of the main objectives of this paper is to analyze how licensing affects the outcomes for public and private sector workers. As we have shown in the theoretical section, licensing, serving as risk-aversion parameter, impacts a worker's choice of sector. Therefore, we will start by examining how the probability of an individual selecting into the public or private sector can be affected by licensing. The basic linear probability regression is as follows:

$$Y_{it} = \beta_0 + \beta_1 L_{it} + \epsilon_{it}, \quad (1)$$

where the outcome Y_{it} indicates the sector choice of specific individuals at year t, and $Y_{it} = 1$ if individuals select into the public sector and 0 otherwise. The term L_{it} is the licensing indicator

[9] Results using months 1 and 5 are included in the Appendix A1 as a robustness check.

[10] We also redo the ORG earnings weight by dividing it by 12, because the earner weight is gathered from 12 months from the two rotations that were originally weighted to give a full sample (Autor et al., 2008), and we weight the CPS sample weight with usual hours of work, since it can give a better representation of the dispersion of wages for every hour worked in the labor market (Dinardo et al., 1995). All of the wages are adjusted based on the CPI factor from the BLS.

and equals 1 if the individual is licensed in the data, according to the criteria discussed above, and 0 otherwise. The last term ϵ_{it} is the unobservable.[11]

We adjust the linear probability model by adding more controls for individual characteristics as well as occupation, state, and year fixed effects. We also implement a propensity score matching strategy (PSM) to get a more balanced distribution between licensed and unlicensed workers. The PSM model specification is specified below:

$$Y_{it} = \beta_0 + \beta_1 L_{it} + X_{it}\gamma + \alpha_s \times \mu_o + \theta_t + \epsilon_{it}. \quad (2)$$

As discussed in (1), L_{it} is the licensing indicator; β_1 is our main parameter of the effect of licensing on the probability of being in the public sector; and X_{it} is a vector of individual characteristics in time t including age (and age-squared), experience (and experience-squared), gender, race, education, log wage, region, marital status, citizenship, union membership, veteran status, and metro status. Lastly, $\alpha_s \times \mu_o$ denotes the state-by-occupation fixed effects,[12] and θ_t is the year fixed effects. For PSM, we first match individual characteristics on the probability of

[11] This linear probability model has a couple of issues. First, there may be other factors in the error term that are affecting the outcome. For example, women may prefer the more secure working environment in the public sector more than men do, and they might select into the public sector without going through licensing. Similarly, individuals with higher levels of education may select into the public sector because public service employment is associated with more altruistic or meaningful personal achievement. If these selection issues were to occur, the coefficient on the licensing variable would be biased. The second issue is that the treatment of licensing is not random. For example, people with higher education may select into licensing, since they might be more capable of passing all licensing requirements and exams. Another example would be that in Kleiner and Soltas (2023), which finds that workers bear a significant amount of the costs of licensing. As a result, those who evaluate these costs to be greater than the benefits associated with licensing may select away from being in licensed occupations.

[12] Occupational fixed effects include 22 occupational categories based on 2010 Census classification scheme. The 22 occupational categories are 1. Management in Business, Science, and Arts; 2. Business Operations and Financial Specialists; 3. Computer and Mathematical; 4. Architecture and Engineering; 5. Technicians; 6. Life, Physical, and Social Science; 7. Community and Social Services; 8. Legal; 9. Education, Training, and Library; 10. Arts, Design, Entertainment, Sports, and Media; 11. Healthcare Practitioners, Technicians and Support; 12. Protective Service; 13. Food Preparation and Serving; 14. Building and Grounds Cleaning and Maintenance; 15. Personal Care and Service; 16. Sales and Related; 17. Office and Administrative Support; 18. Farming, Fisheries, and Forestry; 19. Construction and Extraction; 20. Installation, Maintenance, and Repair; 21. Production; and 22. Transportation and Material Moving.

being licensed, and then we use the generated score as weights in the above linear probability regression.

Beyond the PSM, we also adopt the bound estimate for selection on unobservables approach from Oster (2019), which builds upon Altonji et al. (2005) in estimating bound treatment effects to help solve for selection on unobservables. The essence of this method is using bounding to replace the unknown terms with feasible values that can minimize or maximize the average treatment effect. In order to achieve this, several assumptions are needed to tighten the bounds. The first assumption is that the importance of selection on observables equals to that of the selection on unobservables, and the second is to define R_{max} as the R^2 from the regression as if we did observe the unobservables. Since we cannot really estimate R_{max}, there can exist a lot of variation in choosing the value for the bound on R_{max}. Oster (2019) uses a sample of randomized articles and nonrandomized articles using this method and derives a cutoff value for $R_{max} = \tilde{R} \times 1.3$ to be a general value for the bound on R_{max}.[13] 90% of the randomized results and 45% nonrandomized results would survive this standard, and this is the standard we are using in our results as well.

4.2 Licensing Effects on Wages and Hours Worked between Sectors

Next, we turn to the effect of licensing on changes in wages and total hours worked for workers in different sectors. Our theory implied that the probability of choosing private sector jobs requires larger positive shocks compared with that of choosing public sector jobs, using licensing as an indicator for risk aversion. Although we do not use maximum likelihood estimators to solve the dynamic choice model in that section, we alternatively use regression

[13] $\tilde{R}$ is R^2 from the fully controlled regression with all observables included.

analysis and show that there is a positive selection into the public sector for licensed workers, compared with unlicensed ones. This means that licensed workers are normally risk averse, since licensed jobs, owing to the entry requirements associated with them, can be more stable than unlicensed jobs. The fact that licensed workers tend to select into the public sector shows that public sector workers are risk averse, whereas private sector workers are more likely to be risk takers. What we want to examine are licensing's effects on labor market outcomes in the public sector, with selection into the sectors proxied by licensing as an indicator for risk aversion corrected for workers in different sectors.

Therefore, we use the two-stage correction procedure developed by Heckman (1979) to account for selection bias into the public and private sectors. In the first stage, we use a probit version of the probability equation in section 4.1. Then, we use the predicted values from this first-stage regression to calculate the inverse Mills ratio, which can be considered as the transformation of the predicted individual probabilities of being in the public sector.[14]

To test for the effects of licensing and sector on wages and total hours usually worked, we estimate the following regression model based on equation (2) by changing the dependent variable and the primary independent variables:

$$Y_{it} = \beta_0 + \beta_1 L_{it} + \beta_2 S_{it} + X_{it}\gamma + \alpha_s \times \mu_o + \theta_t + \epsilon_{it}, \quad (3)$$

[14] Then we can estimate the second-stage regression of our preferred specification defined below, including the inverse Mills ratio as a control to account for selection issues, and thereby estimate the average treatment effect. An important condition for the Heckman procedure to work is the exclusion restriction, which means [?] that there needs to be at least one covariate that is in the first-stage regression but is not in the second-stage regression. In our model, we use metro status as the exclusion variable, meaning we include the metro status variable in the first stage probit regression, but we do not include it in the second-stage linear labor regression.

where Y_{it} is the labor market outcome of interest (either log of wages or log of total hours worked), L_{it} is still the licensing indicator, and S_{it} is the sector indicator and equals 1 if the individual is in the public sector. As was the case above, X_{it} is a vector of individual characteristics, including the inverse Mills ratio defined above; $\alpha_s \times \mu_o$ is the state-by-occupation fixed effects; and θ_t is the year fixed effects. We use the PSM score as weights in these estimates as well.

We chose not to use interaction term between licensing and the public sector; instead, we use a sub-sample analysis to find the differential effects of licensing and sector choice. We use six sub-samples: public licensed vs. public unlicensed, licensed public vs. licensed private, unlicensed public vs. licensed private, private licensed vs. private unlicensed, unlicensed public vs. unlicensed private, and licensed public vs. unlicensed private. The results from the subsamples can not only reveal some of the differential effects of licensing in different sectors but also serve as robustness checks for the baseline results derived from the whole sample.

5. Baseline Results

5.1 Descriptive Statistics

In this section, we will explain the baseline results shown in Tables 1–5. We will start with the descriptive statistics displayed in Table 1. For the full sample, licensing and the public sector have similar means: 14% of the workers are employed in the public sector, and around 15% are licensed workers. The biggest education category is high school graduate, which constitutes around 27% of the entire sample, and 24% of individuals have a bachelor's degree. Only 12% of workers have graduate degrees. The sample is composed mainly of white workers (77%), and 18% of the entire sample is of Hispanic origin. Marital status and sex are balanced for the entire

sample, and the mean person in the sample is around 40 years old and has about 20 years of experience. The results in the sample show that the average person usually works around 42 hours per week, and their average real hourly wage, adjusted to 2015-dollar values, is around $27. Only 11% workers in the entire sample are members of labor unions.[15]

We not only show the statistics for the full sample but also present two types of comparisons in the descriptive statistics: comparisons between licensed and unlicensed groups and comparisons between the public and private sectors. In the licensed group, 27% of the workers work in the public sector, while only 12% of the workers in the unlicensed group work in the public sector. Licensed workers generally have higher educational levels, with most of them having a bachelor's degree or more, while unlicensed individuals have a much higher percentage of high school graduates. There are more married women who are older and who are also union members in the licensed group, and regulated workers on average earn $7.59 more per hour and work around 2 hours more per week than unlicensed workers. Among licensed workers, 21% are in the unionized group, about twice as high as the percentage of unionized workers in the whole sample, 11%.

Comparing the public and the private sectors reveals similar trends. In the public sector, 29% of workers are licensed, which is more than twice the private sector value of 13%. Public sector workers tend to have a bachelor's degree (29%) or a graduate degree (25%), while for private sector workers, the educational group with the highest percentage is high school graduate (28%). The demographics of the public sector show that there are more women (57%) and married workers (61%). However, public sector employees work about 0.82 fewer hours per week than

[15] This is about the same as national estimates.

private sector workers, but the mean workers in both sectors still work full time at over 40 hours per week. Finally, 37% of public sector workers are in unions, but the percentage of union members in the private sector is only 7%.

The public sector has considerable heterogeneity among the federal, state, and local government levels, and disaggregating these sectors allows us to examine labor market outcomes in more detail. Figure 2 shows that federal government employees are paid significantly more than workers in other sectors (around $38 per hour). Private nonprofit workers on average are the second highest paid category, with an hourly wage around $30. State government workers are paid slightly more than private for-profit workers but less than private nonprofit workers, and local government workers are paid the least at around $26.73 per hour. In the figure, we also show mean weekly hours usually worked for employees in the three government sectors compared with those for their private sector counterparts. Federal workers still have the highest weekly working hours on average, while private nonprofit workers on average work much less per week than workers in all the other sectors. But for all these sectors, the mean total weekly hours worked are over 40 hours per week.

Table 2 shows the estimated annual population employment for selected occupations in two groups, the high state variation in licensing attainment group and the low state variation in licensing attainment group. Low state variation in licensing attainment means that most states in the U.S. have similar laws concerning an occupation's licensing requirements, while the high state variation means that different states have different laws regarding whether a certain

occupation needs to be licensed.[16] For example, social worker is an occupation that is rather balanced between the public and private sectors. Most social workers (74%) have not attained a license, and there are around 2.5 million workers in this occupation. Another illustration is the 9,000 workers who are brokerage clerks, a private-sector-only occupation. Teachers are included because of the occupation's uniqueness. This occupation supposedly has large heterogeneous treatment effects, the annual estimated employment is around 14 million, and teachers are balanced in both licensing and sector choice.[17] For economists, total estimated annual employment is only around 73,000, and being an economist is an almost entirely unlicensed occupation.

5.2 Probability of Sector Selection Regression Results

Table 3 shows the results from estimating equation (2). The dependent variable is the probability of choosing the public sector, and columns A–E are five different specifications. Column A is basically the estimation of equation (1); column B adds some of the individual characteristics as control variables, such as wage, education, sex, and race; column C further adds controls into the equation; column D adds occupation and state interaction fixed effects; and column E adds the year fixed effects. All the specifications include PSM weighting. Across the four specifications, licensing positively affects one's probability of choosing the public sector; the magnitude of this positive effect keeps decreasing when more controls and weights are added. Column E is our preferred specification in this case, since it has the highest R-squared

[16] These occupations are also chosen according to the occupational ranks by their treatment-effect weights, as described in de Chaisemartin and d'Haultfoeuille (2020) which proposes a method of calculating the implicit weights on potentially heterogeneous treatment effects by occupation in the two-way fixed effect estimator.

[17] The category "teachers" includes multiple occupations and levels of teachers, ranging from postsecondary teachers to special education teachers.

and the most comprehensive set of controls. From this result, we can conclude that licensing can increase one's likelihood of working in the public sector by around 3.91%, holding all else constant, and this effect is significant at 99% confidence level.

We also report both the bound estimates of the coefficient under the first assumption described above and the relative importance of the selection on observables and selection on unobservables (δ). Following Oster (2019, we choose the value of R_{max} to be R^2 from the fully controlled model times 1.3, and we also choose the value of 0.7 and 1 to add to the robustness of the bound estimates. The results are included in the fully controlled specification under column E, with the higher bounds being the coefficient from the fully controlled model and the lower bounds being the calculated coefficients using different values of R_{max} and under the assumption of $\delta = 1$. When we use an R_{max} of 0.47 in the first case, the value of δ is 4.51, meaning that the selection on unobservables (such as social values and job satisfaction) associated with being in the public sector must be around 4.5 times more important than the selection on observables for the causal effect of licensing on the probability of being in the public sector to be zero. When increasing the value of R_{max}, the value of δ decreases, and only in the most restrictive case of $R_{max} = 1$ do we find that the bound of the coefficients starts to cover 0. This result suggests that our baseline probability results are robust to potential unobservables.

In sum, licensing yields a positive effect on one's probability of working in the public sector. This result is in accordance with our hypothesis described in Section 2 that licensing can be used to measure one's risk aversion and licensed individuals are more risk averse. As a result, they are more likely to select into the public sector.

5.3 Wage and Total Hours Worked Estimates

Table 4 displays the estimation in equation (3). The specifications in columns A–E are the same as those described in Section 5.2, and specification E has the most comprehensive set of controls and thus is our preferred specification. In Table 4, we can see that licensing is associated with a wage premium. Licensed workers on average earn 6.5 log points more than unlicensed workers, and this is in accordance with many of the findings in the literature; for instance, Kleiner and Krueger (2013) find that a worker with a license tends to have a wage premium ranging from 5% to 15%. However, comparing wages across sectors, we see that private sector employees tend to enjoy a higher wage premium. Table 4 shows that public workers earn 4.9 fewer log points than those in the private sector. This is consistent with some of the empirical literature. In terms of total hours worked and employment, licensing increases total weekly hours worked by 4.3 log points, and it decreases employment by around 31.5 log points; this result is similar to the estimate in Kleiner and Soltas (2023) of around 29%. Working in the public sector has a significant impact on hours worked, but the magnitude of this effect is less than 1 log point, and it does not have a significant impact on employment.[18] The effect of unions on labor market outcomes is similar to that of occupational licensing. Union workers enjoy a wage premium of 7.3%, union workers work 8.4% more weekly hours than non-union workers, and unions have a negative employment effect of around 23%.

In column E we also report the bound estimates of the effect of the main treatment indicator for licensing. We keep adding the control variables from specifications A to E, and we estimate the calculation of bounding coefficients under the assumption that $\delta = 1$ and different values of

[18] We aggregate employment at state-occupational level.

R_{max}. Still, the R^2 gradually increases as we keep adding more controls, but the magnitude and sign on the coefficients do not follow a regular pattern, unlike those in Table 3. The bound and δ estimates are in column E. In panel A, we can see that licensing has a positive effect on wages, and licensed workers on average earn 6.5% more than unlicensed workers. Using an R_{max} of 0.4 in the first case, we find that the value of δ is -16.63, meaning that the selection on unobservables (such as innate ability of the individuals) associated with wage outcomes must be around 16 times more important than the selection on observables for the causal effect of licensing on log of hourly wages to be zero, and the negative sign here demonstrates that the selection on unobservables should be of opposite sign compared with the selection on observables.[19] None of the three bounds for the coefficient estimates cover 0, but when increasing the value of R_{max}, the value of δ decreases. In the most extreme cases of $R_{max} = 0.7$, δ is still around 4, which suggests that our results do not suffer from selection on unobservables. Compared with licensed workers, union workers have a slightly larger wage premium of 7.3%, while public sector workers earn around 5% less than private sector workers. Panel B reports the labor market outcome effects of log of total weekly hours worked. Licensed workers in general work 4.3% more than unlicensed workers, and based on the bound estimate, this result is robust if we choose theR_{max} to be 1.3 times the R-squared from the controlled regression, and the selection on unobservables (such as individuals' motivation at work) needs to be 6 times more significant compared to the selection on observables for the effect of licensing on weekly hours worked to be zero. Workers in the public sector work 0.8 percentage points less than private sector workers, and union workers work 8.4% more per week than non-union

[19] The issue of unobservables is based on the absolute value of δ, which does not change the basic notion that the unobsevables would need to be extremely large to overturn these results.

workers. In panel C, to attain an estimate for employment from CPS data, we conduct the regression at the state-occupation cell level, and therefore no individual covariates are included in this panel. From this result, we conclude that for the entire sample, licensing has a negative impact on employment of around 31.5%, while working in the public sector does not have any significant impact on employment. Similar to licensing, unionization has a negative impact on employment, but the magnitude, which is around 23%, is smaller than that for licensing.

In Tables 5–10 we examine six sub-group comparisons of licensing's effects on labor market outcomes: licensed public vs. licensed private, public licensed vs. public unlicensed, unlicensed public vs. licensed private, private licensed vs. private unlicensed, unlicensed public vs. unlicensed private, and licensed public vs. unlicensed private. Since our focus is licensing's labor market effects in the public sector, Table 6 contains our main results, which compare the outcomes between the licensed and unlicensed workers in the public sector. We find that licensing in the public sector generally yields a 6.4% wage premium, and this effect is almost the same as the overall licensing wage effect (6.5%). The effects of licensing in the public sector are comparable to those in the whole sample: licensing increases weekly hours worked by 5% and reduces employment by 23%. Union effects in the public sector are also comparable to those in the whole sample, with positive wage and hours worked effects and negative employment effects.

Table 11 looks at licensing's effects on labor market outcomes by separating the public sector into detailed sub-sectors. In general, working in the federal sector and working in the state and local sector have positive effects on both wages and hours worked. Federal workers in the licensed group earn 4.8 log points more and work around 4 log points more than unlicensed workers. These effects have higher magnitudes in the state and local government sector. State

and local workers in the licensed group earn 7.5 log points more and work 4.2 log points more than their unlicensed counterparts. Licensing does not have a significant impact on employment in the federal sector, but it has a significant impact on state and local sector employment of around 28.7%. Working in the federal sector has a positive wage effect of 9% but does not have a significant impact on weekly hours worked, and it positively affects employment, with the influence around 44.5%.[20] However, working in the state and local sector has a negative wage effect of 8.7% and a negative effect on weekly hours worked (though it is less than 1%), but no statistically significant effect on employment.

Because licensing serves as a barrier for new workers entering the occupation, there are potential monopoly rents in wages for existing workers. Licensed state and local sector workers earn even higher rents than unlicensed workers, implying that being in this sector increases the monopoly power of licensing. This is plausible because licensed practitioners can create labor market monopolies through their power to set licensing requirements for practitioners. Working in the public sector has a negative effect on wages for the whole sample, but when we break down the public sector into sub-sectors, the federal sector has a positive wage effect of around 9%, while the state and local sectors have a negative wage effect of around 8.7%, suggesting heterogeneity within the public sector. Since the federal government has the broadest market power, it is possible that in industries or occupations relating to federal public utility services such as public roads, water supply, and so on, workers have potential monopoly rents. For the state and local sector, the negative wage effect can be ascribed to the monopsony power existing in this level of the public sector (Gregory, 1999). Examples would be that in a small local

[20] Because teachers is a unique occupation in the state and local sector, in the Appendix A2, we look at the baseline results when teachers are left out of our whole sample.

geographical area, there may be few options for employment apart from specific public sector occupations such as teaching, and this would give the state and local sector employers some level of monopsony power. This also indicates that by looking only at the overall public sector, some heterogenous effects existing in different industries or occupation levels are lost.

6. Heterogeneous Occupational Effects

In this section, we examine how licensing's effects differ across occupational groups. Although we are still estimating the baseline specification of equations (2) and (3), we separate the different sub-samples of occupational groups by combining the 2010 Census definition for occupational groups into different occupational categories. Figure 3 illustrates licensing and sector percentages by occupational categories by showing that health-related and legal occupations have the highest licensing rates. As expected, these two groups contain many universally licensed occupations, such as lawyers and doctors.[21] The least licensed occupational group is building and grounds cleaning and maintenance. Most people in the protective services and social science and services groups are public sector workers, and most of the workers in the sales and production groups are in the private sector. This illustrates the market-driven attributes of private sector occupations. Figure 4 shows the mean labor market outcomes by occupational groups. The trends are similar for hourly wages and total hours usually worked per year, suggesting that those who earn the most also work the most hours.[22] Not surprisingly, workers in the legal, architecture and engineering, computer and mathematical, and management groups are among those who both are high earners and work the most hours. Individuals in food

[21] Some papers exclude universally licensed occupations from the sample, but we do not.

[22] Here, we choose to report the total hours worked per year to see the differentials among heterogenous occupations, since total weekly hours worked would not be too different among these occupations (they would all be around 40 hours per week).

preparation and serving, building and grounds cleaning and management, and personal care and services earn and work the least. Table 12 further demonstrates the mean descriptive statistics by combined occupations, with the percentages of licensed, unlicensed, public and private sector workers shown for each occupational subgroup. The results in the table show that the most licensed categories are still healthcare and legal practitioners, and the least licensed categories are computer and mathematical and production occupations.

From the descriptive statistics, we select six groups to be in our heterogenous effects analysis.[23] The results are in Tables 13 through 16. Table 13 shows that in most of the occupational subgroups, licensing still has a significant influence on the probability of choosing a sector. However, for some of the subgroups, the sign for the probability has changed to negative, in contrast with our main results. For occ1 and occ2, licensing does not significantly impact individuals' sector choices. In Table 14, the wage effect of licensing in occupational groups matches with our baseline results. For occ2, occ3, and occ4, licensing has positive and significant effects on wages, while for other occupational groups, the effect of licensing on wages is not significant.

There are mixed results for working in the public sector. For workers in the life, physical and social sciences and legal categories, the wage effect is negative for public sector workers, and private sector workers have a wage premium. However, the earnings for workers in the community and social services and protective services categories would be higher in the public sector. These seemingly contradictory results might be due to the heterogeneous characteristics of these occupations. For example, although most of the workers in community and social

[23] These groups are 1. Life, Physical, and Social Science; 2. Community and Social Services; 3. Legal; 4. Education, Training, and Library; 5. Protective Service; 6. Personal Care and Service.

services occupations still work in the private sector, government plays a significant role in social work–related occupations.[24] In Table 15, there is mixed evidence on the effect of sector and licensing on total hours worked for different occupational groups. Similarly, Table 16 shows mixed employment effects for licensing and working in the public sector.

In Tables 17–18, we further break down the occupational groups into specific occupations.[25] The three occupations in panel A are the most influential occupations, and the three occupations in panel B are the most overweighted occupations. Supposedly, when labor market outcomes are estimated, the panel A occupations are the ones that will generate the most heterogenous effects, and the occupations in panel B will not produce major heterogenous effects. In Table 17, we report the wage effect. We can see that there are significant effects only on the first two occupations, teachers and social workers, which are also panel A occupations. The effects of licensing on wages for these two occupations are similar to those in our baseline estimates: licensed teachers earn 5.5% more than unlicensed ones, and licensed social workers have a wage premium of around 8%. For the other occupations, licensing has no significant effect on wages, perhaps owing to the small sample size when we disaggregate to a specific single occupation, but the sign for the coefficient is mostly positive. In Table 18, the significant licensing effects on total weekly hours worked for teachers and bus and ambulance drivers and attendants still correspond to our baseline results, which hold that licensing has a positive effect on hours worked. There is mixed evidence on the effects of sector choice and union membership

[24] The mixed results might also be due to the business models of industries/firms hiring workers in the occupation. For example, in the legal market, public sector employers have much less funding than private employers. And since funding drives how much employers can pay to recruit, the labor demand will be different in different sectors.

[25] These occupations are selected according to Appendix Table A6 in Kleiner and Soltas (2023), which reports the implicit weights attached to the regression associated with different occupations, using the method described in de Chaisemartin and d'Haultfoeuille (2020). The underlying implication of this method is that if the implicit ratio calculated from the implicit weights is not very large, then the two-way fixed effect estimated treatment effects are not robust to the heterogenous effects that exist over time or across groups.

on wages and hours worked. Because the employment variable is estimated at the state by occupation cell level, we are not able to report the employment effects for single occupations here. By looking at the labor market outcomes in the subgroup occupations as well as in specific single occupations, we confirm the robustness of the main licensing effects. However, because of the mixed evidence in sector choice and union effects, we acknowledge that there might be heterogenous effects over time or across groups; for future research, methods such as the one in de Chaisemartin and d'Haultfoeuille (2020) can be used to account for this.[26]

7. Robustness Checks

In our baseline estimates, we have accounted for the endogeneity in sector choice. Another potentially important problem is that licensing, as a proxy for the risk-aversion parameter, is not exogenous to the outcome variables. Licensed workers may be individuals who have higher abilities and motivation, and they may be more likely to earn and work more than unlicensed workers. Although we use PSM to account for the endogeneity of licensing, we want to further correct for its endogeneity. Also, in our baseline estimates, we use only the sample from CPS. This section adopts the instrumental variable approach method to tackle the endogeneity problem; we will also use another sample from a different survey to repeat our empirical analysis. By doing this, we intend to check the robustness of our baseline results.

7.1 Instrumental Variable Approach

The first method we adopt is the instrumental variable approach. Following Kleiner and Soltas (2023), we use the percentage of workers who are licensed in their specific occupation and

[26] We also conduct an analysis using the sample in which the most heterogenous occupations are pulled out of the whole sample to check for the robustness of our results. The results are included in the Appendix A2.

state group as the instrumental variable. In theory, the share would not have direct impacts on outcome variables such as wages, and it is directly related to licensing. We first regress the state-occupation licensed share on licensing, and we recover the residual from this first-stage regression to replace the treatment indicator in our specified second-stage regression.

The results are shown in Table 19. Column (1) is the effect of licensing on the probability of being in the public sector, column (2) is the effect of licensing on log wages, and column (3) is the effect of licensing on log hours worked. Because we are using license share at the state and occupational level as our instrumental variable, we are unable to estimate the employment effects. Panel A reports the results for the whole sample. The probability coefficient has similar signs and significance to those in our baseline results. However, the magnitude of licensing's effect on sector choice is significantly higher, from 4% in baseline estimates to 15% here. The effect on wages in general has the same sign as in the baseline results, but the magnitudes also increase significantly. Licensed workers earn 16.6 log points more and work 23.6 log points more than unlicensed workers, while public workers earn 11 fewer log points hourly and work 4 fewer log points weekly than their private counterparts. Panel B reports the sub-sample estimates for licensing's effects on wages and hours worked in the public sector. Similarly, the signs are the same as those in our baseline sub-sample estimates in the public sector, and the magnitudes of the coefficients are larger. The coefficients in larger magnitude using the instrumental variable approach indicates that the unobservables in our baseline results are biasing our estimates toward zero and correcting it can strengthen estimated licensing effects on the labor market outcomes. The table includes the Cragg-Donald Wald F statistics for all three specifications and both of the panels, and the statistics reject the null hypothesis of weak instrument.

7.2 SIPP Results

In this section, we conduct a robustness check using a different sample from Survey of Income and Program Participation (SIPP) data. SIPP is a nationally representative longitudinal survey of the United States. In this survey, respondents answer a core group of questions every 4 months about the preceding 4 months, and the questions include detailed monthly information such as wages, demographics, and so on. Occupational licensing information is derived from wave 13 of the 2008 panel, since they include the Professional Certifications, Licenses and Educational Certificates modules.[27] Our licensing indicator is based on respondents' response to the following questions:

1. Do you have a professional certification or state or industry license?
2. Who awarded this certification or license?
3. Can this certification or license be used to get a job?

If a respondent answers "yes" to the first question and "federal, state or local government" to the second question, we believe that the respondent is licensed.

The sector choice and labor market outcomes are shown in Tables 20–23. We can see that in the SIPP sample, licensing is still positively associated with selecting into the public sector, but the magnitude of this coefficient drops from around 4% in the CPS to 2% in SIPP. The wage effect for licensing is still positive but large compared with that in the CPS (around 18%), and this effect becomes insignificant in the sub-sample results by comparing licensed and unlicensed

[27] We are aware that there are more panels available in SIPP with licensing information, but we just choose the wave 13 of 2018 to deliver robustness check results.

workers in the public sector alone.[28] In both the whole sample and sub-sample using the SIPP data, we find negative effects of licensing on employment.[29] We can conclude that the SIPP sample does not generate contradictory results for the labor market effects of licensing relative to the CPS.[30]

8. Conclusions

Our study examines the labor effects of occupational licensing in the public sector in the U.S. Initially, we examined the effects of licensing on sector choice and using sector choice to correct for the endogeneity of workers' selection into public/private sectors. We further examined how licensing can affect the labor market outcomes both generally, and exclusively in the public sector. We find that licensing is positively associated with a 4% probability of choosing to work in the public sector. After controlling for selection, licensing has a positive wage and hours effect, with licensed workers earning 6.5% more and working 4.3% more weekly hours than their unlicensed counterparts. Public sector membership generally has a negative wage effect, and individuals in the public sector on average earn 4.9% less compared with individuals in the private sector. Unionization has a larger wage premium of 7.3%, and union workers work 8% more weekly, compared with non-union workers. With respect to employment, licensing in

[28] This might be due to the small sample size for the public sector in the SIPP data in the panel and wave selected. More SIPP panels can be added in the future to test the robustness for the subsample results.

[29] For employment effect of licensing, when we use 2008 Wave 13 panel alone, the sign of the employment coefficient is negative, but still not significant even at 10% level.

[30] When thinking of the welfare effects of licensing in the public sector, we adopt the structural model in Kleiner and Soltas (2023). Suppose that the entire 6.51% wage premium for licensing in the public sector is from market power, and further assume that labor supply is perfectly elastic, and the labor demand elasticity is 0.5 (Hamermesh, 1993). For May 2018, the total licensing workforce in the public sector is around 6.4 million, and the average annual earning is around $50,000 (BLS 2018 [this source is missing from the references]). Therefore, the annual cost to the public of licensing in the public sector = [$50,000 – ($50,000 / 1.061)] x 6.4 million = $18 billion. The percent change of the welfare effects for licensing in the public sector = welfare benefit - welfare loss = (1+6.09%) x 5.2% - 28.33% = -23%. In general, licensing in the public sector will result in a 23% welfare loss for the economy.

general reduces employment by 31.5%, while unions reduce employment to a lesser extent, of around 23%. For licensing's effect in the public sector, we find that licensing has a similar wage premium of 6.4% and slightly larger hours effect of 5%. Licensing's effect on reducing employment in the public sector is relatively smaller.

From our robustness check, we found that our baseline results for licensing's effects on labor market outcomes are robust among the methods adopted and sample selected. There exists some mixed evidence for the labor market effects of sector choice and unionization. First, the CPS data are too heterogenous to be used to compare wages across sectors. We combine CPS data with other datasets to generate more controls to make the individuals in the sample more comparable. Another limitation is the robust and positive effect of licensing when selecting into the public sector. However, this does not rule out an alternative interpretation: employers in the public sector may prefer to hire more risk averse workers. Moreover, we do not consider the nonpecuniary job benefits, such as job injury rate and job satisfaction, which can affect workers' choices. Lastly, we look only at wage differentials without including benefits, and compensation gains may be more readily seen for benefits than for wages (Hirsch, 2013). The empirical results thus raise some further questions: How would licensing causally affect wage distribution and employment across sectors? How would licensing and sector choice individually and together affect compensation and nonpecuniary job benefits? What policy implications would these empirical results generate? These are all questions that could be answered in further studies on this topic.

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Table 1. Selected Descriptive Statistics, 2015–2021 CPS

	By Licensing				By Sector	
	Full Sample	Licensed	Unlicensed		Public	Private
Public	0.14	0.29	0.71	Licensed	0.27	0.73
Private	0.86	0.13	0.87	Unlicensed	0.12	0.88
Licensed	0.15	-	-			
Unlicensed	0.85	-	-			
Education Category				*Education Category*		
Less than high school	0.08	0.02	0.10	Less than high school	0.02	0.09
High school graduate	0.27	0.14	0.29	High school graduate	0.18	0.28
Some college	0.18	0.13	0.19	Some college	0.16	0.18
Associate degree	0.10	0.15	0.10	Associate degree	0.11	0.10
Bachelor's degree	0.24	0.28	0.23	Bachelor's degree	0.29	0.23
Graduate degree	0.12	0.28	0.10	Graduate degree	0.25	0.10
Race				*Race*		
White	0.77	0.80	0.77	White	0.76	0.78
Black	0.13	0.12	0.13	Black	0.16	0.13
Asian	0.08	0.07	0.08	Asian	0.06	0.08
Hispanic	0.18	0.11	0.20	Hispanic	0.13	0.19
Personal				*Personal*		
Marital status	0.53	0.62	0.51	Marital status	0.61	0.51
Union status	0.11	0.21	0.10	Union status	0.37	0.07
Female	0.47	0.56	0.46	Female	0.57	0.46
Experience	19.91	20.52	19.80	Experience	22.05	19.55
Age	40.07	42.10	39.71	Age	43.28	39.54
Labor Outcomes				*Labor Outcomes*		
Real hourly wage ($ 2015)	26.87	33.29	25.70	Real hourly wage ($ 2015)	27.86	26.70
Real weekly earning ($ 2015)	987.90	1217.20	946.27	Real weekly earning ($ 2015)	1057.47	976.22
Full-time worker	0.78	0.83	0.78	Full-time worker	0.80	0.78
Total weekly hours worked	41.55	43.29	41.24	Total weekly hours worked	40.85	41.67
Observations	807,918	129,377	678,541	Observations	125,689	682,229

Note: Sample includes individuals aged 16–64 who are not self-employed, not in the armed forces and not unpaid family workers. The sample also excludes people with computed hourly wages in the top 1% and bottom 1%. For top-coding issues regarding labor market outcomes, the sample follows Autor et al. (2008) and winsorizes hours, wages, and earnings. The real hourly wage and real weekly earnings are in 2015$.

Table 2. Estimated Annual Population Employment

Occupation		% Licensed	% Public
Name	Employment	Mean	Mean
Panel A. High State Variation in Licensing Attainment			
Brokerage Clerks	9,000	15	0
Dispensing Opticians	97,000	28	1
Social Workers	2,500,000	26	49
Fire Inspectors	40,000	35	73
Panel B. Low State Variation in Licensing Attainment			
Teachers	14,000,000	50	60.5
Registered Nurses	6,000,000	75	11
Economists	73,000	1	56
Crossing Guards	110,000	7	54

Note: Sample includes individuals aged 16–64 who are not self-employed, not in the armed forces and not unpaid family workers. The sample also excludes people with computed hourly wages in the top 1% and bottom 1%. For top-coding issues regarding labor market outcomes, the sample follows Autor et al. (2008) and winsorizes hours, wages, and earnings. The real hourly wage and real weekly earnings are in 2015$. Total employment is estimated from the state-by-occupation employment share from the dataset.

Table 3. Control Sensitivity and Treatment Effect Bounds—Probability of Sector Choice

	A	B	C	D	E
Variable of Interest					
License	0.0578***	0.0558***	0.0558***	0.0392***	0.0391***
	(0.00727)	(0.00644)	(0.00652)	(0.00277)	(0.00276)
Union	0.417***	0.406***	0.399***	0.308***	0.308***
	(0.0115)	(0.00978)	(0.00980)	(0.00638)	(0.00638)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.47$					(0.03146, 0.03907), $\delta = 4.51$
$Rmax = 0.7$					(0.01373, 0.03907), δ =1.46
$Rmax = 1$					(-0.01370, 0.03907), δ =0.78
Controls					
Wage, education, sex, race		X	X	X	X
Other controls			X	X	X
Occupation*state, fixed effects				X	X
Year fixed effects					X
PSM Weighting	Yes	Yes	Yes	Yes	Yes
Observations	807,811	807,811	807,811	807,811	807,811
R-squared	0.163	0.201	0.205	0.362	0.362

Note: Date Source: CPS IPUMS. The dependent variable is the probability of being in public sector. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects used in the interaction with the state fixed effects are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. All standard errors are clustered at the state by occupation level.

Table 4. Control Sensitivity and Treatment Effect Bounds—Labor Market Outcomes

	A	B	C	D	E
Panel A. Log of Wage					
License	-0.0487***	0.0133	0.0543***	0.0677***	0.0652***
	(0.00882)	(0.00917)	(0.0121)	(0.00887)	(0.00861)
Public	-0.113***	-0.0994***	-0.0920***	-0.0506***	-0.0492***
	(0.00890)	(0.00794)	(0.00788)	(0.00564)	(0.00560)
Union	-0.522***	-0.177***	0.0830*	0.0663*	0.0733**
	-0.0487***	0.0133	0.0543***	0.0677***	0.0652***
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.39$					(0.06518, 0.10624), $\delta = -16.63$
$Rmax = 0.5$					(0.06518, 0.33057), $\delta = -7.45$
$Rmax = 0.7$					(0.06518, 14.53875), $\delta = -3.74$
Observations	807,551	807,551	807,551	807,551	807,551
R-squared	0.068	0.195	0.204	0.289	0.299
Panel B. Log of Total Weekly Hours					
License	0.0329***	0.0249***	0.0301***	0.0427***	0.0428***
	(0.00379)	(0.00334)	(0.00440)	(0.00419)	(0.00418)
Public	-0.00993**	-0.00866**	-0.00758**	-0.00879***	-0.00879***
	(0.00394)	(0.00362)	(0.00360)	(0.00300)	(0.00300)
Union	0.0184***	-0.0252***	0.00884	0.0839***	0.0839***
	(0.00665)	(0.00890)	(0.0189)	(0.0182)	(0.0183)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.08$					(0.04281, 0.05683), $\delta = 6.29$
$Rmax = 0.5$					(0.04281, 39.96590), $\delta = 0.28$
$Rmax = 0.7$					(0.04281, 60.67866), $\delta = 0.19$
Observations	807,317	807,317	807,317	807,317	807,317
R-squared	0.003	0.030	0.033	0.063	0.063
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year fixed effects					X
Panel C. Log of Employment					
%License					-0.315***
					(0.0922)
%Public					0.0722
					(0.0776)
%Union					-0.228***
					(0.0648)
Clusters					24,374
Occupation, year fixed effects					Yes
PSM Weighting					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at the individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table 5. Sub-sample Bound Estimates for Licensed Public vs. Licensed Private

	A	B	C	D	E
Panel A. Log of Wage					
Licensed Public vs. Private	-0.109***	-0.149***	-0.135***	-0.0372***	-0.0356***
	(0.00901)	(0.00757)	(0.00716)	(0.00553)	(0.00554)
Licensed Union vs. Non-union	-0.589***	-0.237***	0.106	0.00765	0.0124
	(0.0236)	(0.0195)	(0.0655)	(0.0357)	(0.0353)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.46$					(-0.08652, -0.03559), $\delta = -1.08$
$Rmax = 0.7$					(-0.42662, -0.03559), $\delta = -0.33$
$Rmax = 1$					(-3.91920, -0.03559), $\delta = -0.18$
Observations	129,377	129,377	129,377	129,377	129,377
R-squared	0.106	0.252	0.267	0.342	0.352
Panel B. Log of Total Hours					
Licensed Public vs. Private	0.00607	-0.00119	0.00200	-0.00458	-0.00456
	(0.00409)	(0.00373)	(0.00372)	(0.00332)	(0.00332)
Licensed Union vs. Non-union	0.0479***	-0.0164*	0.0930***	0.129***	0.129***
	(0.00710)	(0.00844)	(0.0190)	(0.0190)	(0.0190)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.09$					(-0.01745, -0.00456), $\delta = -0.49$
$Rmax = 0.5$					(-6.67596, -0.00456), $\delta = -0.03$
$Rmax = 0.7$					(-10.94750, -0.00456), $\delta = -0.02$
Observations	129,336	129,336	129,336	129,336	129,336
R-squared	0.002	0.043	0.049	0.079	0.079
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year, fixed effects					X
Panel C. Log of Employment					
Licensed %Public					-0.0550
					(0.0957)
Licensed %Union					-0.272***
					(0.0580)
Clusters					15,968
Occupation, year fixed effects					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at the individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table 6. Sub-sample Bound Estimates for Public Licensed vs. Public Unlicensed

	A	B	C	D	E
Panel A. Log of Wage					
Public Licensed vs. Unlicensed	-0.00468	0.0222**	0.0303***	0.0575***	0.0542***
	(0.0112)	(0.00911)	(0.00903)	(0.00679)	(0.00665)
Public Union vs. Non-union	0.0857***	0.0442***	0.0608***	0.0580***	0.0581***
	(0.0147)	(0.0101)	(0.00972)	(0.00715)	(0.00704)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.37$					(0.05421, 0.07818), $\delta = -2.15$
$Rmax = 0.5$					(0.05421, 0.11329), $\delta = -0.87$
$Rmax = 0.7$					(0.05421, 0.16679), $\delta = -0.45$
Observations	125,678	125,678	125,678	125,678	125,678
R-squared	0.005	0.177	0.191	0.276	0.286
Panel B. Log of Total Hours					
Public Licensed vs. Unlicensed	0.0508***	0.0497***	0.0518***	0.0516***	0.0516***
	(0.00371)	(0.00358)	(0.00359)	(0.00349)	(0.00348)
Public Union vs. Non-union	0.0285***	0.0256***	0.0284***	0.0542***	0.0542***
	(0.00423)	(0.00413)	(0.00410)	(0.00411)	(0.00411)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.10$					(0.05155, 0.05421), $\delta = -14.76$
$Rmax = 0.7$					(0.05155, 0.09671), $\delta = -0.96$
$Rmax = 1$					(0.05155, 0.11604), $\delta = -0.66$
Observations	125,634	125,634	125,634	125,634	125,634
R-squared	0.006	0.028	0.031	0.077	0.078
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year fixed effects					X
Panel C. Log of Employment					
Public %Licensed					-0.229**
					(0.109)
Public % Union					-0.254***
					(0.0669)
Clusters					14,181
Occupation, year fixed effects					Yes
PSM Weighting					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at the individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table 7. Sub-Sample Bound Estimates for Unlicensed Public vs. Licensed Private

	A	B	C	D	E
Panel A. Log of Wage					
Unlicensed Public vs. Licensed Private	0.0730***	0.109***	0.113***	0.0558***	0.0523***
	(0.0154)	(0.0148)	(0.0205)	(0.0180)	(0.0176)
Union	-0.512***	-0.249***	-0.133*	-0.134*	-0.126*
	(0.0209)	(0.0307)	(0.0759)	(0.0752)	(0.0741)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.36$					(-0.29137, 0.05230), $\delta = 0.34$
$Rmax = 0.5$					(-4.52863, 0.05230), $\delta = 0.12$
$Rmax = 0.7$					(-11.95002, 0.05230), $\delta = 0.07$
Observations	182,988	182,988	182,988	182,988	182,988
R-squared	0.058	0.162	0.177	0.263	0.274
Panel B. Log of Total Hours					
Unlicensed Public vs. Licensed Private	0.0331***	0.0242***	0.0408***	0.0507***	0.0511***
	(0.00674)	(0.00588)	(0.00887)	(0.00828)	(0.00825)
	-0.000592	-0.0567***	0.0529	0.0694**	0.0685**
Union	(0.00777)	(0.0146)	(0.0342)	(0.0334)	(0.0334)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.10$					(0.05111, 0.11752), $\delta = 2.89$
$Rmax = 0.5$					(0.05111, 24.88506), $\delta = 0.17$
$Rmax = 0.7$					(0.05111, 37.65829), $\delta = 0.12$
Observations	182,919	182,919	182,919	182,919	182,919
R-squared	0.003	0.030	0.037	0.079	0.079
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year, fixed effects					X
Panel C. Log of Employment					
%Unlicensed Public vs.% Licensed Private					-0.366***
					(0.0911)
%Union					-0.284***
					(0.0692)
Clusters					18,744
Occupation, year fixed effects					Yes
PSM Weighting					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at the individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table 8. Sub-sample Bound Estimates for Private Licensed vs. Private Unlicensed

	A	B	C	D	E
Panel A. Log of Wage					
Private Licensed vs. Unlicensed	0.208***	0.101***	0.0814***	0.0830***	0.0785***
	(0.0131)	(0.0114)	(0.0110)	(0.00717)	(0.00712)
Private Union vs. Non-union	-0.0571***	-0.0354***	-0.0349***	0.0136*	0.0135*
	(0.0107)	(0.00989)	(0.00995)	(0.00738)	(0.00737)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.44$					(0.03089, 0.07850), $\delta = 1.58$
$Rmax = 0.7$					(-0.12856, 0.07850), $\delta = 0.44$
$Rmax = 1$					(-0.40080, 0.07850), $\delta = 0.24$
Observations	681,873	681,873	681,873	681,873	681,873
R-squared	0.015	0.220	0.230	0.325	0.335
Panel B. Log of Total Hours					
Private Licensed vs. Unlicensed	0.0100*	0.0162***	0.0131***	0.0305***	0.0309***
	(0.00528)	(0.00449)	(0.00435)	(0.00375)	(0.00374)
Private Union vs. Non-union	0.0216***	0.0155***	0.0145***	0.0358***	0.0358***
	(0.00388)	(0.00365)	(0.00364)	(0.00334)	(0.00334)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.10$					(0.03090, 0.03760), $\delta = -6.87$
$Rmax = 0.5$					(0.03090, 1.38520), $\delta = -0.39$
$Rmax = 0.7$					(0.03090, 4.47211), $\delta = -0.26$
6					
Observations	681,683	681,683	681,683	681,683	681,683
R-squared	0.001	0.039	0.043	0.078	0.078
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year, fixed effects					X
Panel C. Log of Employment					
Private %Licensed					
					-0.510***
					(0.0891)
Private % Union					-0.163*
					(0.0873)
Clusters					23,271
Occupation, year fixed effects					Yes
PSM Weighting					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at the individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table 9. Sub-sample Bound Estimates for Unlicensed Public vs. Unlicensed Private

	A	B	C	D	E
Panel A. Log of Wage					
Unlicensed Public vs. Private	-0.0452***	-0.0448***	-0.0490***	-0.0186***	-0.0184***
	(0.00736)	(0.00495)	(0.00485)	(0.00303)	(0.00297)
Unlicensed Union vs. Non-union	-0.582***	-0.112***	0.316***	0.0219	0.0313*
	(0.0113)	(0.00989)	(0.0370)	(0.0170)	(0.0167)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.58$					(-0.07734, -0.01840), $\delta = -0.35$
$Rmax = 0.7$					(-0.13892, -0.01840), $\delta = -0.19$
$Rmax = 1$					(-0.35448, -0.01840), $\delta = -0.09$
Observations	678,540	678,540	678,540	678,540	678,540
R-squared	0.131	0.341	0.346	0.436	0.447
Panel B. Log of Total Hours					
Unlicensed Public vs. Private	-0.0537***	-0.0493***	-0.0485***	-0.0289***	-0.0289***
	(0.00276)	(0.00232)	(0.00233)	(0.00204)	(0.00204)
Unlicensed Union vs. Non-union	-0.0434***	0.0253***	0.0852***	0.154***	0.155***
	(0.00441)	(0.00476)	(0.0135)	(0.0127)	(0.0127)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.16$					(-0.03170, -0.02107), $\delta = -3.03$
$Rmax = 0.5$					(-1.89961, -0.02107), $\delta = -0.29$
$Rmax = 0.7$					(-6.02547, -0.02107), $\delta = -0.19$
Observations	678,346	678,346	678,346	678,346	678,346
R-squared	0.011	0.092	0.104	0.131	0.131
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year, fixed effects					X
Panel C. Log of Employment					
Unlicensed %Public					-0.149
					(0.100)
Unlicensed % Union					-0.0932
					(0.0589)
Clusters					24,374
Occupation, year fixed effects					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. The dependent variable is probability of being in public sector. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. All standard errors are clustered at the state level. For Panel A and B, the regression is at the individual level; for Panel C, the regression is at the state-occupation cell level.

Table 10. Sub-sample Bound Estimates for Licensed Public vs. Unlicensed Private

	A	B	C	D	E
Panel A. Log of Wage					
Licensed Public vs. Unlicensed Private	-0.156***	-0.0731***	-0.0157	0.0361***	0.0349***
	(0.0106)	(0.0101)	(0.0141)	(0.0105)	(0.0103)
Union	-0.520***	-0.144***	0.172***	0.139***	0.145***
	(0.0198)	(0.0280)	(0.0539)	(0.0434)	(0.0421)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.40$					(0.03489, 0.04455), $\delta = -3.52$
$Rmax = 0.7$					(0.03489, 0.05432), $\delta = -1.74$
$Rmax = 1$					(0.03489, 0.07446), $\delta = -0.85$
Observations	624,563	624,563	624,563	624,563	624,563
R-squared	0.067	0.202	0.210	0.302	0.311
Panel B. Log of Total Hours					
Licensed Public vs. Unlicensed Private	0.0182***	0.0119***	0.0119**	0.0234***	0.0234***
	(0.00454)	(0.00437)	(0.00543)	(0.00512)	(0.00511)
Union	0.0210***	-0.0220**	-0.0191	0.0779***	0.0781***
	(0.00745)	(0.0101)	(0.0219)	(0.0209)	(0.0209)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.09$					(0.02288, 0.02343), $\delta = 54.06$
$Rmax = 0.5$					(0.01267, 0.02343), $\delta = 2.51$
$Rmax = 0.7$					(0.00841, 0.02343), $\delta = 1.72$
Observations	624,398	624,398	624,398	624,398	624,398
R-squared	0.004	0.031	0.032	0.066	0.067
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year, fixed effects					X
Panel C. Log of Employment					
%Licensed Public vs. %Unlicensed Private					-0.287***
					(0.0997)
% Union					-0.209***
					(0.0661)
Clusters					23,599
Occupation, year fixed effects					Yes
PSM Weighting					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. The dependent variable is probability of being in public sector. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. All standard errors are clustered at the state level. For Panel A and B, the regression is at the individual level; for Panel C, the regression is at the state-occupation cell level.

Table 11. Licensing Effects by Sectors—Labor Market Outcomes

	Log Wages		Log Hours		Log Employment	
	Federal	State & Local	Federal	State & Local	Federal	State & Local
License	0.0477***	0.0754***	0.0401***	0.0420***	-0.203	-0.287**
	(0.00850)	(0.00852)	(0.00417)	(0.00414)	(0.141)	(0.112)
Federal	0.0901***		-0.00431		0.444***	
	(0.00930)		(0.00398)		(0.123)	
State and local		-0.0870***		-0.00661**		0.0720
		(0.00622)		(0.00303)		(0.0853)
Union	0.0972***	0.0714*	0.0860***	0.0852***	-0.225**	-0.280***
	(0.0374)	(0.0373)	(0.0183)	(0.0183)	(0.103)	(0.0636)
Constant	1.272***	1.450***	3.021***	3.029***	11.92***	12.78***
	(0.178)	(0.178)	(0.0990)	(0.0990)	(0.0574)	(0.0675)
Controls	Yes	Yes	Yes	Yes	No	No
Fixed Effects	Yes	Yes	Yes	Yes	No	No
PSM Weighting	Yes	Yes	Yes	Yes	Yes	Yes
Two-stage Correction	Yes	Yes	Yes	Yes	Yes	Yes
Observations/Clusters	807,551	807,551	807,317	807,317	7,450	12,140
R-squared	0.299	0.301	0.063	0.063	0.940	0.968

Note: Date Source: CPS IPUMS. Controlled characteristics include age and age-squared, experience and experience-squared, log income, sex, race, education, region, marital status, citizenship, union status, and veteran status. Fixed effects include occupation * state fixed effect and year fixed effect. Occupational fixed effects are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. All standard errors are clustered at the state level.

Table 12. Mean Descriptive Statistics by Occupations

	Licensed	Unlicensed	Public	Private	Observations
1. Management in Business, Science, and Arts	0.12	0.88	0.12	0.88	88,798
2. Business Operations and Financial Specialists	0.13	0.87	0.13	0.87	41,917
3. Computer and Mathematical	0.05	0.95	0.12	0.88	29,445
4. Architecture and Engineering	0.15	0.85	0.11	0.89	15,062
5. Technicians	0.09	0.91	0.13	0.87	3,055
6. Life, Physical, and Social Science	0.14	0.86	0.32	0.68	9,079
7. Community and Social Services	0.25	0.75	0.35	0.65	14,965
8. Legal	0.48	0.52	0.24	0.76	8,146
9. Education, Training, and Library	0.43	0.57	0.61	0.39	47,797
10. Arts, Design, Entertainment, Sports, and Media	0.06	0.94	0.08	0.92	13,435
11. Healthcare Practitioners, Technicians and Support	0.55	0.45	0.10	0.90	60,995
12. Protective Service	0.28	0.72	0.68	0.32	16,936
13. Food Preparation and Serving	0.05	0.95	0.05	0.95	45,225
14. Building and Grounds Cleaning and Maintenance	0.04	0.96	0.14	0.86	28,554
15. Personal Care and Service	0.17	0.83	0.14	0.86	23,565
16. Sales and Related	0.08	0.92	0.01	0.99	78,782
17. Office and Administrative Support	0.06	0.94	0.16	0.84	107,111
18. Farming, Fisheries, and Forestry	0.05	0.95	0.03	0.97	6,654
19. Construction and Extraction	0.11	0.89	0.06	0.94	39,639
20. Installation, Maintenance, and Repair	0.13	0.87	0.08	0.92	28,070
21. Production	0.05	0.95	0.03	0.97	50,497
22. Transportation and Material Moving	0.13	0.87	0.07	0.93	50,190

Note: Date Source: CPS IPUMS

Table 13. Licensing Effects by Occupations—Sector Choice

	Selected Occupations					
	occ1	occ2	occ3	occ4	occ5	occ6
License	0.0380	-0.0346	-0.0640*	0.0293**	-0.100***	-0.0530**
	(0.0360)	(0.0233)	(0.0387)	(0.0149)	(0.0196)	(0.0207)
Union	0.359**	0.199**	0.169	-0.138**	-0.453***	0.352***
	(0.150)	(0.0974)	(0.162)	(0.0564)	(0.0968)	(0.0812)
Constant	1.045	1.779***	1.175*	2.517***	3.062***	0.0441
	(0.739)	(0.519)	(0.675)	(0.277)	(0.494)	(0.394)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
PSM	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,079	14,965	8,146	47,794	16,935	23,560
R-squared	0.214	0.266	0.158	0.178	0.257	0.179

Note: Date Source: CPS IPUMS. The occupations are 1. Life, Physical, and Social Science; 2. Community and Social Services; 3. Legal; 4. Education, Training, and Library; 5. Protective Service; 6. Personal Care and Service. Controlled characteristics include age and age-squared, experience and experience-squared, log income, sex, race, education, region, marital status, citizenship, union status, and veteran status. Fixed effects include state fixed effect and year fixed effect. All standard errors are clustered at the state level.

Table 14. Licensing Effects by Occupations—Log of Wages

	Selected Occupations					
	occ1	occ2	occ3	occ4	occ5	occ6
License	-0.0319	0.0976***	0.284***	0.0823***	-0.0276	0.0603
	(0.0541)	(0.0359)	(0.0741)	(0.0159)	(0.0350)	(0.0720)
Public	-0.105***	0.0985***	-0.172***	0.00712	0.217***	0.0223
	(0.0403)	(0.0175)	(0.0581)	(0.0107)	(0.0308)	(0.0251)
Union	-0.154	0.316**	0.625**	0.301***	-0.255	0.372
	(0.230)	(0.153)	(0.281)	(0.0822)	(0.165)	(0.332)
Constant	1.784	-0.000104	-0.738	0.649	3.178***	-0.0779
	(1.103)	(0.768)	(1.410)	(0.410)	(0.861)	(1.448)
Observations	9,079	14,963	8,146	47,787	16,929	23,551
R-squared	0.279	0.185	0.223	0.192	0.223	0.171

Note: Date Source: CPS IPUMS. The occupations are 1. Life, Physical, and Social Science; 2. Community and Social Services; 3. Legal; 4. Education, Training, and Library; 5. Protective Service; 6. Personal Care and Service. Controlled characteristics include age and age-squared, experience and experience-squared, log income, sex, race, education, region, marital status, citizenship, union status, and veteran status. Fixed effects include state fixed effect and year fixed effect. All standard errors are clustered at the state level.

Table 15. Licensing Effects by Occupations —Log of Total Hours Worked

	Selected Occupations					
	occ1	occ2	occ3	occ4	occ5	occ6
License	0.0306	-0.0410**	-0.00741	0.0637***	0.0381**	0.0503
	(0.0264)	(0.0203)	(0.0273)	(0.00949)	(0.0154)	(0.0755)
Public	-0.0538***	0.0221**	-0.0801***	0.0491***	0.0374**	-0.0107
	(0.0161)	(0.00887)	(0.0115)	(0.00807)	(0.0148)	(0.0259)
Union	0.0881	-0.218**	-0.171	-0.0228	0.00574	-0.0939
	(0.102)	(0.0950)	(0.119)	(0.0411)	(0.0780)	(0.270)
Constant	2.782***	4.697***	4.275***	3.501***	3.925***	4.152***
	(0.533)	(0.504)	(0.599)	(0.243)	(0.436)	(1.511)
Observations	9,079	14,960	8,146	47,756	16,926	23,538
R-squared	0.066	0.049	0.082	0.055	0.083	0.068

Note: Date Source: CPS IPUMS. The occupations are 1. Life, Physical, and Social Science; 2. Community and Social Services; 3. Legal; 4. Education, Training, and Library; 5. Protective Service; 6. Personal Care and Service. Controlled characteristics include age and age-squared, experience and experience-squared, log income, sex, race, education, region, marital status, citizenship, union status, and veteran status. Fixed effects include state fixed effect and year fixed effect. All standard errors are clustered at the state level.

Table 16. Licensing Effects by Occupations —Log of Employment

	Selected Occupations					
	occ1	occ2	occ3	occ4	occ5	occ6
%License	-0.925***	-0.312	2.480***	2.170***	0.256	0.0643
	(0.204)	(0.303)	(0.132)	(0.372)	(0.253)	(0.230)
%Public	-0.896***	-0.407*	-4.182***	0.407	-2.085***	4.110***
	(0.201)	(0.213)	(0.418)	(0.275)	(0.267)	(0.563)
%Union	-1.128*	0.422	-1.963	0.136	1.855***	-1.382
	(0.566)	(0.413)	(2.000)	(0.578)	(0.265)	(1.036)
Constant	11.72***	12.06***	12.44***	11.76***	12.55***	11.60***
	(0.0816)	(0.0829)	(0.112)	(0.115)	(0.0968)	(0.141)
Clusters	51	51	51	51	51	51
R-squared	0.613	0.491	0.855	0.641	0.627	0.543

Note: Date Source: CPS IPUMS. The occupations are 1. Life, Physical, and Social Science; 2. Community and Social Services; 3. Legal; 4. Education, Training, and Library; 5. Protective Service; 6. Personal Care and Service. Controlled characteristics include age and age-squared, experience and experience-squared, log income, sex, race, education, region, marital status, citizenship, union status, and veteran status. Fixed effects include state fixed effect and year fixed effect. All standard errors are clustered at the state level.

Table 17. Licensing Effects by Specific Occupations—Log of Wages

	Panel A: Most Influential Occupations			*Panel B: Most Overweighted Occupations*		
	Teachers	Social Workers	Registered Nurses	Bus and Ambulance Drivers and Attendants	Fire Inspectors	Dispensing Opticians
License	0.0550***	0.0794*	0.0105	0.0292	0.282	-0.0448
	(0.0164)	(0.0443)	(0.0278)	(0.0656)	(0.997)	(0.178)
Public	0.0163	0.0704***	-0.0211	0.102***	-0.0309	-0.0709
	(0.0113)	(0.0238)	(0.0162)	(0.0381)	(0.257)	(0.174)
Union	0.306***	0.201	-0.280**	0.564*	0.793	-0.0357
	(0.0887)	(0.194)	(0.131)	(0.331)	(3.973)	(0.858)
Constant	0.693	-0.303	3.414***	0.892	-6.711	2.737
	(0.456)	(1.173)	(0.766)	(1.643)	(20.33)	(3.268)
Observations	38,650	6,595	16,271	2,704	121	272
R-squared	0.176	0.232	0.171	0.247	0.893	0.653

Note: Date Source: CPS IPUMS. Panel A occupations (teachers, social workers and registered nurses) are the most influential occupations according to the implicit weights on potentially heterogeneous treatment effects by occupation in the two-way fixed effect estimator, as derived by de Chaisemartin and d'Haultfoeuille (2019). Panel B occupations are overweighted occupations, as defined by the ratio of the implicit weight and the occupation's sample share of workers. Controlled characteristics include age and age-squared, experience and experience-squared, log income, sex, race, education, region, marital status, citizenship, union status, and veteran status. Fixed effects include state fixed effect and year fixed effect. All standard errors are clustered at the state level.

Table 18. Licensing Effects by Specific Occupations —Log of Total Hours Worked

	Panel A: Most Influential Occupations			*Panel B: Most Overweighted Occupations*		
	Teachers	Social workers	Registered Nurses	Bus and Ambulance Drivers and Attendants	Fire Inspectors	Dispensing Opticians
License	0.0455***	-0.0161	-0.00674	0.169**	-0.183	-0.154
	(0.00955)	(0.0270)	(0.0166)	(0.0773)	(0.184)	(0.193)
Public	0.0560***	0.0385***	0.0350***	-0.0751*	0.0203	0.285
	(0.00874)	(0.0126)	(0.00948)	(0.0394)	(0.110)	(0.227)
Union	-0.0574	-0.192	0.158	1.033***	-0.668	-0.713
	(0.0437)	(0.134)	(0.0997)	(0.393)	(0.752)	(0.997)
Constant	3.795***	4.361***	2.754***	-0.210	2.926	9.086***
	(0.262)	(0.640)	(0.488)	(2.399)	(4.188)	(3.155)
Observations	38,627	6,594	16,266	2,702	121	272
R-squared	0.046	0.072	0.041	0.208	0.863	0.401

Note: Date Source: CPS IPUMS. Panel A occupations (teachers, social workers and registered nurses) are the most influential occupations according to the implicit weights on potentially heterogeneous treatment effects by occupation in the two-way fixed effect estimator, as derived by de Chaisemartin and d'Haultfoeuille (2019). Panel B occupations are overweighted occupations, as defined by the ratio of the implicit weight and the occupation's sample share of workers. Controlled characteristics include age and age-squared, experience and experience-squared, log income, sex, race, education, region, marital status, citizenship, union status, and veteran status. Fixed effects include state fixed effect and year fixed effect. All standard errors are clustered at the state level.

Table 19. Instrumental Variable Results

	(1) Public	(2) Log Wage	(3) Log Hours
Panel A: Whole Sample			
License	0.150***	0.166***	0.236***
	(0.00345)	(0.0276)	(0.0148)
Public		-0.109***	-0.0401***
		(0.00605)	(0.00322)
Union	0.399***	0.478***	0.708***
	(0.00229)	(0.0956)	(0.0511)
Constant	-0.0438*	-1.116***	0.130
	(0.0263)	(0.429)	(0.228)
Observations	804,655	804,396	804,163
R-squared	0.194	0.212	0.004
Cragg-Donald Wald F statistic	2.5e+05	7.6e+04	7.6e+04
Panel B: Public Sector Sub-Sample			
License		0.0956**	0.397***
		(0.0428)	(0.0237)
Union		0.348**	1.220***
		(0.154)	(0.0859)
Constant		-0.298	-2.146***
		(0.706)	(0.389)
Observations		125,107	125,063
R-squared		0.201	-0.066
Cragg-Donald Wald F statistic		9333	9338
PSM Weighting		Yes	Yes
Two-State Correction		Yes	Yes

Note: Date Source: CPS IPUMS. Not shown controlled characteristics include age and age-squared, experience and experience-squared, log income, sex, race, education, region, marital status, citizenship, union status, and veteran status. Fixed effects include occupation, state fixed effect and year fixed effect (since the IV is generated by state by occupation cell). Occupational fixed effects are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. All standard errors are robust SE.

Table 20. Selected Descriptive Statistics, SIPP

	By Licensing				By Sector	
	Full Sample	Licensed	Unlicensed		Public	Private
Public	0.11	0.17	0.10	Licensed	0.21	0.13
Private	0.89	0.83	0.90	Unlicensed	0.79	0.87
Licensed	0.14	-	-			
Unlicensed	0.86	-	-			
Education Category				*Education Category*		
Less than high school	0.10	0.03	0.11	Less than high school	0.05	0.10
High school graduate	0.32	0.16	0.34	High school graduate	0.23	0.33
Some college	0.20	0.16	0.21	Some college	0.22	0.20
Associate degree	0.23	0.38	0.20	Associate degree	0.26	0.22
Bachelor's degree	0.13	0.21	0.12	Bachelor's degree	0.20	0.12
Graduate degree	0.03	0.07	0.02	Graduate degree	0.06	0.02
Race				*Race*		
White	0.80	0.82	0.79	White	0.78	0.80
Black	0.13	0.11	0.13	Black	0.13	0.13
Asian	0.03	0.04	0.03	Asian	0.03	0.03
Hispanic	0.20	0.11	0.22	Hispanic	0.15	0.21
Personal				*Personal*		
Union status	0.11	0.16	0.11	Union status	0.33	0.09
Female	0.50	0.61	0.49	Female	0.56	0.50
Experience	17.24	19.02	16.94	Experience	21.18	16.73
Age	38.74	41.11	38.35	Age	43.12	38.18
Labor Outcomes				*Labor Outcomes*		
Hourly wage	14.83	18.82	14.17	Hourly wage	17.51	14.49
Weekly hours worked	35.73	36.33	35.63	Weekly hours worked	34.89	35.84
Observations	47,007	6,684	40,323	Observations	5,318	41,689

Note: Date Source: SIPP 2008 Panel Wave 13. We include employed workers who are between the age of 18-64 with hourly wage on the main job between $5-$100, and we drop observations with imputed wages.

Table 21. SIPP Results—Probability of Sector Choice

	A	B	C	D
Variable of Interest				
License	0.0187*	0.0157	0.0185*	0.0215*
	(0.0101)	(0.0109)	(0.0102)	(0.0109)
Union	0.296***	0.293***	0.285***	0.271***
	(0.0265)	(0.0291)	(0.0254)	(0.0215)
	0.0187*	0.0157	0.0185*	0.0215*
Bounds and Deltas				
$Rmax = \tilde{R} \times 1.3 = 0.5$				(0.02148, 0.02207), $\delta = -38.08$
$Rmax = 0.7$				(0.02148, 0.02309), $\delta = -14.12$
$Rmax = 1$				(0.02148, 0.02464), $\delta = -7.25$
Controls				
Wage, education, sex, race		X	X	X
Other controls			X	X
Occupation*state, fixed effects				X
PSM Weighting	Yes	Yes	Yes	Yes
Two-stage Correction	Yes	Yes	Yes	Yes
Observations	46,955	46,955	46,955	46,955
R-squared	0.090	0.100	0.113	0.387

Note: Date Source: SIPP 2008 Panel Wave 13. The dependent variable is the probability of being in the public sector. Other controlled characteristics include age and age-squared, experience and experience-squared, gender, race, educational attainments, marital status, citizenship, and veteran status. Occupational fixed effects used in the interaction with the state fixed effects are defined by aggregating occupational classification code into 22 occupation groups based on SOC. All standard errors are clustered at the state by occupation level.

Table 22. SIPP Results—Labor Market Outcomes Whole Sample

	A	B	C	D
Panel A. Log of Wage				
License	0.110***	0.112***	0.197***	0.181***
	(0.0142)	(0.0161)	(0.0401)	(0.0260)
Public	0.000333	-0.00414	-0.00574	0.0191
	(0.0279)	(0.0248)	(0.0241)	(0.0198)
Union	-0.0108	-0.0168	0.658**	1.004***
	(0.0229)	(0.0440)	(0.314)	(0.194)
Bounds and Deltas				
$Rmax = \tilde{R} \times 1.3 = 0.7$				(0.18098, 0.26099), $\delta = 1.98$
$Rmax = 1$				(0.18098, 20.44519), $\delta = 0.74$
Observations	46,955	46,955	46,955	46,955
R-squared	0.156	0.256	0.276	0.546
Panel B. Log of Total Weekly Hours				
License	0.0421***	0.00883	-0.0158	0.0310
	(0.0128)	(0.0130)	(0.0246)	(0.0201)
Public	-0.0145	-0.0193	-0.0182	0.00778
	(0.0234)	(0.0202)	(0.0203)	(0.0197)
Union	0.315***	-0.00708	-0.206	0.159
	(0.0309)	(0.0466)	(0.184)	(0.178)
Bounds and Deltas				
$Rmax = \tilde{R} \times 1.3 = 0.33$				(0.03104, 0.06827), $\delta = 6.70$
$Rmax = 0.5$				(0.03104, 22.48029), $\delta = 2.06$
$Rmax = 0.7$				(0.03104, 58.83430), $\delta = 1.14$
Observations	46,955	46,955	46,955	46,955
R-squared	0.033	0.080	0.091	0.253
Wage, education, sex race		X	X	X
Other controls			X	X
Occupation*state fixed effects				X
Panel C. Log of Employment				
%License				-0.319***
				(0.0495)
%Public				-0.00820
				(0.0829)
%Union				-0.165**
				(0.0651)
Clusters				4.817
Occupation, state fixed effects				Yes
PSM Weighting	Yes	Yes	Yes	Yes
Two-stage Correction	Yes	Yes	Yes	Yes

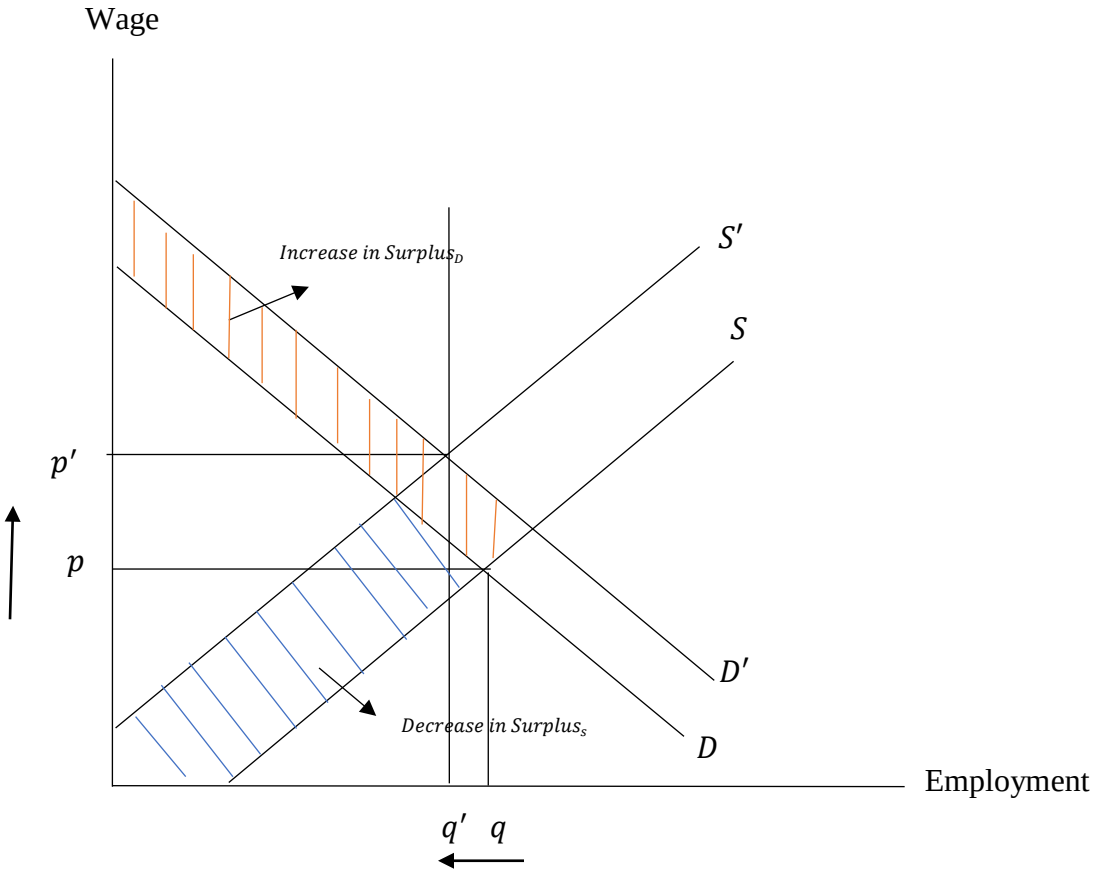
Note: Date Source: SIPP 2008 Panel Wave 13. For Panel A and B, the regression is at individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, gender, race, educational attainments, marital status, citizenship, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occupational classification code into 22 occupation groups based on SOC. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table 23. SIPP Sub-Sample Bound Estimates for Public Licensed vs. Public Unlicensed

	A	B	C	D
Panel A. Log of Wage				
Public Licensed vs. Unlicensed	0.0734**	0.0507	0.127**	0.0918
	(0.0295)	(0.0351)	(0.0515)	(0.0636)
Public Union vs. Non-union	0.0724	0.0209	0.664*	0.861**
	(0.0605)	(0.118)	(0.355)	(0.407)
Bounds and Deltas				
$Rmax = \tilde{R} \times 1.3 = 0.89$				(0.09184, 1.80015), $\delta = 1.03$
$Rmax = 1$				(0.09184, 146.18770), $\delta = 0.69$
Observations	5,318	5,318	5,318	5,318
R-squared	0.124	0.211	0.225	0.691
Panel B. Log of Total Hours				
Public Licensed vs. Unlicensed	0.0578	-0.00767	0.00163	-0.111
	(0.0363)	(0.0454)	(0.0600)	(0.0732)
Public Union vs. Non-union	0.337***	-0.0845	0.00269	-0.00787
	(0.0647)	(0.148)	(0.463)	(0.601)
Bounds and Deltas				
$Rmax = \tilde{R} \times 1.3 = 0.74$				(-0.93673, -0.11086), $\delta = -1.24$
$Rmax = 1$				(-6.58614, -0.11086), $\delta = -0.50$
Observations	5,318	5,318	5,318	5,318
R-squared	0.044	0.083	0.103	0.571
Wage, education, sex race		X	X	X
Other controls			X	X
Occupation*state fixed effects				X
Year fixed effects				X
Panel C. Log of Employment				
Public %Licensed				-0.480***
				(0.0919)
Public % Union				-0.189*
				(0.0991)
Clusters				1,004
Occupation, year fixed effects				Yes
PSM Weighting	Yes	Yes	Yes	Yes
Two-Stage Correction	Yes	Yes	Yes	Yes

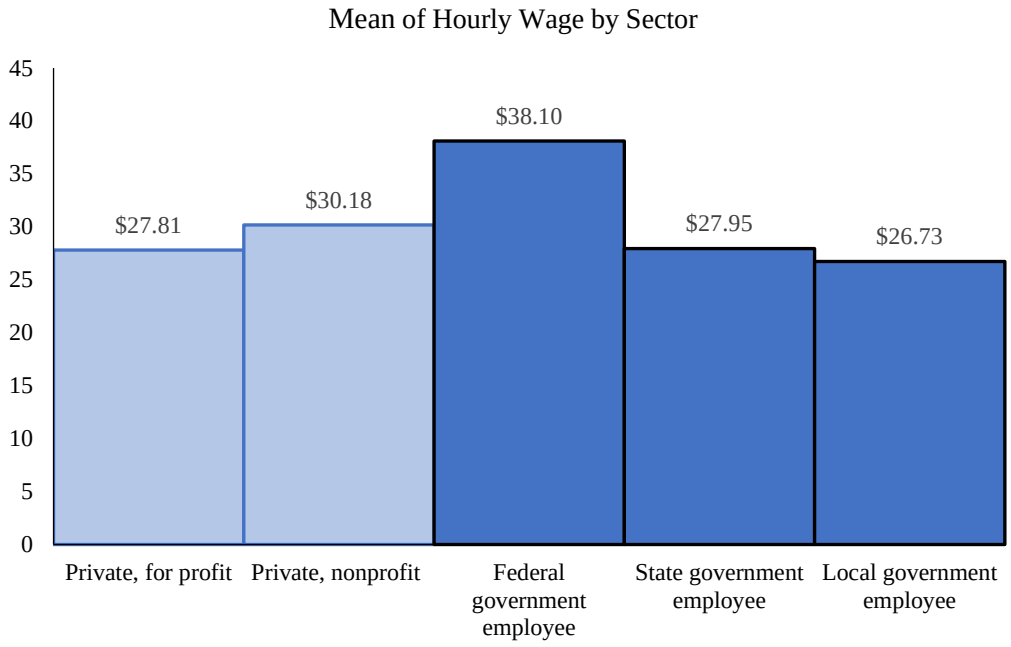
Note: Date Source: SIPP 2008 Panel Wave 13. For Panel A and B, the regression is at individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, gender, race, educational attainments, marital status, citizenship, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occupational classification code into 22 occupation groups based on SOC. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Figure 1. Welfare Model for Occupational Licensing



Note: This is an interpretation of Kleiner and Soltas (2023).

Figure 2. Labor Market Outcomes by Specific Sectors



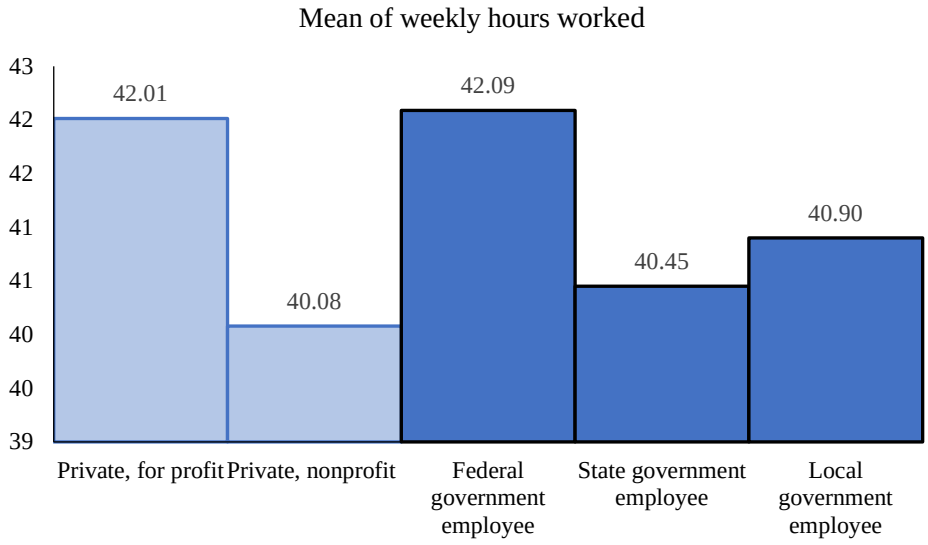
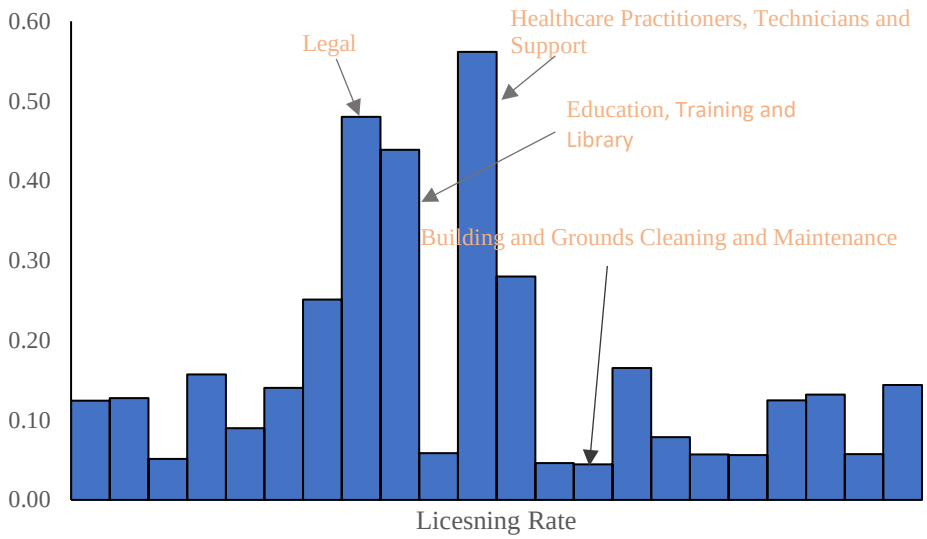


Figure 3. Licensing and Sector Percentage by Occupational Categories



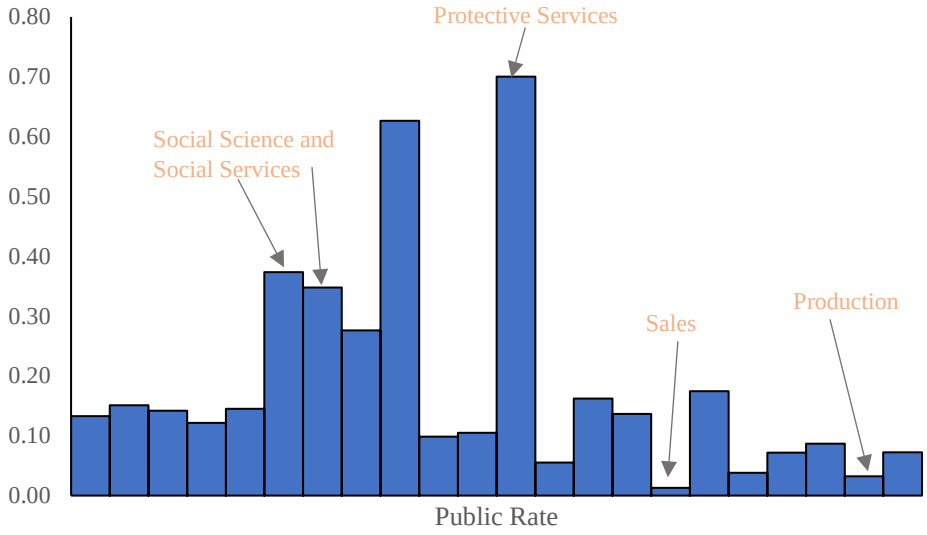
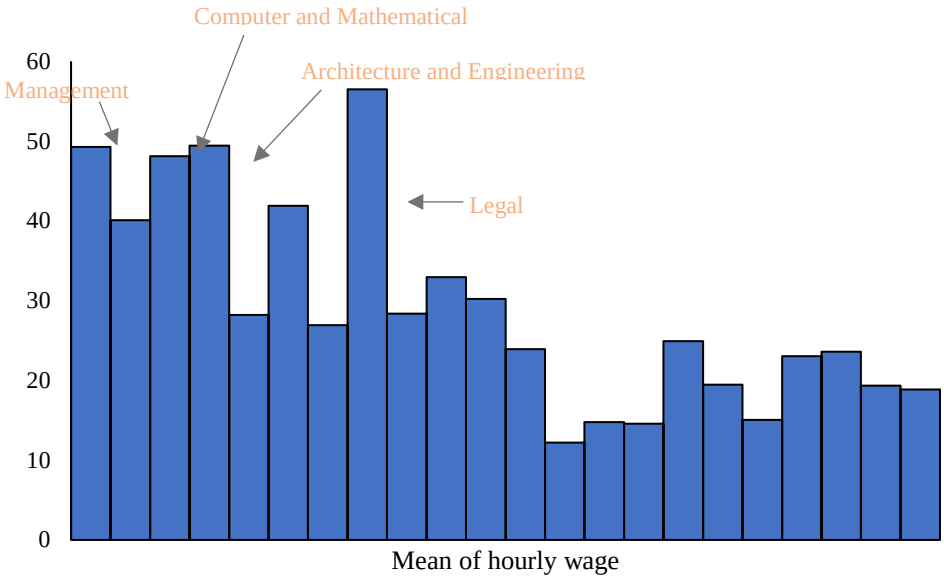


Figure 4. Labor Market Outcomes by Occupational Categories



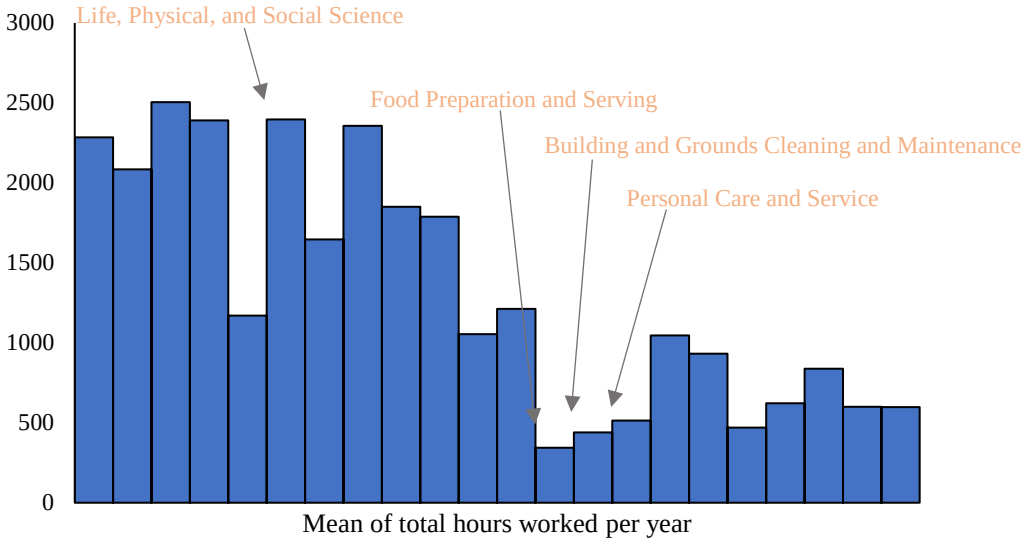


Figure 5. Labor Market Outcomes: Licensing Comparison between Sectors

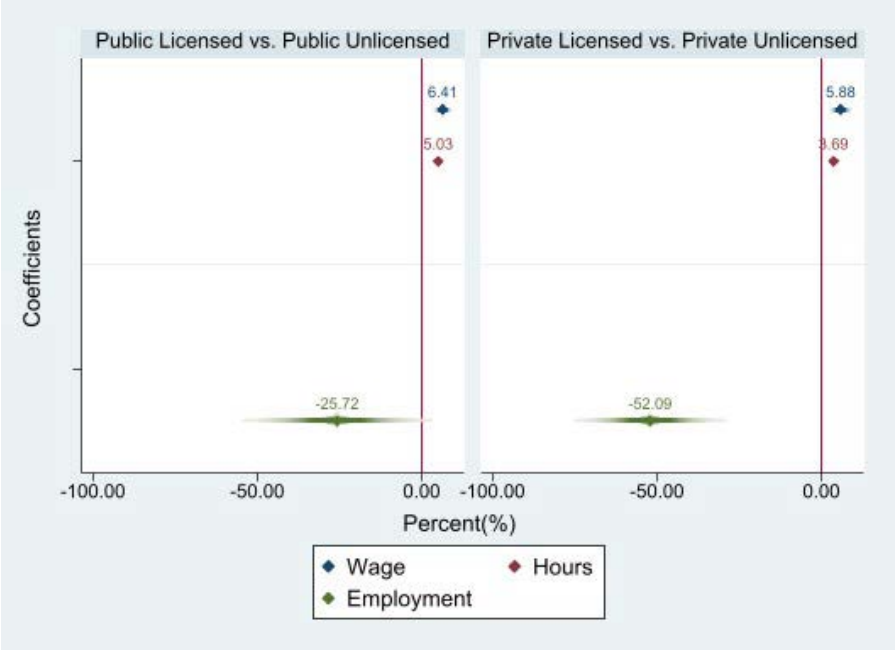


Figure 6. Labor Market Outcomes: Sector Comparison between Licensing

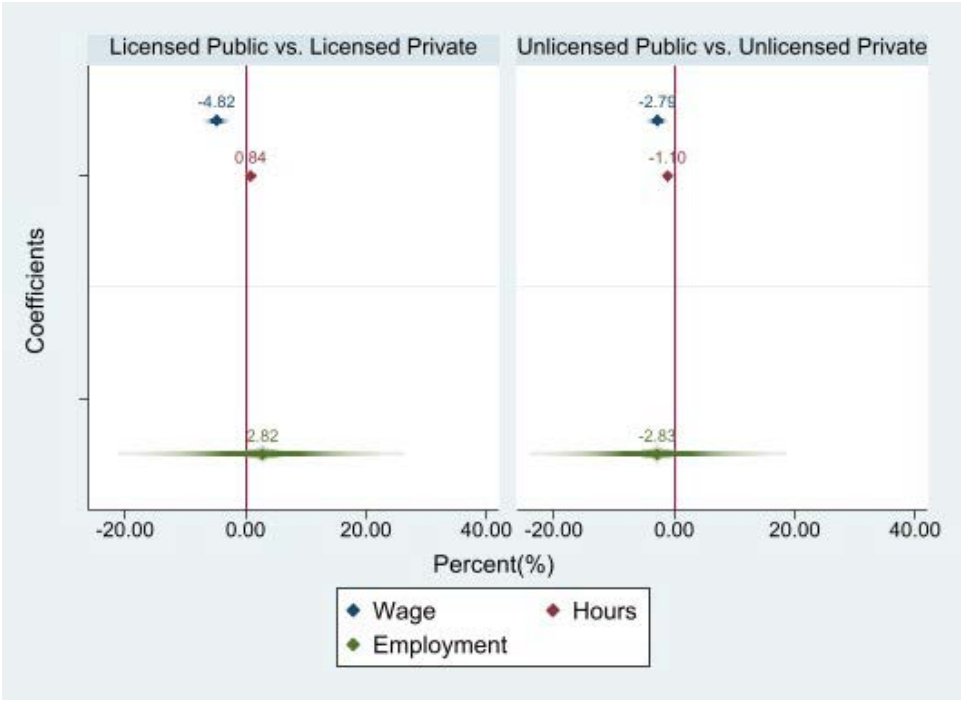
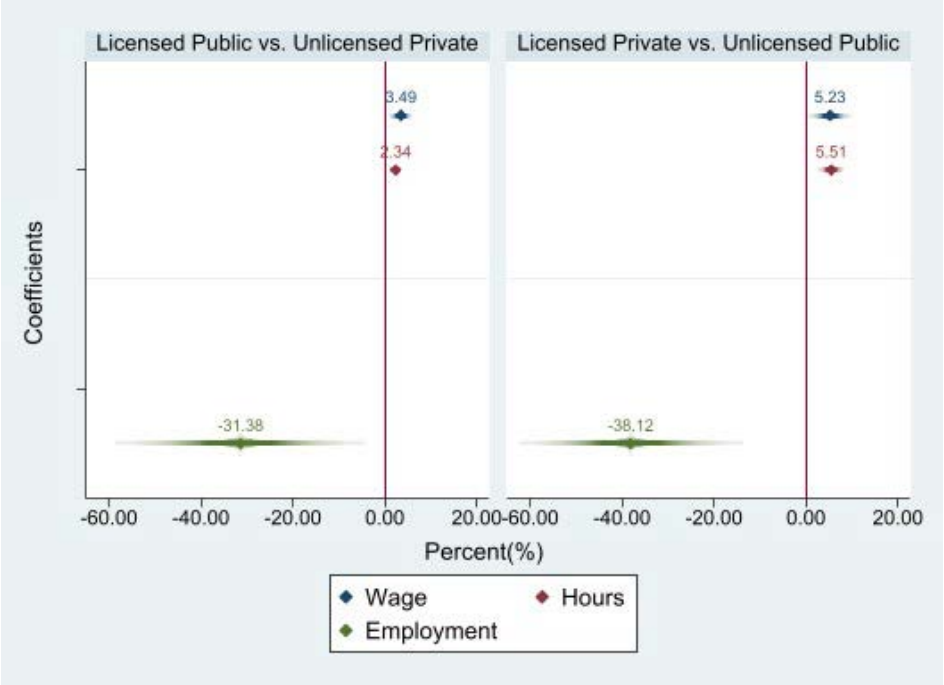


Figure 7. Labor Market Outcomes: Interactor Groups Comparison



Appendices.

A. Further Results Using Different Samples

A1. Robustness Check Using Different CPS Sample

For our baseline results, we use the CPS sample of keeping the wage and hours information from mish 4 and 8 and impute the inaccurate licensing status using licensing indicator information from mish 1 and 5 to deliver our baseline results. Now in this section, we are going to use the CPS sample of keeping workers most accurate licensing information in mish 1 and 5 and use the wage and hours information in mish 4 and 8 to match individuals in mish 1 and 5. The descriptive statistics for this sample are shown in Table C1. We can see that using this CPS sample, both the percentage for public sector and licensing workers increased a little. Now in the whole sample, 17% of workers are in the public sector and 21% are licensed workers (these are 14% and 15% in our baseline sample). Accordingly, the number of licensed workers in the public sector has increased more than 10% from 27% to 38% as well. This is an indicator that even using imputation methods as described in our data section, when we use the most accurate licensing information in mish 1 and 5, there still exist some discrepancies for the licensing percentage. Other characteristics remain rather similar in the two samples. In terms of the labor outcomes, there are some small differences as well. In CPS sample 2 the mean hourly wage is around $3 higher compared with the baseline sample; and the mean of total weekly hours worked is around 39.50, which is slightly lower than the full-time job of 40 hours per week. The sample size for the CPS sample we are using here is smaller, with total observations being around 500,000 while the sample size in our baseline results is over 800,000.

Moving onto the labor market outcomes both in the whole sample and in the public sector only as displayed in Table C2-C3, the signs for the main coefficients remain the same, while the there are some differences in the magnitudes of the coefficients. For the whole sample, in our results here the wage effect for licensing is 8.7%, which is a 2.2% increase compare with the baseline wage effects. Hours' effect of licensing also increased around 2%. The effects of working in the public sector on wage and hours worked have slightly increased as well while for union, in our sample here it has transformed from a 7.3% significant impact on wages from the baseline results a no significant impact on wages. For the new CPS sample results in the public sector, both licensing's effects on wages and total weekly hours worked have increased, while licensing does not have a significant impact on employment using the new cps sample here.

A2. Robustness Check Excluding Heterogenous Occupations

In the main section of our paper, we estimate the labor market outcomes for heterogenous occupations such as teachers separately to see whether the coefficients would be different within each specific occupation. Here in this section, we are trying to exclude these heterogenous occupations from our main sample to test whether our baseline results are robust by excluding these heterogenous occupations. In Figure C1, we are excluding a list of heterogenous occupations.[31] We can see that both the signs and magnitudes for licensing's effects on labor market outcomes are compared to that in our baseline results. In the public sector subsample, the coefficients of licensing on wages (5.25%) and employment (-22.27%) are slightly smaller comparing with the baseline results (6.41% and -25.72%). In Figure C2, we are only excluding teacher occupations and teaching assistants and we still get coefficients comparable in the sense of both magnitudes and signs to our baseline results. This section provides some evidence for the robustness of our baseline results from occupational heterogeneity.

[31] This list is the occupations in the Panel A of Table A6. from Kleiner and Soltas (2023), and the occupations include electricians, nursing, psychiatric, and hole health aides, patrol officers, pipelayers, plumbers, etc., teaching occupations and teacher assistants, construction managers, social workers, personal and home care aides, dental assistants, and automotive service technicians and mechanics.

B. Further Results Using Different Licensing Indicators

B1. Licensing Indicator of Answering "Yes" to All Three Questions

In our data section, we explain that there are three questions asked in the CPS, that:

1. Do you have a currently active professional certification or a state or industry license? 2. Were any of your certifications or licenses issued by the federal, state, or local government? 3. Is your certification or license required for your job?

In our baseline results we construct the licensing indicator to be respondents answer "yes" only to the first question. Here we construct a more restrict indicator, that starting from 2016, if a respondent answer "yes" to all three questions, then he/she will be considered as licensed.[32] The results are shown from Table C4-C5. In the whole sample using this new indicator as well as in the public sector sample, we can see that the sign and magnitudes are comparable to that in using the original licensing indicator in our baseline results. Therefore, we conclude that using different indicators for the answer to the first two or to the first three questions does not have any impact on the results we are estimating here.

[32] Note in this section, since the third licensing question started to be asked only from 2016, our sample here is from 2016-2021.

B2. Licensing Indicator of Universally Licensed Occupations

In this section, we do not use the CPS sample questions to construct our individual licensing status indicator. Instead, we are using universally licensed occupations as a proxy indicator for licensing. We construct the universally licensed occupation based on Gittleman el al. (2018), and the universally licensed occupations we included here are:

- Chiropractors, Nurse practitioners, Veterinarians, Dentists, Occupational therapists, Optometrists, Physicians and surgeons, Nurse anesthetists, Respiratory therapists, Pharmacists, Registered nurses, Lawyers, Judges, magistrates, and other judicial workers, Physician assistants, Occupational therapist assistants and aides, Physical therapists, Dental hygienists, Secondary school teachers, Emergency medical technicians and paramedics, Special education teachers, Elementary and middle school teachers, Morticians, undertakers, and funeral directors, Hairdressers, hairstylists, and cosmetologists, Audiologists, Real estate brokers and sales agents, Licensed practical and licensed vocational nurses, Barbers, Insurance sales agents, Water and liquid waste treatment plant and system operators, Pest control workers, Architects, except naval, Driver/sales workers and truck drivers, Taxi drivers and chauffeurs.

For this alternative indicator, we say that if the individual works in any of the above occupations, then the status of the individual is licensed, otherwise it is unlicensed. The mean comparison of the three licensing indicators are shown in Figure C3. We can see that using the universally licensed occupation, the licensing share in the whole sample is the lowest at 11%, while using the answer "yes" to all three questions has the highest licensing share of 16%. The results using the universally licensed indicator are in Table C6-C7. We can see that all three effects for licensing are increasing. For the wage and hours effects of licensing, the increases are around 4%, while the employment effect increases even more tremendously. However, for the employment, since it is the employment share at state and occupation level, and our licensing indicator is constructed based on the occupations being universally licensed or not, using this indicator to predict the employment effect of licensing may not be appropriate compared with using individual licensing indicators. The increase of the coefficients' magnitudes is similar in the public sector, but in both two samples using this proxy licensing indicator, the signs are comparable, and the bound estimate are robust not using the most restrictive $Rmax$. Therefore, we believe our baseline results pass the robustness check using different licensing indicators.

B3. Adding Interaction Term Between Licensing and Public Sector

In this section, other than looking at licensing and public sector indicator separately in the regression, now we add the interaction term of these two indicators into the regression to check whether the results are consistent with our baseline results. The results are shown in Table C8.

When adding the interaction term, we do not need to conduct separate sub-sample analysis; instead, we can just use the coefficient on the interaction term to uncover the effect of licensing on the labor market outcomes in the public sector. We can see that for the overall effect of licensing, it has a 7.7% positive impact on wages, and this is comparable to the 6.5% in our baseline results. Similarly for hours effect, occupational licensing has a 1.7% positive effect on total weekly hours worked, and this is slightly lower compared with the 4.3% in our baseline results. The employment effect is lower as well, with licensing having a 21.8% negative impact on employment, while the magnitude is 31.5% in the main results. Although there are some discrepancies, the magnitudes for the licensing coefficients still fall under acceptable range compared to our baseline results.

Taking the interaction term into consideration and looking at licensing's effects on the labor market outcomes in the public sector only, we find comparable results as well. Licensing has a positive effect of 5.9% on wages and a positive effect of 5.7% on total weekly hours worked. These are comparable to the 6.4% wage effects and the 5% hours worked effects of licensing in the public sector from our baseline results. For the employment effect, the interaction term is not significant so we cannot really determine licensing's effects on employment using interaction term method. However, the magnitude is still within the comparable range.

C. Additional Tables and Figures

Table C1. Selected Descriptive Statistics, 2015–2021 CPS Sample 2

	By Licensing				By Sector	
	Full Sample	Licensed	Unlicensed		Public	Private
Public	0.17	0.31	0.69	Licensed	0.38	0.62
Private	0.83	0.13	0.87	Unlicensed	0.17	0.83
Licensed	0.21	-	-			
Unlicensed	0.79	-	-			
Education Category				*Education Category*		
Less than high school	0.07	0.02	0.09	Less than high school	0.02	0.08
High school graduate	0.24	0.12	0.27	High school graduate	0.14	0.26
Some college	0.17	0.12	0.18	Some college	0.14	0.18
Associate degree	0.11	0.15	0.10	Associate degree	0.10	0.11
Bachelor's degree	0.26	0.28	0.25	Bachelor's degree	0.29	0.25
Graduate degree	0.15	0.31	0.11	Graduate degree	0.30	0.12
Race				*Race*		
White	0.80	0.82	0.79	White	0.79	0.80
Black	0.11	0.10	0.12	Black	0.13	0.11
Asian	0.07	0.06	0.08	Asian	0.05	0.08
Hispanic	0.17	0.11	0.19	Hispanic	0.12	0.18
Personal				*Personal*		
Marital status	0.56	0.65	0.53	Marital status	0.64	0.54
Union status	0.14	0.25	0.11	Union status	0.41	0.08
Female	0.48	0.57	0.46	Female	0.57	0.46
Experience	20.00	20.52	19.87	Experience	21.85	19.63
Age	40.43	42.28	39.95	Age	43.42	39.84
Labor Outcomes				*Labor Outcomes*		
Real hourly wage ($ 2015)	29.41	35.96	27.70	Real hourly wage ($ 2015)	29.26	29.44
Real weekly earning ($ 2015)	1058.70	1291.74	998.04	Real weekly earning ($ 2015)	1114.51	1047.56
Full-time worker	0.79	0.83	0.78	Full-time worker	0.81	0.79
Total weekly hours worked	39.50	41.35	39.02	Total weekly hours worked	39.93	39.42
Observations	500,526	107,789	392,737	Observations	89,749	410,777

Note: Sample includes individuals aged 16–64 who are not self-employed, not in the armed forces and not unpaid family workers. The sample also excludes people with computed hourly wages in the top 1% and bottom 1%. For top-coding issues regarding labor market outcomes, the sample follows Autor et al. (2008) and winsorizes hours, wages and earnings. The real hourly wage and real weekly earnings are in 2015$.

Table C2. CPS Sample 2—Labor Market Outcomes

	A	B	C	D	E
Panel A. Log of Wage					
License	-0.0606***	0.00530	0.0336**	0.0809***	0.0865***
	(0.0123)	(0.0134)	(0.0167)	(0.0106)	(0.0105)
Public	-0.173***	-0.165***	-0.158***	-0.0905***	-0.0893***
	(0.0122)	(0.0116)	(0.0114)	(0.00719)	(0.00716)
Union	-0.551***	-0.264***	-0.0807	-0.0123	-0.00848
	(0.0240)	(0.0323)	(0.0576)	(0.0411)	(0.0406)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.39$					(0.08650, 0.20873), $\delta = 7.83$
$Rmax = 0.5$					(0.08650, 11.01630), $\delta = -2.43$
$Rmax = 0.7$					(0.08650, 32.68773), $\delta = -1.3$
Observations	509,396	509,396	509,396	509,396	509,396
R-squared	0.088	0.206	0.226	0.346	0.355
Panel B. Log of Total Weekly Hours					
License	0.0320***	0.0275***	0.0429***	0.0626***	0.0630***
	(0.00492)	(0.00473)	(0.00563)	(0.00516)	(0.00517)
Public	0.0179***	0.0189***	0.0202***	0.00988***	0.00999***
	(0.00462)	(0.00426)	(0.00424)	(0.00301)	(0.00301)
Union	0.00109	-0.0261***	0.0514**	0.112***	0.113***
	(0.00705)	(0.00968)	(0.0201)	(0.0199)	(0.0199)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.08$					(0.06303, 0.10337), $\delta = 3.14$
$Rmax = 0.5$					(0.06303, 24.13790), $\delta = 0.24$
$Rmax = 0.7$					(0.06303, 37.73340), $\delta = 0.16$
Observations	499,875	499,875	499,875	499,875	499,875
R-squared	0.008	0.044	0.049	0.096	0.096
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year fixed effects					X
Panel C. Log of Employment					
%License					-0.127*
					(0.0724)
%Public					0.0688
					(0.0767)
%Union					-0.0817
					(0.0649)
Clusters					21,741
Occupation, year fixed effects					Yes
PSM Weighting					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at the individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table C3. CPS Sample 2 for Public Licensed vs. Public Unlicensed

	A	B	C	D	E
Panel A. Log of Wage					
Public Licensed vs. Unlicensed	-0.0111	0.0156	0.0273**	0.0787***	0.0831***
	(0.0140)	(0.0118)	(0.0115)	(0.00758)	(0.00758)
Public Union vs. Non-union	0.0906***	0.0524***	0.0772***	0.0554***	0.0560***
	(0.0166)	(0.0130)	(0.0123)	(0.00822)	(0.00812)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.47$					(0.08313, 0.12103), $\delta = -2.19$
$Rmax = 0.7$					(0.08313, 0.20809), $\delta = -0.70$
$Rmax = 1$					(0.08313, 0.32874), $\delta = -0.38$
Observations	90,653	90,653	90,653	90,653	90,653
R-squared	0.007	0.182	0.211	0.348	0.358
Panel B. Log of Total Hours					
Public Licensed vs. Unlicensed	0.0630***	0.0628***	0.0653***	0.0726***	0.0731***
	(0.00483)	(0.00481)	(0.00482)	(0.00398)	(0.00397)
Public Union vs. Non-union	0.0290***	0.0250***	0.0278***	0.0581***	0.0582***
	(0.00412)	(0.00402)	(0.00410)	(0.00414)	(0.00415)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.14$					(0.07315, 0.07947), $\delta = -12.36$
$Rmax = 0.7$					(0.07315, 0.17350), $\delta = -1.41$
$Rmax = 1$					(0.07315, 0.25978), $\delta = -0.94$
Observations	89,701	89,701	89,701	89,701	89,701
R-squared	0.012	0.043	0.048	0.111	0.111
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year fixed effects					X
Panel C. Log of Employment					
Public %Licensed					-0.0938
					(0.0884)
Public % Union					-0.0867
					(0.0670)
Clusters					12,144
Occupation, year fixed effects					Yes
PSM Weighting					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at the individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on the IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table C4. All-Three-Yes Licensing Indicator—Labor Market Outcomes

	A	B	C	D	E
Panel A. Log of Wage					
License	0.0253***	0.0590***	0.0850***	0.102***	0.0643***
	(0.00838)	(0.00805)	(0.00857)	(0.00663)	(0.00713)
Public	-0.145***	-0.111***	-0.0940***	-0.0513***	-0.0468***
	(0.00851)	(0.00750)	(0.00769)	(0.00553)	(0.00550)
Union	-0.490***	-0.128***	0.122***	0.0913***	0.0154
	(0.0178)	(0.0216)	(0.0327)	(0.0280)	(0.0276)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.39$					(0.06425, 19.28293), $\delta =$ 9.52
$Rmax = 0.5$					(0.06425, 0.33057), $\delta =$ 4.27
$Rmax = 0.7$					(0.06425, 63.99133), $\delta =$ 2.14
Observations	807,551	807,551	807,551	807,551	807,551
R-squared	0.067	0.196	0.206	0.292	0.299
Panel B. Log of Total Weekly Hours					
License	0.0356***	0.0289***	0.0298***	0.0338***	0.0491***
	(0.00332)	(0.00302)	(0.00334)	(0.00315)	(0.00357)
Public	-0.00751*	-0.00792**	-0.00656*	-0.00629**	-0.00783***
	(0.00385)	(0.00360)	(0.00357)	(0.00297)	(0.00297)
Union	0.0165**	-0.0298***	-0.0151	0.0254*	0.0626***
	(0.00642)	(0.00877)	(0.0154)	(0.0141)	(0.0146)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.08$					(0.04905, 0.14651), $\delta =$ 2.70
$Rmax = 0.5$					(0.04905, 64.68022), $\delta =$ 0.12
$Rmax = 0.7$					(0.04905, 96.04275), $\delta =$ 0.08
Observations	807,317	807,317	807,317	807,317	807,317
R-squared	0.004	0.031	0.033	0.063	0.064
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year fixed effects					X
Panel C. Log of Employment					
%License					-0.343***
					(0.0979)
%Public					0.0726
					(0.0776)
%Union					-0.230***
					(0.0652)
Clusters					24,374
Occupation, year fixed effects					Yes
PSM Weighting					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table C5. All-Three-Yes Licensing Indicator for Public Licensed vs. Public Unlicensed

	A	B	C	D	E
Panel A. Log of Wage					
Public Licensed vs. Unlicensed	0.0668***	0.0593***	0.0644***	0.0914***	0.0687***
	(0.0101)	(0.00814)	(0.00803)	(0.00657)	(0.00747)
Public Union vs. Non-union	0.0945***	0.0472***	0.0630***	0.0582***	0.0556***
	(0.0137)	(0.00962)	(0.00923)	(0.00703)	(0.00695)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.37$					(0.06867, 0.18463), $\delta = -1.65$
$Rmax = 0.5$					(0.06867, 1.18105), $\delta = -0.67$
$Rmax = 0.7$					(0.06867, 6.11761), $\delta = -0.35$
Observations	125,678	125,678	125,678	125,678	125,678
R-squared	0.008	0.179	0.193	0.279	0.287
Panel B. Log of Total Hours					
Public Licensed vs. Unlicensed	0.0456***	0.0430***	0.0442***	0.0419***	0.0604***
	(0.00335)	(0.00327)	(0.00326)	(0.00329)	(0.00390)
Public Union vs. Non-union	0.0241***	0.0214***	0.0240***	0.0491***	0.0513***
	(0.00421)	(0.00409)	(0.00408)	(0.00404)	(0.00406)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.10$					(0.06036, 0.08390), $\delta = 3.95$
$Rmax = 0.5$					(0.06036, 17.63249), $\delta = 0.25$
$Rmax = 0.7$					(0.06036, 27.18524), $\delta = 0.17$
Observations	125,634	125,634	125,634	125,634	125,634
R-squared	0.007	0.028	0.031	0.077	0.080
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year fixed effects					X
Panel C. Log of Employment					
Public %Licensed					-0.262**
					(0.116)
Public % Union					-0.254***
					(0.0670)
Clusters					14,181
Occupation, year fixed effects					Yes
PSM Weighting					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table C6. Universally Licensed Indicator—Labor Market Outcomes

	A	B	C	D	E
Panel A. Log of Wage					
License	-0.0167	-0.00511	-0.00459	0.0971***	0.101***
	(0.0186)	(0.0163)	(0.0157)	(0.00979)	(0.00942)
Public	-0.133***	-0.0940***	-0.0830***	-0.0420***	-0.0410***
	(0.00842)	(0.00754)	(0.00792)	(0.00547)	(0.00543)
Union	-0.505***	-0.199***	-0.106***	-0.123***	-0.106***
	(0.0172)	(0.0202)	(0.0272)	(0.0219)	(0.0215)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.39$					(0.10146, 0.18459), $\delta = -7.06$
$Rmax = 0.5$					(0.10146, 0.65741), $\delta = -3.22$
$Rmax = 0.7$					(0.10146, 9.47971), $\delta = -1.61$
Observations	807,552	807,552	807,552	807,552	807,552
R-squared	0.067	0.195	0.203	0.291	0.301
Panel B. Log of Total Weekly Hours					
License	0.0198***	0.0273***	0.0259***	0.0828***	0.0826***
	(0.00569)	(0.00525)	(0.00531)	(0.00564)	(0.00566)
Public	0.00269	-0.00362	-0.00484	-0.00342	-0.00342
	(0.00387)	(0.00356)	(0.00356)	(0.00293)	(0.00293)
Union	0.00922	-0.0551***	-0.0705***	-0.0283**	-0.0284**
	(0.00608)	(0.00836)	(0.0132)	(0.0116)	(0.0116)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.09$					(0.08258, 0.13722), $\delta = -14.48$
$Rmax = 0.5$					(0.08258, 10.81100), $\delta = -0.77$
$Rmax = 0.7$					(0.08258, 16.42957), $\delta = -0.52$
Observations	807,318	807,318	807,318	807,318	807,318
R-squared	0.002	0.031	0.033	0.068	0.068
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year fixed effects					X
Panel C. Log of Employment					
%License					-2.806***
					(0.106)
%Public					-0.194***
					(0.0582)
%Union					1.213***
					(0.111)
Clusters					24,374
Occupation, year fixed effects					Yes
PSM Weighting					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table C7. Universally Licensed Indicator for Public Licensed vs. Public Unlicensed

	A	B	C	D	E
Panel A. Log of Wage					
Public Licensed vs. Unlicensed	0.0658***	-0.0138	-0.00612	0.100***	0.103***
	(0.0213)	(0.0169)	(0.0163)	(0.0121)	(0.0116)
Public Union vs. Non-union	0.0804***	0.0409***	0.0554***	0.0425***	0.0432***
	(0.0122)	(0.00958)	(0.00901)	(0.00693)	(0.00685)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.37$					(0.10337, 0.14257), $\delta = -2.4$
$Rmax = 0.5$					(0.10337, 0.19937), $\delta = -1.01$
$Rmax = 0.7$					(0.10337, 0.28923), $\delta = -0.53$
Observations	125,678	125,678	125,678	125,678	125,678
R-squared	0.008	0.177	0.190	0.277	0.288
Panel B. Log of Total Hours					
Public Licensed vs. Unlicensed	0.0297***	0.0361***	0.0380***	0.0931***	0.0931***
	(0.00633)	(0.00614)	(0.00618)	(0.00702)	(0.00702)
Public Union vs. Non-union	0.0159***	0.0138***	0.0162***	0.0402***	0.0403***
	(0.00427)	(0.00410)	(0.00409)	(0.00398)	(0.00398)
Bounds and Deltas					
$Rmax = \tilde{R} \times 1.3 = 0.11$					(0.09306, 0.10828), $\delta = -3.23$
$Rmax = 0.5$					(0.09306, 0.32442), $\delta = -0.3$
$Rmax = 0.7$					(0.09306, 0.42375), $\delta = -0.2$
Observations	125,634	125,634	125,634	125,634	125,634
R-squared	0.004	0.026	0.029	0.083	0.083
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year fixed effects					X
Panel C. Log of Employment					
Public %Licensed					-5.137***
					(0.212)
Public % Union					-0.267***
					(0.0729)
Clusters					14,181
Occupation, year fixed effects					Yes
PSM Weighting					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Table C8. Adding Interaction Terms—Labor Market Outcomes

	A	B	C	D	E
Panel A. Log of Wage					
License	-0.00587	0.0625***	0.0948***	0.0803***	0.0766***
	(0.0130)	(0.0122)	(0.0142)	(0.0111)	(0.0109)
Public	-0.0792***	-0.0612***	-0.0615***	-0.0415***	-0.0409***
	(0.00939)	(0.00786)	(0.00792)	(0.00668)	(0.00659)
License*Public	-0.0686***	-0.0778***	-0.0621***	-0.0191**	-0.0174*
	(0.0142)	(0.0125)	(0.0120)	(0.00952)	(0.00940)
Bounds and Deltas (Interaction)					
$Rmax = \tilde{R} \times 1.3 = 0.39$					(-0.01742, -0.00999), $\delta = 2.41$
$Rmax = 0.5$					(-0.01742, -0.00119), $\delta = 1.08$
$Rmax = 0.7$					(-0.01742, 0.01363), $\delta = 0.54$
Observations	807,552	807,552	807,552	807,552	807,552
R-squared	0.069	0.195	0.204	0.289	0.299
Panel B. Log of Total Weekly Hours					
License	0.00584	-0.00227	0.000194	0.0163***	0.0165***
	(0.00577)	(0.00486)	(0.00588)	(0.00516)	(0.00516)
Public	-0.0312***	-0.0298***	-0.0301***	-0.0280***	-0.0280***
	(0.00359)	(0.00338)	(0.00345)	(0.00321)	(0.00321)
License*Public	0.0433***	0.0429***	0.0459***	0.0401***	0.0400***
	(0.00589)	(0.00539)	(0.00536)	(0.00466)	(0.00466)
Bounds and Deltas (Interaction)					
$Rmax = \tilde{R} \times 1.3 = 0.08$					(-0.01532, 0.01648), $\delta = 0.74$
$Rmax = 0.5$					(-74.50689, 0.01648), $\delta = 0.03$
$Rmax = 0.7$					(-111.19985, 0.01648b), $\delta = 0.02$
Observations	807,318	807,318	807,318	807,318	807,318
R-squared	0.004	0.031	0.033	0.063	0.063
Wage, education, sex race		X	X	X	X
Other controls			X	X	X
Occupation*state fixed effects				X	X
Year fixed effects					X
Panel C. Log of Employment					
%License					-0.218**
					(0.0962)
%Public					0.116
					(0.0853)
%License*Public					-0.178
					(0.156)
Clusters					24,374
Occupation, year fixed effects					Yes
PSM Weighting					Yes
Two-stage Correction					Yes

Note: Date Source: CPS IPUMS. For Panel A and B, the regression is at individual level. Other controlled characteristics include age and age-squared, experience and experience-squared, marital status, citizenship, union status, and veteran status. Occupational fixed effects in these two panels are defined by aggregating occ2010 into 22 occupation groups based on IPUMS definition for occ2010. For Panel C, the regression is at the state-occupation cell level. Therefore, no individual covariates or other fixed effects are included in Panel C regression. All standard errors are clustered at the state by occupation level.

Figure C1. Labor Market Outcomes Non-Heterogeneous Sample

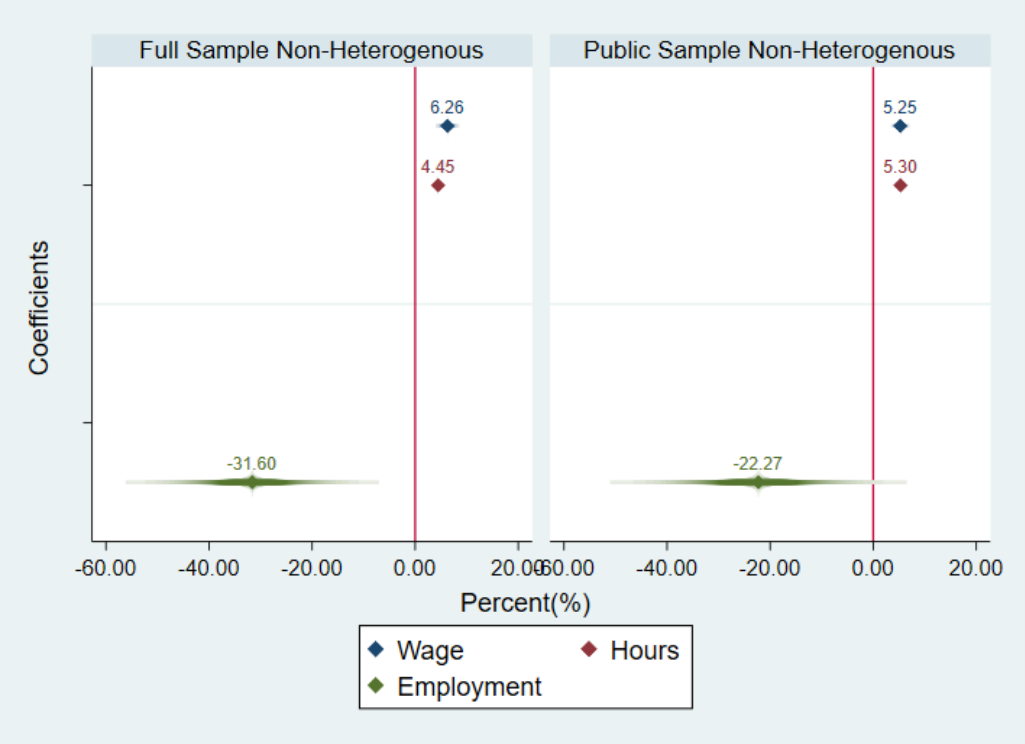


Figure C2. Labor Market Outcomes Without Teaching Occupations

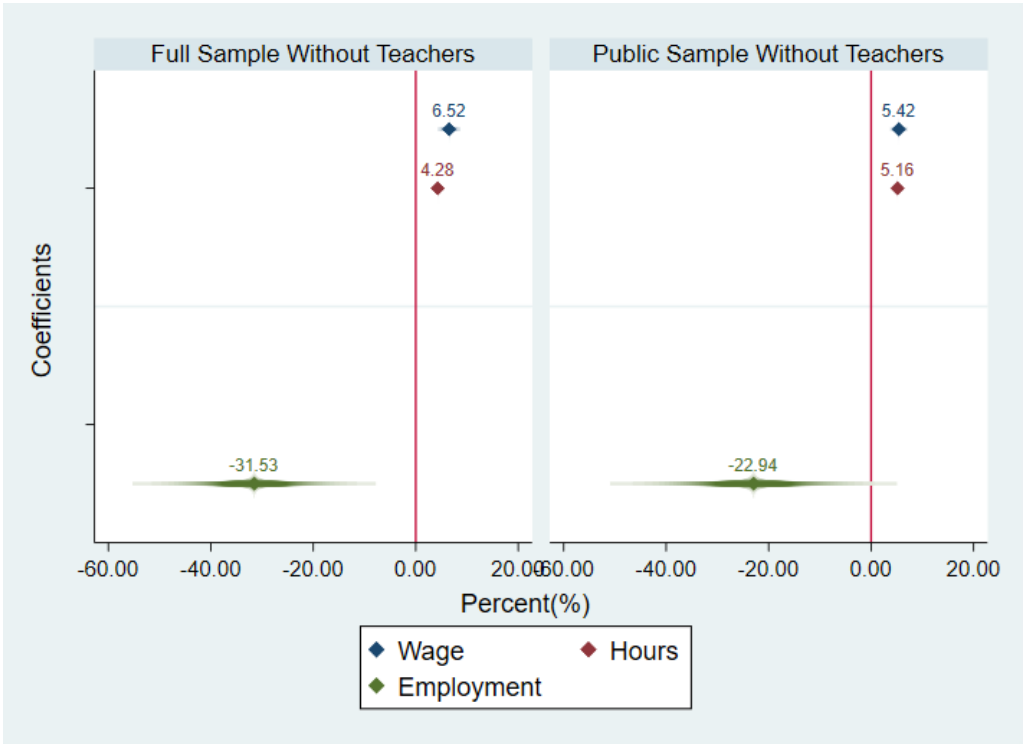


Figure C3. Mean Licensing Indicators Share