Updated Preliminary Draft

Battles Among Licensed Occupations: Analyzing Government Regulations on Labor Market Outcomes for Dentists and Hygienists*

Morris M. Kleiner, University of Minnesota and NBER

Kyoung Won Park, University of Minnesota

Abstract

One of the key features of occupational licensing is that the law determines who gets to do the work. In those cases where universally licensed occupations are both complements and substitutes for one another in providing a service, the states determine who can do the tasks that are required for the consumer. In this study we examine dentists and dental hygienists, who are both universally licensed and provide complementary services to patients, but may also be substitutes as service providers. We focus on the labor market implications of governmental requirements on permissible tasks and the supervision of hygienists' activities by dentists. Since there are elements of monopsony in the market we examine, we use the model as a guide for our analysis. We find that states that allow hygienists greater autonomy in doing work independently of dentists have significantly higher earnings, and that dentists in those states have somewhat lower earnings and slower employment growth. Our results are consistent with the view that winning the policy and legal battle in the legislature and courts on the independence of work rules matters in the labor market for these occupations.

*We thank McKenzie Smith from the American Dental Hygienists Association for providing us with some of the data for the research project. We also thank Hwikwon Ham and Tanya Wanchek for comments on our research, and to Yaffa Epstein for her assistance in data collection. We also appreciated comments from participants at a seminar at the University of Minnesota for helpful suggestions. We also thank the Upjohn Institute for Employment Research for their support of the research program on occupational regulation.

Tennessee recently became the most recent of a handful of states to crack down on the teeth-whitening business. Teeth-whitening franchises have run afoul of several state dental boards and, in January, the Tennessee Board of Dentistry declared that the kiosk-whiteners are practicing dentistry without a license. Joyce Osborn, president of the trade group Council for Cosmetic Teeth Whitening, went before the board to unsuccessfully argue that teeth-whitening is safe.

"In doing lots of research, we have made sure we are not practicing dentistry, that we are providing a self-administered application for whitening the teeth that is safe, affordable and effective," Osborn tells NPR's Robert Siegel. Dentist John Douglass, who sits on the Tennessee Board of Dentistry, disagrees. "The main problem is the perception that they are doing a dental procedure," he tells Siegel. "We on the board feel that it is our responsibility to regulate any procedure that is deemed to be practicing dentistry and this is to protect the health, safety and well-being of the people of Tennessee."

—National Public Radio broadcast, March 4, 2009

Introduction

Occupational licensing is among the fastest-growing labor market institutions in the U.S. economy and encompasses about 29 percent of the U.S. workforce (Kleiner and Krueger, 2009; Kleiner and Krueger, forthcoming). In health care, the issue is even more pervasive: about 76 percent of all non-physician workers are required to have a government license to work (PDII, 2008). One of the key features of occupational licensing is that it determines who is allowed to do work for pay under state law. In those cases where universally licensed occupations are both complements and substitutes for one another in providing a service, the states determine who can do and supervise the tasks that are required for the patient.

In this study, we examine two occupations—dentists and dental hygienists—that are both universally licensed and provide complementary services to patients, but which are also substitutes for certain tasks as service providers. However, for key services the states determine

who can do the work and what is required for the patient. We examine the labor market implications of these governmental requirements. With the number of state-licensed occupations now numbering more than 800, and the growth in the number of individuals who are regulated or seeking regulation by the states, our case study can illuminate the potential issues of the increased regulation of occupations in the U.S. labor market especially where the work of the regulated occupations overlaps.

In order to examine these relationships between dentists and hygienists, we initially explore the evolution and anatomy of state regulation for both occupations over time. We next develop a model that includes the basic production function in dentistry, with dentists and hygienists as key elements. We then show how the monopsony relationship between dentists and hygienists influences the earnings and employment of hygienists and dentists. The empirical section shows the impact of state regulations on hygienists' earnings, and how the ability of hygienists to practice without the supervision of dentists is associated with an earnings increase of approximately 10 percent. Further, when hygienists are able to work without the supervision of a dentist, there is an associated increase in the state-level employment growth of hygienists, but lower employment growth for dentists. To the extent that these estimates suggest monopsony deadweight loss, we provide some results of these estimated losses. The rest of the analysis shows how we developed these results.

Evolution and Anatomy of the Regulation of Dentists and Dental Hygienists

In this part of our study, we present the evolution and anatomy of state licensing of dentists and hygienists, and show how state policies have changed to favor greater autonomy for hygienists (Adams, 2004).

State licensing of dentists first began in South Carolina in 1876; Pennsylvania followed suit the next year. The last state to fully license dentists was North Carolina in 1935. Currently, most members of licensing boards are appointed by the governor through a list provided by the state dental association. Generally, dentists dominate the state licensing boards; other licensed professionals such as hygienists have a minority role in the process. Typically, state licensing boards either have no hygienists or, more likely, have dentists that dominate the boards; however, 17 states have separate hygienists' committees that provide recommendations to the board and, in some cases, to the legislature (Wanchek, forthcoming). As recently as 1994, 9 states forbid the employment of more than two hygienists in a dental office (ADHA, 1994). The licensing board deals with disciplinary issues involving dentists. However, the portion that deals with the allocation of work among various service providers and that gives services to clients is of interest for our analysis. For example, the board makes recommendations to the legislature on regulations governing which occupation provides dental services, and provides legal services to defend regulatory practices in state courts.

The state licensing of dental hygienists began with the regulation of hygienists by New York in 1868. Over 50 years passed before other state governments followed suit: 5 additional states licensed this occupation between 1919 and 1921 (Council of State Governments, 1952). By 1952, 29 states had full licensing of dental hygienists, and in recent years, all the other states have come to license dental hygienists (Council of State Governments, 1952). Dental hygiene is unique among licensed professions in that it is regulated by dentists, rather than self-regulated, in most states (Wanchek, forthcoming).

Initially, dental hygiene programs were one year long but have been expanded to between 2 and 4 years. A particularly illustrative example of regulatory oversight by the occupation

occurred when military dental hygienists who returned to the civilian workforce requested to sit for the hygienist's exam. The civilian hygienists protested, saying that the military hygienists needed the same years of dental hygiene training as the civilian hygienists in order to take the licensing exam. One of the key issues for the licensing boards of dental services was the work that dentists could do relative to hygienists and the supervision of dental hygienists by dentists (Helm, 1993). Traditionally, dentists are required to be physically present when hygienists are doing their work. As early as 1932, the issue of determining the proper tasks of hygienists relative to dentists was raised at national meetings of hygienists, with a view that hygienists should have greater autonomy. A key part of the history of the profession focused on the importance of hygienists playing a more important role in the policy process, particularly with respect to legislative issues. Until 1988, when Colorado first allowed hygienists to practice without the direct supervision of a dentist, hygienists have been required to work for or be under the direction of a dentist. Since that time seven states have allowed hygienists to open their own practice and care for patients without the direct oversight of a dentist. [1] As of 2007, no state permitted reciprocity of the movement of dental hygienists from other states.

In order to show the growth in hygienists' autonomy over time, in Figure 1 we develop and show a box-and-whisker graphic analysis of state regulation, which gives the mean and variance of the regulation of hygienists over the period 2001–2007. The key components of the provisions of licensing consist of the extent to which hygienists are supervised by dentists and allowed to do the following procedures on their own: prophylaxis (cleaning), fluoride treatment, sealant application, X-rays, amalgam restorations, local anesthesia, nitrous oxide, initial screening, and patient referral (Center for Health Workforce Studies, 2004). In panel A, we give

[1] As of 2007, seven states California, Colorado, Montana, Nebraska, New Mexico, Oregon and Washington allow hygienists to open offices on their own, but the work is restricted to specific kinds of dental practices. Montana and Nebraska adopted the provision in 2003 and 2007, respectively.

the overall ranking of dental hygienists tasks that are allowed by statute or legal rulings. In panel B we show the number of dental tasks that hygienists were permitted to do independent of dentists by state law or administrative or court rulings in the state.

The results in Figure 1 panels A and B show a movement toward greater autonomy for hygienists in dental practice from 2001 to 2007. The mean value of the summated rating scale for all states was 43.67 (S.D.=19.84) in 2001 and increased to 49.10 (S.D.= 20.54) by 2007 (out of 100 possible points). Most of the changes in state regulations occurred between 2002 and 2007, a period during which more states allowed hygienists to perform additional procedures. Panel A give the overall results which suggests that in spite of generally greater control of the regulatory process by dentists, hygienists have been able to gain more autonomy over the delivery of dental services to include the ability to control their own offices without the supervision of a dentist. Moreover, even within states that have full control of the delivery of dental services, there has been growth in the independence of hygienists from monitoring by dentists with respect to specific dental procedures, and likely an increase in the skills and education provided to clients of dental services.

In the next section, we model the role for dentists and hygienists in the production function of dental services and how the market for hygienists' services may resemble a monopsony in certain elements of the market for dentists and hygienists.

A model of dental services production

This section initially develops the basic production function for dental services and then expands it to include government regulation of work practices, where dentists are required to supervise hygienists. The model serves as a basis to inform the empirical work, rather than as a fully specified general equilibrium model of dental production under regulation. The unit of

analysis for the model is the office-based dental practice. Following Reinhardt (1972), this entity can be treated as a firm of which the dentist is the owner/manager who faces a profit maximization decision. The dentist makes decisions regarding her own effort to maximize income, subject to constraints including the technical production relationship between her labor and other inputs:

$Q_d = HH = f[D(z),K]$ (1)

$Q_h = HL = f[D(z), H(z),K]$ (2)

Q_d is the output produced by the dentists, which we will refer to as "high skilled dental services (*HH*)." Q_h is the output produced by the hygienists, which we will refer to as "low skilled dental services (*HL*)." $D(z)$ represents the dentist's labor, recognizing that output relies on his decision of personal input and $H(z)$ represents the hygienist's labor, recognizing that output relies on her decision of personal input. *K* represents the quantities of capital inputs used in a dental practice. For simplicity we consider capital (office space and equipment), and dental employees, who are of two types of labor: dentists and hygienists.[2]

Following Shapiro (1986) when analyzing occupations that are licensed, he models a labor market where service output has two types of workers: high skilled and lower skilled ones in the labor market. In order to adapt the model to our production function and the market for dentists and hygienists we have created a stylized version of production and output. The specifics of the model are presented next.

An explanation of the theory with licensing can be written as follows for dentists:

$$HH = A\, L_d^{\alpha}\, K_d^{\beta}, \quad (3)$$

[2] We, of course, realize that other workers are in dental offices who contribute to production such as dental technicians, aides, and clerical and administrative assistants. In our empirical work we expand upon the theoretical production function to include these additional worker inputs.

where *HH* is the high-skilled dental services provided, and *A* is the technology provided to produce *HH*, *L* is the labor input, and *K* is capital.

Similarly, the output for the hygienists can be given by the following expression:

$$HL = B\ L_h^{\gamma}\ K_h^{\delta}, \qquad (4)$$

where *HL* is the low-skilled dental services provided, and B is the technology provided to produce *HL*.

However, by law the technology needed to produce HL for the hygienists is tied to supervision by the dentist. This expression can be written as follows:

$$B = \theta\ L_d. \qquad (5)$$

Therefore the production function for hygienists can be written as follows:

$$HL = (\theta\ L_d)\ L_h^{\gamma}\ K_h^{\delta}, \qquad (6)$$

where in the case of L_d =0 with regulation, there is no production of dental services.

We also assume that $L_d + L_h = 1$. Therefore $L_d \leq 1$ and $L_h \leq 1$.

The cost function for dental services can be written as

$$\rho B\ L^{\gamma}{}_h K^{\delta}{}_h - w_h L_h - r_h K_h \qquad (7)$$

$$P_d A\ L^{\alpha}{}_d K^{\beta}{}_d + (1\text{-}\rho)(\theta\ L_d)\ L^{\gamma}{}_h K^{\delta}{}_h - w_d L_d - r_d K_d \qquad (8)$$

where $\rho = 1$ is the case of no regulation, and $0 < \rho \leq 1$, and *P* is price of the service.

Equation (7) is a profit function for the hygienist if the price of the service is normalized as 1. Equation (8) is a profit function for the dentist, where $w_h L_h$ is the cost of labor and $r_h K_h$ is the cost of capital. Within this profit function, the hygienist's wage is tied to the decisions of the dentist to use of the hygienist's labor input, and technology mix to the high-skilled provider, *HH*. As the hygienist's wage goes down, the dentist's wage will go up. Also implied is that the hygienist's employment will go up and the dentist's employment will go down. These

conditions, which are a modified production function, can therefore lead to conditions that are consistent with a monopsony market for hygienists. In the next section, we show how regulation by the state can provide conditions consistent with a monopsony model of the labor market for hygienists.[3]

Can Regulation Result in Conditions Consistent with Monopsony in the Labor Market?

Under occupational licensing, both dentists and hygienists are often assumed to attempt to capture the rents of licensing and reallocate resources from the consumer to the regulated practitioners (Friedman, 1962). The application to our case study assumes that the relatively low-skilled (hygienist) workers, *HL*, can by law do only low-skilled work and are allowed to work only under the supervision of relatively high-skilled workers, *HH*. With favorable regulation, for dentists, the high-skilled workers are monopsonists who employ lower-skilled workers and capture rents. When regulation of employment by high-skilled workers of low-skilled workers ceases, low-skilled workers can open their own establishments and capture the licensing rents for themselves (Groshen, 1991).

For monopsony to exist, there are generally two key assumptions in the labor market (Manning, 2003). First, there are assumed to be important frictions in the labor market. In the case of two universally licensed occupations, with one dominant, this requires the supervision of the other, and the assumptions of frictions in the labor market are established. Second, employers have some ability to set wages. For hygienists, when there are no other major options for employment other than working for a dentist, employers, who are dentists, can have significant market power. For example, consistent with baseball players being subject to reserve clauses,

[3] The first order condition shows that $\rho B\gamma\, L^{\gamma-1}{}_h K^{\delta}{}_h - w_h = 0, \rho B\, \delta L^{\gamma}{}_h K^{\delta-1}{}_h - r_h = 0$, $P_d A\, \alpha L^{\alpha-1}{}_d K^{\beta}{}_d + (1-\rho)\theta\, L^{\gamma}{}_h K^{\delta}{}_h - w_d = 0$ and $P_d A\beta\, L^{\alpha}{}_d K^{\beta-1}{}_d - r_d = 0$. It implies that wage of hygienist will go down and dentists wage will go up. Also, it implies that the employment of hygienists will go down and dentist's employment will go up (Varian, 1992).

there are few other labor market options open to hygienists when state law requires the supervision of hygienists by dentists (Scully, 1974; Kahn, 2000).

A simple static partial equilibrium model of monopsony in the context of occupational licensing is shown in Figure 2, where a monopsonist employer maximizes profits with employment *L*, which equates demand, given by the marginal revenue product (*MRP*) curve, to marginal cost *MC* at point *A*. With licensing both occupations are able to restrict the supply of labor and raise wages within each occupation. Although we do not estimate a structural model of an equilibrium model of monopsony, the model informs our empirical work in the next section of our study.

We further assume that the occupation (i.e., dentists who employ hygienists) is a simple monopsonist who has to pay a single wage to all its workers. The occupation also has a revenue function. In the model, the occupation is assumed to face a labor supply curve that relates the wage paid *w* to the level of employment, *L*. Denote the supply of labor to the occupation if it pays *w* by $L(w)$, and $w(L)$ will be referred to as the labor supply curve to the individual occupation. Both $L(w)$ and $w(L)$ will be referred to as the labor supply curve to the occupation. Total labor costs are given by $w(L)L$. Assume that the occupation, dentistry, is a simple monopsonist who has to pay a single wage to all the workers under its control. Assume the occupation has a revenue function $Y(L)$. It wants to choose *L* to maximize profits, which are given by

$$\pi = Y(L) - w(L)L \qquad (9)$$

The first order condition is

$$Y'(L) = w(L) + w'(L)L \qquad (10)$$

The value $Y'(L)$ is the marginal revenue product of labor and $w(L) + w'(L)L$ is the marginal cost of labor, which is the increase in total labor costs when an additional worker is hired (Manning, 2003). Although in our case dentists are making positive profits on the marginal hygienists, there is no incentive to increase employment because doing so would require increasing the wage to attract the extra worker, and this higher wage must be paid to all existing workers. The gap between the wage and the marginal revenue product in Figure 2 is referred to as the rate of exploitation (Manning, 2003). In our case, the model predicts that laws that require hygienists to work for or be supervised by dentists would result in lower wages and employment for hygienists. In addition, if the laws were relaxed there would likely be lower earnings and employment for dentists, since the level of exploitation would be reduced. Further, the lower employment and wage caused by monopsony power has two distinct effects on the economic welfare of the occupations. First, it redistributes welfare away from workers (hygienists) and to their employer (dentists). Second, it reduces the aggregate (or social) welfare enjoyed by both groups taken together, as the employers' net gain is smaller than the loss inflicted on workers. It is a net social loss or deadweight loss. It is a measure of the market failure caused by monopsony power, through a misallocation of resources.

In Figure 2 a monopsonist employer in the face of licensing maximizes profits with employment L^M, that equates demand, given by the marginal revenue product (MRP) curve, to marginal cost MC at point A. Supply curve S^L is the supply curve that is the result of licensing. The wage is then determined on the supply curve of licensed workers S^L, at point M, and is equal to w^M. By contrast, a competitive labor market would reach equilibrium at point C, where supply S^* equals demand. This would lead to employment L^* and wage w^*. Triangle AML is deadweight loss, the part that has been lost by society as a result of the monopsonistic restriction of

employment; and rectangle $w^L w^M MM'$ is the part that the monopsonist licensed employer has exploited from the other licensed workers. Triangle $LL''C$ is deadweight loss, the part of the competitive social surplus that has been lost by society due to the licensing of workers.

The estimates of the empirical influence of monopsony without licensing have been mixed. Table 1 gives the results for specific industries such as major league baseball, where the impact has been large (100 to 600 percent), to teachers and nurses, where the influence has been 5 percent or less. For the overall labor market, the impact of monopsony has been estimated at less than 3 percent. Our analysis is the first attempt to estimate monopsony for both workers and their primary occupational employer as a result of variations in occupational licensing statutes, and specifically related to the ability of hygienists to open their own dental practice offices or do work independently of dentists..

Measurement of Dental Hygiene Professional Practice Index (DHPPI)

To assess state government regulations on the professional practice environment of dental hygienists, we extend the Dental Hygiene Professional Practice Index (DHPPI). The Center for Health Workforce Studies (2004) originally compiled this index, which consists of state government regulations in the fifty states and the District of Columbia for 2001. For the period 2002–2007, we update all the changes in sub-items of four major professional components that were used to create the DHPPI for the year 2001. For each state and the District of Columbia for each year from 2002 through 2007, we track whether each item under the four main regulatory components has changed since 2001, and if any change occurred, we then assign the same value for each item as the Center for Health Workforce Studies (2004) listed. The four major professional components include the following (Center for Health Workforce Studies, 2004: for detailed DHPPI computations, see Appendix C):

1. Legal and regulatory environment. Governance of the profession through the State regulatory board of dental hygiene or a dental hygiene committee empowered by a dental board with a mandate to regulate the profession, licensure by Credential/Endorsement with no new clinical exam required, scope of practice defined in law or regulations, and restriction to patient of record of primary employing dentist.
2. Supervision in different practice settings. Dental supervision requirements across a variety of health settings including private dental practice and other non-traditional settings such as schools, nursing homes, long-term care facilities, and correctional institutions. The supervision requirements vary from direct supervision to general and collaborator supervision, and to complete autonomy.
3. Tasks permitted under varying levels of supervision. Tasks allowed for dental hygienists to provide basic services such as prophylaxis, sealants, fluorides, X-rays, hygiene screening and assessment, as well as expanded functions such as placing amalgam restorations, administration of local anesthesia, and administration of nitrous oxide.
4. Reimbursement. Direct Medicaid reimbursement and direct payment to hygienists by other third party insurers or patients.

The raw score of the DHPPI is a 100 point scale with different weights to sub-items under the four major components, indicating that a higher score means less restrictive practice environment for dental hygienists.

For empirical analysis, we use the DHPPI as an overall index to capture variance in each state's regulatory system for the professional practice environment, as coded by the Center for Health Workforce Studies (2004). Because certain regulatory components are more important to wage determination and employment outcomes than other components, we also examine each

individual component in two ways. In particular, we focus on two major components: tasks permitted and supervision requirements. Because the weights to the sub-items of these components of the DHPPI are assigned in somewhat arbitrary fashion, we develop both the summated rating scale (*the summated rating scale*) and the statistically weighted index (*Rasch index*) for each component. Therefore, we examine how each state's regulatory system on the professional practice environments affects the market outcomes of the professions by using both linear (summated rating scale) and nonlinear (Rasch index) measures of the regulatory system. Finally, we analyze whether the provision that permits hygienists to open their office affect the market outcomes. Appendix A presents the operational definition of our regulatory variables.[4]

Table 2 shows the top and bottom five states ranked by their summated DHPPI. While the rankings of the top five states have remained the same with a minor change in the DHPPI for the years 2001-2007, the rankings of the bottom five states have changed with a relatively larger growth in the DHPPI. In particular, Kentucky, the second lowest state in the DHPPI, went through a substantial change during the period. The state with the largest growth was Montana with an increase of 43 points.

Labor Market Analysis for Dentists and Hygienists with Occupational Licensing Regulations

Table 3 provides descriptive statistics for key labor market variables as well as other market and regulatory variables used in our analysis from the American Community Survey (ACS).[5] The values show that the average age of dentists is about six years higher than for

[4] The correlations among the major components of the original DHPPI range from 0.56 to 0.96 and their inter-correlation (i.e., Cronbach's alpha) is 0.77. While the correlations among the two summated ratings of the task permitted and self-employment range from 0.50 to 0.75 and their inter-correlation is 0.67, the correlations among the two rasch indices and self-employment range from 0.41 to 0.73 and their inter-correlation is 0.51.

[5] For a detailed description of how we constructed the variables on dentists and hygienists from the ACS data, see Appendix B. We correlated the data from the ACS with membership data from American Dental Hygienists

hygienists and that dentists have six more years of schooling. Further, dentists tend to be male dominated, whereas 97 percent of hygienists are female. The average hourly earnings of dentists are more than 2.5 times as high as for hygienists. One important distinction from the data is that although 71 percent of dentists are self-employed, only 2 percent of hygienists work for themselves. Part of this difference may be due to state laws that require dentists to directly supervise the work of hygienists. The use of the ACS over time allows us to have enough observations by state to fully implement the empirical model that requires state and year controls.[6]

Our estimates in Tables 4 and 5 demonstrate the association between DHPPI and hourly earnings for dentists and dental hygienists, using individual-level data in the ACS. For example, Table 4 presents estimates of the relationship between regulation and annual earnings from 2001 to 2007 using the individual practitioner data for each year. The basic general earnings equation can be stated as follows:

$$\ln\left(Earnings_{ist}^{D/H}\right) = \alpha + \beta R_{st} + \gamma \boldsymbol{X}_{ist} + \delta_s + \eta_t + \mu_{ist}, \qquad (11)$$

where $Earnings_{it}$ is the hourly earnings of dentist (D) or dental hygienist (H) *i* at state *s* in time period *t*; R_{st} is the DHPPI in person *i*'s state *s* in time period *t*; the vector $\boldsymbol{X}_{ist}$ includes covariates measuring characteristics of each person; δ_s and η_t are state and year fixed effects, respectively; and u_{ist} is the error term.[7]

Association by state and found the correlation to be .95. This suggests that the ACS is an appropriate measure of hygienists' employment by state and year.

[6] We choose to analyze the ACS as our main dataset over alternative data sets such as the CPS, because we would not be able to have sufficient observations even using pooled data to examine how state statutes' influence on the central labor market variables such as wages and employment. For example, while the CPS contains a probability sample of approximately 60,000 household, the ACS sampled between 740,000 and 900,000 addresses annually in 2000 through 2004, and more than 1,000,000 since 2005 when it was fully implemented into all counties.

[7] Although an alternative specification might be a difference in difference approach, we do not have the same individuals over time by state. However our ability to control for time and state fixed effects suggest that our policy variables influence wages for each occupation beyond state or time varying characteristics.

In Table 4 we show the impact of the overall DHPPI index on the logarithm of hourly wages with all the controls for individual characteristics shown in Table 3 that were extracted from the ACS. Our results show that the DHPPI level is not significant factor in determining wages. However, the legal ability to be either self-employed or to have tasks unsupervised are key factors influencing wage determination. Our results are descriptive estimates of these relationships. For example, the results from Table 4 show that having the ability for hygienists to be self-employed raises wages by approximately a statistically significant 10 percent and working unsupervised is associated with an additional seven percent wage increase for hygienists using a model that includes both state and year fixed effects.[8]

In contrast for dentists in Table 5 the estimates from the model using the same set of controls from the ACS as in Table 4 shows that having state provisions that allow for hygienists to be self employed is associated with approximately 19 percent lower hourly earnings for the dental occupation that is generally required by law to supervise dental hygienists. [9] The estimates from the model also specify state and time fixed effects. It appears that dentists lose more perhaps because they are no longer able to require hygienists to only work for them in order to provide dental services. In addition, the consequence of the legal provision may result in higher costs due to higher wages and lost income because hygienists may be taking away patients from full service dentists. Further, the signs of the coefficients for the ability of hygienists to engage in

[8] We also examined whether or not hygienists are directly reimbursed under the state government regulations with the same specifications. While not shown in this paper, the direct reimbursement is associated with approximately 4.1 percent higher earnings for hygienists and 3.4 percent lower earnings for dentists, but statistically significant at the 0.05 level only for hygienists. However, the direct reimbursement is not statistically significant in the employment growth models in Table 6 and 7.

[9] We also examined the impact of the state government regulations on the hourly earnings gap between dentists and hygienists. To do this we computed the state median hourly earnings of each profession. Consistent with the results in Table 4 and 5, Appendix C shows that the state regulations reduced the hourly earnings gap between these professions.

broader work assignments are negative in the remainder of the specifications for dentists' wage determination.

The employment effects of variations in state statutes for dental hygienists and dentists are given in Table 5 and 6, respectively. The general employment equation can be stated as follows:

$$Employment_{st}^{D/H} = \alpha + \beta R_{st} + \gamma \boldsymbol{X}_{st} + \delta_s + \eta_t + \mu_{st}, \qquad (12)$$

where $Employment_{st}$ is the employment growth of dentists (D) and hygienists (H) at state *s* in time period *t*; R_{st} is the DHPPI at state *s* in time period *t*; the vector $\boldsymbol{X}_{st}$ includes covariates measuring economic and dental characteristics within each state; δ_s and η_t are state and year fixed effects, respectively; u_{st} is the error term.

The estimates from our reduced form model in Table 5 show that the overall index is not significantly associated with employment growth of hygienists in equations that includes state level controls such as the growth in the number of dentists in the state, the unemployment rate, the percent uninsured in the state, and the state median prices of amalgam restoration and prophylaxis in each specification in the Table. However whether hygienists can open their own establishment is positively and statistically significant in its association with employment growth of hygienists. Further, enhancing the ability of hygienists to do various tasks without the supervision of dentists, also is associated with positive employment growth for their occupation. This outcome is consistent with our production model of dental services, and with the monopsony model of dentist and hygienists in the determination of wages and employment.

Table 6 shows the relationship between the statutes and the growth of employment in the state. Using a model similar to that specified in Table 5 we find that giving greater autonomy to hygienists is associated with a significantly negative 26 percent employment growth of dentists.

Since the average growth rate of dentists' employment is 2 percent, having a law that allows hygienists to have an independent business would reduce their growth rate to about 1.5 percent. Since hygienists and dentist are often substitutes for each other's services in the production of dental services, the state provisions favoring hygienists may reduce the need for dentists in the state.

Since our results show elements of monopsony in our theory and evidence there are potential redistribution effects and economic losses within the context of both occupations being licensed. If there is no reduction in the quality of services provided to patients with fewer regulations in dentistry, then an application of a dead weight loss analysis can give us the parameters to estimate losses to society from monopsony in the market (Kleiner and Kudrle, 2000). Using the results from theory and our estimates, we show in Table 8 that the reallocation from hygienists to dentists is approximately is $.16 billion per year. When we include the losses due to licensing the overall effect is between 1.21 and 1.67 billion dollars. Therefore, the total losses associated with overall occupational licensing and within occupation regulation to be between 1.37 and 1.67 billion dollars. We further show that this results in approximately a 1.3 and 1.7 percent reduction in the output of dental services for those states that required dentist's supervision of dental hygienists using a basic dead weight loss analysis (Carneiro, Heckman, and Vylacil, 2009).

Conclusions

The licensing of occupations is most pervasive among health care occupations. Our study examines two occupations—dentists and dental hygienists—that are universally licensed in all fifty states in the United States. We initially explore the evolution of licensing for these two occupations, and the legal conditions governing permissible tasks for hygienists that impact both

occupations. Next we show the anatomy and timing of the implementation of regulations by state that guides the work that each of the occupations can legally do by state statutes and administrative decisions. Given this institutional background, we extend a model of dental production that has elements of occupational licensing that favors dentists in the production of services to patients. The model shows that regulations requiring dentists to supervise hygienists results in higher earnings for dentists and lower earnings and employment for dental hygienists. We then extend the model to show that it has elements of monopsony, which can result in potential deadweight losses to society if licensing and these monopsony rents are pervasive.

Our estimates from our empirical models show the impact of regulations that favor tasks that hygienists can perform on the wages and employment of dentists and hygienists for the period 2000 to 2007. During this time period, hygienists were allowed to do more tasks and in seven states were allowed to work without the supervision of a dentist. The time and state fixed effects models for both dentists and hygienists showed that greater autonomy by legally allowing hygienists to work independently of dentists is associated with an approximately 10 percent higher wage and a 5 percent increase in the employment growth of dental hygienists. In contrast, these state provisions are associated with approximately a 19 percent reduction in dental hourly earnings and a 26 percent reduction in dental employment in the states. Using a simple deadweight loss analysis consistent with a monopsony model, the typical state would lose between approximately 1.3 and 1.8 percent by not allowing hygienists to practice on their own.

Overall, the results suggest that state laws on permissible tasks matter in wage and employment determination for both dentists and hygienists. With occupational licensing, the final arbiter of who gets to do work is the responsibility of the state legislature and the courts.

The decisions by these policy makers appear to influence wage and employment outcomes for practitioners in the occupations. Additional potential conflicts for licensed occupations such for architects and interior designers over who can legally do certain tasks also can be examined in this manner. Further, more data and analysis on the impact of who gets to do the work on patient outcomes would further assist policy makers on whether allowing hygienists greater autonomy in dental services would have a net benefit to the public. Along with the analysis in this study, such data would add more to the evaluation of licensing laws in health care and the battles between licensed occupations for enhanced work and pay.

References

Adams, Tracey, 2004. "Inter-professional conflict and professionalization: dentistry and dental hygiene in Ontario," *Social Science & Medicine* 58: 2243–2252.

American Dental Hygienists' Association (ADHA). 1994. State Dental Board Composition. Chicago: ADHA, January.

Boal, William, 1995. "Testing for Employer Monopsony in Turn-of-the-Century Coal Mining." *RAND Journal of Economics*, 26(3) (Autumn): 519-536.

Boal, William M., and Michael R. Ransom. 1997. "Monopsony in the Labor Market." *Journal of Economic Literature* 35(1) (March): 86–112.

———. 2000. "Empirical Tests of Labor Monopsony: School Teachers in Missouri." Working Paper, February.

Brown, Charles, and James L. Medoff. 1989. "The Employer Size-Wage Effect." Working Paper 2870, National Bureau of Economic Research.

Carneiro, Pedro, James J. Heckman, Edward J. Vytlacil, 2009, "Evaluating Marginal Policy Changes and the Average Effect of Treatment for Individuals at the Margin." NBER Working Paper No. 15211 (August).

Card, David, and John E. DiNardo. 2002. "Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles." *Journal of Labor Economics* 20(4) (October): 733–783.

Center for Health Workforce Studies. April 2004. "The Professional Practice Environment of Dental Hygienists in the Fifty States and the District of Columbia, 2001." Available at http://bhpr.hrsa.gov/healthworkforce/reports/hygienists/dh1.htm.

Council of State Governments. 1952. *Occupational Licensing Legislation in the States*. Chicago: Council of State Governments.

Friedman, Milton. 1962. *Capitalism and Freedom*. Chicago: University of Chicago Press.

Groshen, Erica L. 1991. "Five Reasons Why Wages Vary Among Employers." *Industrial Relations* 30(3) (Fall): 350–381.

Hammermesh, Daniel, 1993. *Labor Demand*, Princeton, New Jersey, Princeton, University Press

Helm, Maria R. 1993. "Survival of the Fittest: Dental Hygiene's Future Evolves from Its Past." *Access* (September–October): 25–32.

Hirsch, Barry T., and Edward J. Schumacher. 1995. "Monopsony Power and Relative Wages in the Labor Market for Nurses." *Journal of Health Economics* 14(4) (October): 443–476.

Kahn, Lawrence M. 2000. "The Sports Business as a Labor Market Laboratory." *Journal of Economic Perspectives* 14(3) (Summer): 75–94.

Kleiner, Morris, and Alan Krueger. 2009. "Analyzing the Extent and Influence of Occupational Licensing on the Labor Market." Working Paper 14979, National Bureau of Economic Research.

———. Forthcoming. "The Prevalence and Effects of Occupational Licensing." *British Journal of Industrial Relations.*

Kleiner, Morris M., and Robert T. Kudrle. 2000. "Does Regulation Affect Economic Outcomes?: The Case of Dentistry." *The Journal of Law and Economics* 43(2): 547-82.

Manning, Alan. 2003. *Monopsony in Motion: Imperfect Competition in Labor Markets.* Princeton, NJ: Princeton University Press.

Princeton Data Improvement Initiative (PDII). 2008. Available at http://www.krueger.princeton.edu/PDIIMAIN2.htm.

Ransom, Michael R. 1993. "Seniority and Monopsony in the Academic Labor Market." *American Economic Review* 83(1) (March): 221–233.

Reinhardt, Uwe. 1972. "A Production Function for Physician Services." *Review of Economics and Statistics* 54(1) (February): 55–66.

Scully, Gerald W. 1974. "Pay and Performance in Major League Baseball." *American Economic Review* 64(6) (December): 915–930.

Shapiro, Carl. 1986. "Investment, Moral Hazard, and Occupational Licensing." *Review of Economic Studies* 53(5) (October): 843–862.

Varian, Hal R. 1992. Microeconomic Analysis (The 3rd Edition), W.W. Norton: New York.

Vedder, Richard K., Lowell E. Gallaway, and David Klingaman. 1978. "Discrimination and Exploitation in Antebellum American Cotton Textile Manufacturing." *Research in Economic History* 3: 217–262.

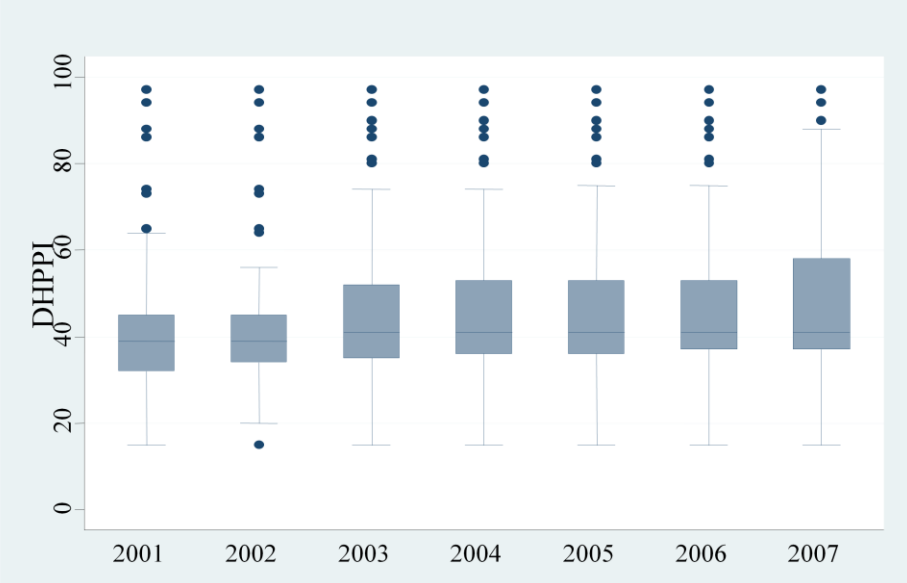
Wanchek, Tanya. Forthcoming. "Dental Hygiene Regulation and Access to Oral Health Care: Assessing the Variation across U.S. States." *British Journal of Industrial Relations*.

Zevin, Robert B. 1975. *The Growth of Manufacturing in Early Nineteenth Century New England.* New York: Arno Press.

Zimbalist, Andrew. 1992. *Baseball and Billions: A Probing Look Inside the Big Business of Our National Pastime*. New York: Basic Books.

Figure 1: Growth and Variation of State Regulations on
Professional Practice Environment of Dental Hygienists by State over Time

Panel A: Dental Hygiene Professional Practice Index (DHPPI) over 2001-2007

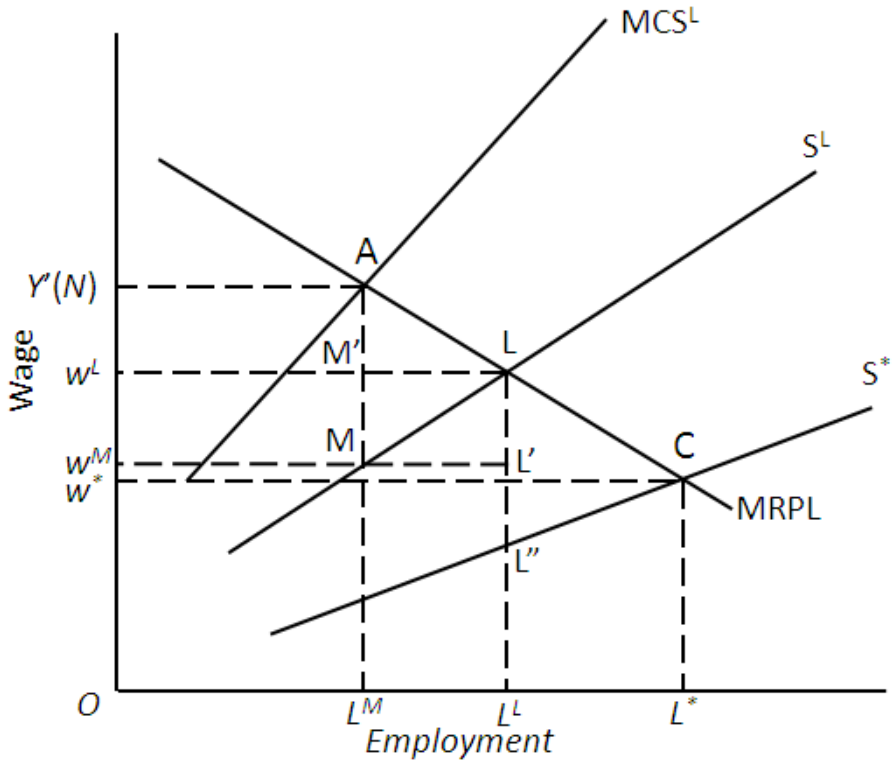


Panel B: Number of Tasks Permitted over 2001-2007



Note: The Box-and-Whisker plot shows annual values of the median, interquartile range, and outliers of the summated rating scale based on the Center for Health Workforce Studies' (2004) Dental Hygiene Professional Practice Index (DDPPI) by year. The line in the middle of the box represents the median. The bottom and top edges of the box are the first and third quartile, respectively. The whiskers extending from the box represent the most extreme point within the range of one and a half times the interquartile range (the difference between the third and first quartile). The remaining points represent outliers that do not fall within the range of the whiskers; for each definition of the variables, Appendix A; and for detailed sample statistics, Panel B in Table 3.

Figure 2: A Graphical Representation on Monopsony and Licensing
within a Partial Equilibrium Framework



A monopsonist employer maximizes profits with employment L^M, that equates demand, given by the marginal revenue product (*MRP*) curve, to marginal cost *MC* at point *A*. Supply curve S^L is the supply curve that is the result of licensing. The wage is then determined on the supply curve of licensed workers S^L, at point *M*, and is equal to w^M. By contrast, a competitive labor market would reach equilibrium at point *C*, where supply *S** equals demand. This would lead to employment *L** and wage *w**. Triangle *AML* is deadweight loss, the part that has been lost by society as a result of the monopsonistic restriction of employment; and Rectangle $w^L w^M MM'$ is the part that the monopsonist licensed employer has exploited from the other licensed workers. Triangle *LL"C* is deadweight loss, the part of the competitive social surplus that has been lost by society due to the licensing of workers.

Table 1: Estimated Rates of Monopsonistic Wage Effects in U.S. Labor Markets*

Labor market	Estimated rate of monopsonistic exploitation*	Source
Baseball players subject to reserve clause	100% to 600%	Scully (1974), Kahn (2000)
Baseball players not subject to reserve clause	Close to zero	Zimbalist (1992)
Teachers and nurses	Close to zero	Boal and Ransom (2000), Hirsch and Schumacher (1995)
University professors	Less than 5-15%	Ransom (1993)
Coal miners in early twentieth century	Less than 5%	Boal (1995)
Textile mill workers in the nineteenth century	Some likely, but no consensus on magnitude	Vedder, Gallaway, and Klingaman (1978), Zevin (1975)
Low-wage workers	No consensus	
Labor market in general	1% to 3%	Brown and Medoff (1989)

*Boal, W.M., and M.R. Ransom (1997) "Monopsony in the Labor Market" *Journal of Economic Literature*, 35(1), pp. 86-112.

Table 2: Rankings of Top and Bottom Five Regulated States and Changes
Using the Summated Rating Scheme by State

	Top Five States		Bottom Five States	
Year	State	DHPPI	State	DHPPI
2001	New Mexico	86	Mississippi	15
	California	86	Alabama	18
	Oregon	88	Kentucky	18
	Washington	94	West Virginia	20
	Colorado	97	Virginia	21
2007	New Mexico	87	Mississippi	15
	California	88	Alabama	20
	Oregon	90	Georgia	23
	Washington	94	West Virginia	26
	Colorado	97	Arkansas	28

	Top 5 States by change in DHPPI 2001-2007		
	2001	2007	Change
Arizona	42	62	20
Kentucky	18	40	22
Nebraska	44	68	24
Oklahoma	28	52	24
Montana	43	86	43

Table 3: Summary Statistics for the Labor Market Variables Using the ACS, 2001-2007

	Dental Hygienists (*n*=5,905)		Dentists (*n*=7,202)		Total (*n*=13,107)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Panel A: Individual Sample Statistics						
Age	40.52	10.13	46.96	10.02	44.06	10.56
Schooling (in Years)	14.65	1.26	20.30	1.05	17.76	3.04
Gender (Male:1; Female: 0)	0.03	0.17	0.79	0.40	0.45	0.50
Married (Married:1; Not married: 0)	0.74	0.44	0.84	0.37	0.79	0.41
Experience (in Years)	19.86	10.09	20.66	10.09	20.30	10.09
Experience-Squared(/1,000)	0.50	0.42	0.53	0.41	0.51	0.42
White (White: 1; Others: 0)	0.92	0.26	0.84	0.36	0.88	0.33
Black (Black: 1; Others: 0)	0.02	0.14	0.02	0.15	0.02	0.15
Others (Others: 1; Others: 0)	0.05	0.23	0.13	0.34	0.10	0.30
Citizen(U.S. Citizen: 1; Others: 0)	0.98	0.13	0.96	0.19	0.97	0.17
Work for For-Profit (Yes: 1; No: 0)	0.94	0.24	0.22	0.41	0.54	0.50
Work for Not-for-Profit (Yes: 1; No: 0)	0.02	0.13	0.02	0.14	0.02	0.13
Work for Government (Yes: 1; No: 0)	0.02	0.15	0.05	0.22	0.04	0.19
Self-employment (Yes: 1; No: 0)	0.02	0.14	0.71	0.45	0.40	0.49
Log of Hourly Earnings (in 2007 Dollars)	3.61	0.42	4.59	0.75		
Panel B: State Sample Statistics	*N*	Mean	S.D.			
DHPPI	357	46.80	20.02			
Tasks Permitted (Summated)	357	7.19	2.55			
Tasks Permitted (Rasch)	357	1.44	1.76			
Independence from Dentists (Summated)	357	1.12	2.56			
Independence from Dentists (Rasch)	357	-8.19	4.27			
Self-Employment Allowed	357	0.11	0.32			
Growth in the number of Dental Hygienists	298	0.04	0.15			
Growth in the number of Dentists	272	0.02	0.21			
Unemployment Rate (%)	357	4.91	1.09			
Percent of Uninsured	357	13.67	3.76			
State Median Price of Amalgam Restoration	336	112.66	19.73			
State Median Price of Prophylaxis	343	49.47	8.54			

Table 4: Pooled OLS Model of Log Hourly Earnings for Dental Hygienists Using the ACS, 2001-2007

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	0.001					
	(0.002)					
Tasks Permitted (Summated)		0.002				
		(0.008)				
Tasks Permitted (Rasch)			0.000			
			(0.009)			
Independence from Dentists (Summated)				0.014*		
				(0.005)		
Independence from Dentists (Rasch)					0.007	
					(0.004)	
Self-Employment Allowed						0.096*
						(0.046)
Experience	0.020***	0.020***	0.020***	0.020***	0.020***	0.020***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Experience squared (/1,000)	-0.407***	-0.407***	-0.407***	-0.406***	-0.406***	-0.406***
	(0.070)	(0.070)	(0.070)	(0.070)	(0.070)	(0.070)
Schooling (in Years)	0.044***	0.044***	0.044***	0.044***	0.044***	0.044***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Gender	-0.069*	-0.069*	-0.069*	-0.069*	-0.069*	-0.069*
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
Marital Status	0.011	0.011	0.011	0.011	0.011	0.011
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
White	0.010	0.010	0.010	0.010	0.010	0.010
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Black	-0.081†	-0.081†	-0.081†	-0.081†	-0.081†	-0.081†
	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)
Citizen	0.145**	0.145**	0.145**	0.145**	0.145**	0.145**
	(0.046)	(0.046)	(0.046)	(0.045)	(0.046)	(0.045)
Working at For-Profit	0.180***	0.180***	0.180***	0.179***	0.179***	0.179***
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
Working at Not-for-Profit	0.096†	0.096†	0.096†	0.096†	0.096†	0.096†
	(0.051)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)
Self-employment	0.157*	0.157*	0.157*	0.156*	0.156*	0.156*
	(0.068)	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)
Constant	2.108***	2.120***	2.122***	2.122***	2.187***	2.122***
	(0.088)	(0.094)	(0.105)	(0.095)	(0.108)	(0.095)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.160	0.160	0.160	0.161	0.160	0.161
N	5,905	5,905	5,905	5,905	5,905	5,905

Note: Robust standard errors clustered at the state level are reported in parentheses, † significant at $p<0.10$; * $p<0.05$; **: $p<0.01$; and ***: $p<0.001$.

Table 5: Pooled OLS Model of Log Hourly Earnings for Dentists Using the ACS, 2001-2007

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	-0.003					
	(0.002)					
Tasks Permitted (Summated)		-0.014				
		(0.018)				
Tasks Permitted (Rasch)			-0.022			
			(0.019)			
Independence from Dentists (Summated)				-0.013		
				(0.014)		
Independence from Dentists (Rasch)					-0.015*	
					(0.007)	
Self-Employment Allowed						-0.173*
						(0.071)
Experience	0.028***	0.028***	0.028***	0.028***	0.028***	0.028***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Experience squared(/1,000)	-0.533***	-0.532***	-0.532***	-0.533***	-0.533***	-0.534***
	(0.112)	(0.112)	(0.112)	(0.112)	(0.112)	(0.112)
Schooling (in Years)	-0.017	-0.017	-0.017	-0.017	-0.017	-0.017
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Gender	0.225***	0.225***	0.225***	0.225***	0.225***	0.225***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Marital Status	0.101***	0.101***	0.101***	0.101***	0.101***	0.101***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
White	0.098***	0.098***	0.098***	0.098***	0.098***	0.098***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Black	-0.015	-0.015	-0.015	-0.016	-0.016	-0.016
	(0.059)	(0.060)	(0.060)	(0.059)	(0.059)	(0.059)
Citizen	0.088*	0.088*	0.088*	0.088*	0.088*	0.088*
	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)
Working at For-Profit	0.375***	0.376***	0.376***	0.375***	0.375***	0.375***
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Working at Not-for-Profit	0.103†	0.102†	0.103†	0.102†	0.102†	0.102†
	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)
Self-employment	0.484***	0.484***	0.484***	0.483***	0.483***	0.483***
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
Constant	4.012***	3.970***	3.894***	3.963***	3.812***	3.961***
	(0.243)	(0.242)	(0.252)	(0.241)	(0.258)	(0.242)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.116	0.116	0.116	0.116	0.116	0.116
N	7,202	7,202	7,202	7,202	7,202	7,202

Note: Robust standard errors clustered at the state level are reported in parentheses, † significant at $p<0.10$; * $p<0.05$; **: $p<0.01$; and ***: $p<0.001$.

Table 6: Models of Employment Growth for Dental Hygienists by State Using the ACS Data, 2001-2007

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	0.004					
	(0.002)					
Tasks Permitted (Summated)		-0.019				
		(0.034)				
Tasks Permitted (Rasch)			-0.031			
			(0.046)			
Independence from Dentists (Summated)				0.008†		
				(0.005)		
Independence from Dentists (Rasch)					0.006*	
					(0.003)	
Self-Employment Allowed						0.059†
						(0.030)
Dental Hygienist's Employment Growth Rate	-0.142*	-0.151*	-0.148*	-0.147*	-0.146*	-0.147*
	(0.064)	(0.062)	(0.063)	(0.064)	(0.064)	(0.064)
Unemployment Rate	-0.023	-0.020	-0.019	-0.022	-0.023	-0.023
	(0.023)	(0.025)	(0.027)	(0.024)	(0.024)	(0.024)
Rate of Uninsured	-0.003	0.000	0.000	-0.002	-0.002	-0.002
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
State Median Price of Prophylaxis	0.009	0.010	0.011	0.009	0.009	0.009
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
State Median Price of Amalgam Restoration	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Constant	0.801	0.850	0.675	0.868	0.920	0.861
	(1.171)	(1.155)	(1.235)	(1.168)	(1.159)	(1.169)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.219	0.214	0.216	0.213	0.213	0.213
N	250	250	250	250	250	250

Note: Robust standard errors clustered at the state level are reported in parentheses, † significant at $p<0.10$; * $p<0.05$; **: $p<0.01$; and ***: $p<0.001$.

Table 7: Models of Employment Growth for Dentists by State Using the ACS Data, 2001-2007

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	-0.005					
	(0.003)					
Tasks Permitted (Summated)		-0.027				
		(0.042)				
Tasks Permitted (Rasch)			0.015			
			(0.051)			
Independence from Dentists (Summated)				-0.035***		
				(0.006)		
Independence from Dentists (Rasch)					-0.023***	
					(0.003)	
Self-Employment Allowed						-0.255***
						(0.039)
Dental Hygienist's Employment Growth Rate	-0.272	-0.289	-0.284	-0.277	-0.277	-0.278
	(0.190)	(0.187)	(0.187)	(0.187)	(0.187)	(0.187)
Unemployment Rate	0.039	0.042	0.037	0.037	0.038	0.038
	(0.037)	(0.037)	(0.039)	(0.037)	(0.037)	(0.037)
Rate of Uninsured	-0.002	-0.003	-0.005	0.000	-0.001	-0.001
	(0.010)	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)
State Median Price of Prophylaxis	0.005	0.008	0.005	0.004	0.004	0.004
	(0.015)	(0.013)	(0.013)	(0.014)	(0.014)	(0.014)
State Median Price of Amalgam Restoration	0.002	0.002	0.002	0.002	0.002	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	0.467	0.332	0.468	0.407	0.197	0.436
	(1.408)	(1.381)	(1.294)	(1.367)	(1.362)	(1.373)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.248	0.244	0.242	0.252	0.250	0.251
N	250	250	250	250	250	250

Note: Robust standard errors clustered at the state level are reported in parentheses, † significant at $p<0.10$; * $p<0.05$; **: $p<0.01$; and ***: $p<0.001$.

Table 8: A Static Simulation of the Effects of State Regulations on U.S. Dental Service Costs

Estimates of US Dental Service Expenditures

- US Dental service expenditures are approximately $96.36 billion (Department of Health & Human Service, 2008).
- Dental hygienists account for approximately 30 percent of the total cost of dental office.
- Therefore, labor costs for hygienists are approximately $28.91 billion (=$96.36 billion*0.30), which is rectangle $w^M OL^M M$ ($=w^M \times L^M$) in Figure 2.

Analysis of Monopsonistic Exploitation and Dead Weight Loss Using Basic Demand Analysis

- Monopsonistic exploitation (Rectangle $w^L w^M MM'$ in Figure 2)
- We substitute the estimates of 0.096 for $(W^L - W^M)/W^M$ and 0.059 for $(L^L - L^M)/L^M$ (from Tables 4 and 6).
- Then, we are able to compute the rectangle $w^M w^L M'M$ as following:
  $(w^L - w^M) \times L^M = 0.096\ w^M \times L^M = 0.096 \times \$28.91 \text{ billion} = \$2.78 \text{ billion}$
- Although we cannot compute a deadweight loss due to the restrictions (i.e., triangle AML as a whole), we can approximate it with triangle $M'ML$ by multiplying two. Then, the deadweight loss due to the monopsony restriction is
  $(w^L - w^M) \times (L^L - L^M) = 0.096\ w^M \times 0.059\ L^M = 0.096 \times 0.059 \times \$28.91 \text{ billion} = \$0.16 \text{ billion}.$

- Licensing Effect
- To compute licensing effect, we compute hygienists' total revenue, rectangle $w^L OL^L L$ in Figure 2. For this, we only need to compute rectangle $ML^M L^L L'$ as following:
  $(L^L - L^M) \times w^M = 0.059\ L^M \times w^M = 0.059 \times \$28.91 \text{ billion} = \$1.71 \text{ billion}.$
- Then, hygienists' total revenue is $33.56 billion (=$28.91 billion + $2.78 billion +$0.16 billion +$1.71 billion).
- Given that the licensing premium is a 15 percent economy wide (Kleiner and Krueger, Forthcoming), then the reallocation from consumers to hygienists' services is $5.03 billion (=0.15*$33.56 billion).
- Also, given that the mean value of demand elasticity of labor is 0.3 (Hamermesh, 1993), the dead weight loss due to licensing (i.e., triangle $LL''C$ in Figure 2) should be about $1.51 billion (=0.3 × $5.03 billion). If only 80 percent is deadweight (Carneiro, Heckman, and Vytlacil 2009), then $1.21 billion.
- Therefore the total licensing loss would be $1.21 billion due to licensing plus the monopsony effect of $0.16 billion which equals $1.37 billion.

Appendix A: Definitions of Regulatory Variables

Variables	Definitions
DHPPI	A simple sum of all the components of the DHPPI, ranging from 0 to 100.
Tasks Permitted (Summated)	A simple sum of whether hygienists are permitted to perform the following practices: Prophylaxis, Fluoride treatment, Sealant application, X-rays, Amalgam restorations, Local anesthesia, Nitrous oxide, Initial screening/assessment, Refer patients, and other expanded functions. We coded each practice as 1 if hygienists are allowed to perform; otherwise coded as 0.
Tasks Permitted (Rasch)	A Rasch scale of tasks permitted that are used to form the summated measure of Tasks Permitted.
Independence from Dentists (Summated)	A simple sum of whether hygienists are able to perform dental hygiene practices without supervision of dentists at the following locations: Dentists Office, Long Term Care Facilities, Schools, Public Health Agencies, Correctional Facilities, Mental Health Facilities, Hospitals/Rehabilitation Hospitals or Convalescent settings, Personal Residences. We coded each location as 1 if hygienists are able to perform dental hygiene practices without supervision of dentists; otherwise coded as 0.
Independence from Dentists (Rasch)	A Rasch scale of independence from dentists that are used to form the summated measure of Independence from Dentists.
Self-Employment Allowed	We coded 1 when the provision allows hygienist to be self employed other than as independent contractor; otherwise 0.

Source: Center for Health Workforce Studies (2004)

Appendix B: Data Construction from the American Community Survey (ACS)

B1. Sample Selection

To generate our sample of dentists and dental hygienists, we started by dropping individuals who do not belong to the categories of (1) Private wage and salary workers, (2) Government workers (who work in any local, state, or federal governmental unit), and (3) Self-employed in own not incorporated business workers. The ACS categorizes individuals into "Private wage and salary workers" when individuals worked for wages, salary, commission, tips, pay-in-kind, or piece rates for (1) a private "for-profit" employer, (2) a private "not-for-profit," tax-exempt, or charitable organization, or (3) when are individuals are "self-employed people," whose business was incorporated (because they are paid employees of their own companies). For obvious reasons, we dropped individuals who belong to the remaining categories, "Working without pay in family business or farm" and "Unemployed."

Given the definition of class of workers, we were unable to clearly distinguish individuals who work as independent contractors from the persons who own their office in states that allow dental hygienists to do so. Because almost half of dentists and a small number of dental hygienists are the "self-employed people," we created a new variable, "wage," which includes the wage and salary income for individuals who do not belong to the category of "Self-employed in own not incorporated business workers" and the income from self-employment for individuals who do belong to the category of "Self-employed in own not incorporated business workers." We then dropped individuals who made both (1) wage and salary income (i.e., wagp) and (2) the income from self-employment (i.e., semp).

Next, we imposed the level of educational attainment. We dropped individuals whose education is "Below Associate" for dentists and individuals whose education is "Below 12th

Grade without Diploma" for dental hygienists. We also dropped individuals whose age is greater than 65 and whose years of experience (=Age - years of schooling – 6) is below zero.

We dropped individuals whose usual working hours in the past 12 months are less than 20 hours or more than 60 hours. After we computed annual hours worked (the usual working hours times the number of weeks for the past 12 months), we then computed the hourly wage by dividing wage by annual hours worked. In examining earnings relative to reported hours of work, one would expect these measures to reflect some level of noise, that is, hourly wages that were implausibly high or low. To address this issue, we trimmed down the sample. We deleted the individuals whose hourly earnings were under the federal minimum of $5.15 during 2001–2007 and the individuals whose wages fell in the top 0.5% of the sample.

Appendix Table B1. Sample Selection from the ACS

		Dentists	Dental Hygienists
Initial observations		8,942	7,510
Selection rule 1:	Unemployed or working without pay in family business or farm	-11	-20
Selection rule 2:	Income from self-employment less than 0	-68	-14
Selection rule 3:	Educational attainment Drop sample: Below associate for dentist; sample below 12th grade w/o diploma for dental hygienist	-27	-48
Selection rule 4:	Age equal to or over 65	-1005	-141
Selection rule 5:	Experience = Age - years of schooling - 6	-36	-8
Selection rule 6:	less than 20 hours and more than 60 hours	-528	-1,302
Selection rule 7:	Hourly earnings(=wagp†semp): Drop the sample with wages under the federal minimum of $5.15 during 2001–2007	-28	-42
Selection rule 8:	Trim down the top 0.5% of the sample	-37	-30
Final sample		7,202	5,905

B2. Top coding and Outliers

The hourly earnings of both dentists and dental hygienists in the ACS have two potential measurement problems. The first problem is the topcoding (or censoring) of income (i.e., the wage and salary income and the income from self-employment) for both professions, particularly for dentists. The ACS's topcoding varies by the type of income and by state over years. To deal with this problem, we adjusted the topcoded incomes by a factor (typically, 1.33 or 1.4) that approximates the mean for those above the censoring point (Card and DiNardo, 2002). In this paper, we adjusted the censored values by a factor of 1.4.

A second problem is the presence of outliers. A few individuals report implausibly high or low earnings relative to their hours of work, which would affect the estimated mean and variance of hourly earnings. As much of the literature does, we trimmed the data to delete extreme values. Specifically, we deleted these observations with measured hourly earnings below the federal minimum wage of $5.15 during 2001–2007 for implausibly low earnings, and we trimmed down the top 0.5% of the sample for implausibly high earnings.

Appendix Table B2. Number of Topcoded Individual Practitioners By Occupation

Wage and Salary Income ("wagp")	Non-topcoded Observations	Topcoded Observations	Total
Dentists	7,985	957	8,942
Dental hygienists	7,505	5	7,510
Total	15,490	962	16,452
Income from Self-Employment("semp")	Non-topcoded	Topcoded	Total
Dentists	8,160	782	8,942
Dental hygienists	7,506	4	7,510
Total	15,666	786	16,452

Appendix C: Models of State Median Hourly Earnings Gap between Hygienists and Dentists

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	-0.004					
	(0.006)					
Tasks Permitted (Summated)		-0.067†				
		(0.039)				
Tasks Permitted (Rasch)			-0.058			
			(0.051)			
Independence from Dentists (Summated)				-0.073***		
				(0.011)		
Independence from Dentists (Rasch)					-0.052***	
					(0.007)	
Self-Employment Allowed						-0.569***
						(0.091)
Employment Growth Ratio	-0.003	0.003	0.000	-0.009	-0.010	-0.009
	(0.028)	(0.027)	(0.028)	(0.026)	(0.026)	(0.026)
Unemployment Rate	-0.012	-0.001	0.000	-0.021	-0.019	-0.019
	(0.046)	(0.045)	(0.046)	(0.047)	(0.047)	(0.047)
Rate of Uninsured	-0.018	-0.015	-0.019	-0.010	-0.011	-0.011
	(0.024)	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)
Constant	1.305*	1.474**	1.158*	1.089*	0.574	1.086*
	(0.488)	(0.495)	(0.485)	(0.481)	(0.511)	(0.481)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.378	0.384	0.379	0.388	0.389	0.389
N	322	322	322	322	322	322

Note: Robust standard errors clustered at the state level are reported in parentheses, † significant at $p<0.10$; * $p<0.05$; **: $p<0.01$; and ***: $p<0.001$.