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

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Abstract

Occupational licensing is among the fastest-growing labor market institutions in the U.S. economy. 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 government determines 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 to be self-employed have about 11 percent higher earnings, and that dentists in those states have 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.

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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 and covers more than 800 occupations (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, the market structure, and what is required for the patient. We examine the labor market implications of these governmental requirements. With the growth in the number of individuals who are regulated or seeking regulation by the states, our case study can illuminate the potential economic 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 of state regulation for both occupations over time, and what battle lines have evolved for both occupations. We then show the anatomy of dental hygienists state regulations over time. We next further develop a model that includes the basic production function in dentistry, with dentists as a scale factor 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 influence of state regulations on hygienists' earnings, and how the ability of hygienists to be self-employed is associated with an earnings increase of approximately 11 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 and earnings for dentists. To the extent that these estimates suggest licensing and monopsonistic deadweight loss, we provide some results of these estimated losses. The rest of the analysis presents 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 direct 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).[1]

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

[1] Exceptions are in Washington where dental hygienists are regulated by the director of the state health department in consultation with a committee of three dental hygienists and a consumer. In Connecticut, dental hygienists are regulated directly by the health department. In New Mexico, hygienists are regulated by a committee of five dental hygienists, one dentist and a consumer (ADHA, 2008). In all the other states dentists dominate the decision process of who gets to do the work.

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 be self-employed without the direct oversight of a dentist.[2] As of 2007, no state permitted reciprocity of the movement of dental hygienists from other states.

In the late 1970s, the American Dental Hygiene Association (ADHA) supported alternative practice methods that would allow the dental hygienist to become the primary provider of initial services in accordance with state dental and dental hygiene practice acts (Moley 1988). In response to these policy changes, the American Dental Association (ADA) passed a resolution stating that dental hygienists are auxiliaries who must work under the supervision of a dentist which also controlled ownership and managerial authority under the control of the dentist (Beach, Shulman, Johns, and Paas, 2007). These policy provisions by both dental service organizations set the battle grounds for conflicts in state legislatures, licensing boards, and the courts.

State-level Anatomy of Dental Hygienists Legally Permitted Job Characteristics

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. In panel A, we give the overall ranking of the professional practice environment of dental hygienists that are allowed by

[2] As of 2007, seven states (California, Colorado, Montana, Nebraska, New Mexico, Oregon and Washington) allow hygienists to be self-employed other than as independent contractors, and only three states (California, Colorado, and New Mexico) permit a dental hygienist to own a dental hygiene practice (Beach, Shulman, Johns, and Paas, 2007). Montana and Nebraska adopted the provision to allow hygienists to be self employed other than independent contractors in 2003 and 2007, respectively. The work by dental hygienists who are self-employed is restricted to specific kinds of dental practices that vary across these states.

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. We provide a full listing of the provisions in Appendix A, but some of the key components of the tasks include 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).

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:

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

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

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.[3]

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

[3] 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.

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:

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

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 hygienists' 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

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

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

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.[4]

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

[4] 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).

options for employment other than working for or under the supervision of a dentist, employers, who are dentists, can have significant market power. For example, consistent with baseball players being subject to reserve clauses, 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. For example, 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 (Scully, 1974, Kahn, and Zimbalist, 1992). For the overall labor market, the impact of monopsony has been estimated at less than 3 percent (Brown and Medoff, 1989). 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 (Boal and Ransom, 1997).

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 of this government report):

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 offices long-term care facilities, schools, public health agencies, correctional facilities, and similar institutional facilties. 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.[5]
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.

[5] We note that this component also includes other provisions, such as whether hygienist may be self employed other than as an independent contractor. We separated this provision from the other components and treat it as a qualitatively different variable in our empirical analysis.

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 be self-employed other than as independent contractors affect the market outcomes. Appendix A presents the operational definition of our regulatory variables.[6]

Table 1 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. Not only has the DHPPI been increasing but there has been considerable variation across states and over time.

[6] 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.

Labor Market Analysis for Dentists and Hygienists with Occupational Licensing Regulations

Table 2 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).[7] The values show that the average age of dentists is about six years higher than for 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 3 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.[8]

Our estimates in Tables 3 and 4 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:

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

[7] For a detailed description of how we constructed the data on dentists and hygienists from the ACS data, see Appendix B. As further test of the reliability of our date we correlated the data from the ACS with membership data from American Dental Hygienists Association by state and found the correlation to be .95. This suggests further that the ACS is an appropriate measure of hygienists' employment by state and year.

[8] 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.

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 and its components in person i's state s in time period t; the vector $\boldsymbol{X}_{ist}$ includes covariates measuring characteristics of each person; the vector $\boldsymbol{Z}_{st}$ includes time-varying state level controls such as the state median household income and the percent uninsured in the state, δ_s and η_t are state and year fixed effects, respectively; and u_{ist} is the error term.[9]

In Table 3 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 a 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 11 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.[10]

In contrast for dentists in Table 4 the estimates from the model using the same set of controls from the ACS as in Table 3 shows that having state provisions that allow for hygienists to be self employed is associated with approximately 22 percent lower hourly earnings for the dental occupation that is generally required by law to supervise dental hygienists. [11] The

[9] 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.

[10] 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 3.5 percent higher earnings for hygienists and 4.4 percent lower earnings for dentists, but is statistically significant at the 0.10 level only for hygienists. However, the direct reimbursement is not statistically significant in the employment growth models in Table 5 and 6.

[11] 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 3 and 4, Appendix C shows that the state regulations reduced the hourly earnings gap between these

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 for hygienists. In addition, there may be lost income because hygienists may be taking away patients from full service dentists, and recommending fewer high cost dental procedures.[12] To illustrate, there are powerful incentive effects for dentists to recommend more costly procedures. An average, sealants cost $37, but most fillings cost more than $100 and also need to be replaced periodically (Simonsen , 1991). Once, filling are installed there is a greater likelihood of both crowns and root canals both of which cost more than $1,000 each. Since hygienists can only work on sealants, having independent hygienists can have a major impact on dental incomes by changing the service and product mix. Sealants provide as good or better protection from further tooth decay as fillings (Gooch, 2009). Further, the signs of the coefficients for the ability of hygienists to engage in 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 and its components at state s in time period t; the vector $\boldsymbol{X}_{st}$

professions. Further, Appendix D shows estimates using the lag of the self-employment policy variable for hourly earnings and employment growth. These results were consistent with those in Tables 3 through 6.

[12] For example, independent dental hygienists are likely to recommend lower cost dental sealants but a hygienist who works in a full service office may have incentives to recommend a higher cost dental filling due to bonuses or promotions opportunities.

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 state median household income, 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 be self-employed is positively and statistically significant at the 0.10 level in its association with employment growth of hygienists by 6 percent. 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 dentists and hygienists in the determination of wages and employment.

Table 6 shows the relationship between the statutes and the growth of employment for dentists 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 as shown in our theory and evidence, there are also 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 the parameters to estimate potential losses to society from monopsony in the market (Kleiner and Kudrle, 2000). Using the results from theory and our estimates, we show in Table 7 that the reallocation from hygienists to dentists is approximately 1.34 billion dollars per year. The output loss due to the monopsonistic restriction of employment is approximately 0.08 billion dollars per year. The output loss due to licensing is between 0.54 to 0.68 billion dollars per year. Therefore, the total losses associated with overall occupational licensing and within occupation regulation to be between 0.62 to 0.75 billion dollars annually. This results in approximately a 1 percent annual 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. We show the conflict that has arisen over the allocation of work and supervision of tasks. 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.

The estimates from the 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 6 percent increase in the employment growth of dental hygienists. In contrast, these state provisions are associated with approximately a 22 percent reduction in dental hourly earnings and a 26 percent reduction in dental employment growth in the states. In part this larger loss by dentists is as a result of a change in the service and product mix that are delivered by hygienists in comparison to full service dental offices. Using a simple deadweight loss analysis consistent with a monopsony model, the typical state would lose approximately 1 percent of dental expenditures due to licensing, and 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 as 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.

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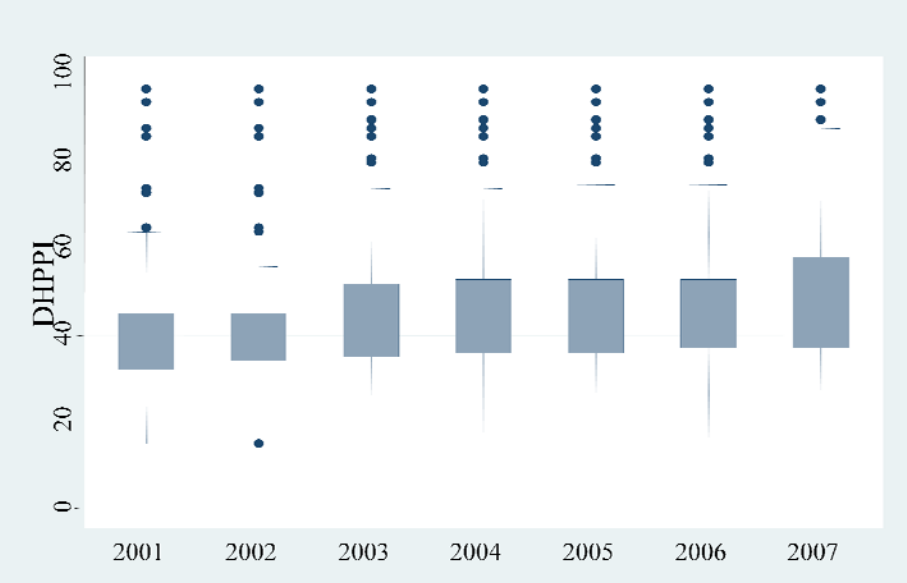
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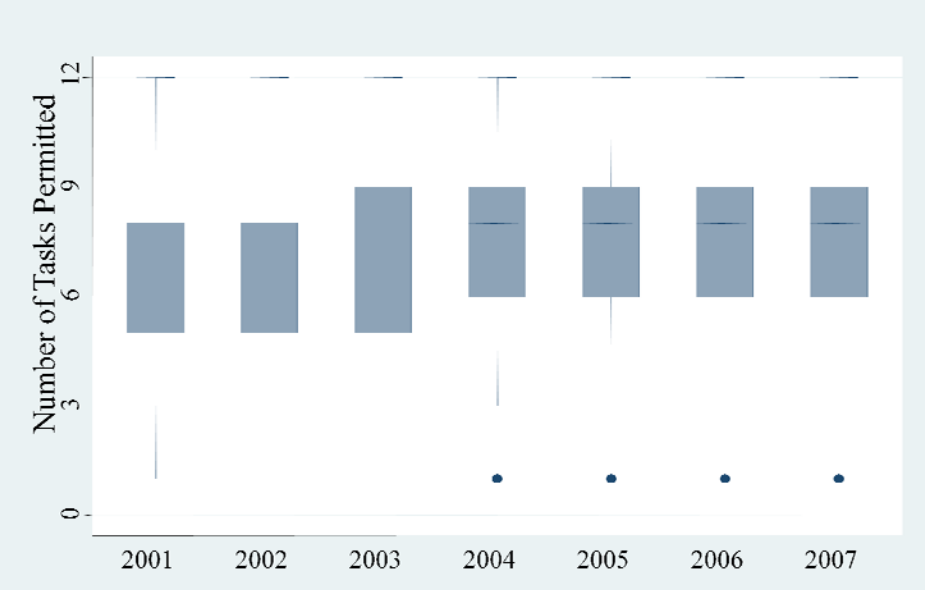
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Figure 1: Growth and Variation of State Regulations on
Professional Practice Environment of Dental Hygienists by State over Time

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

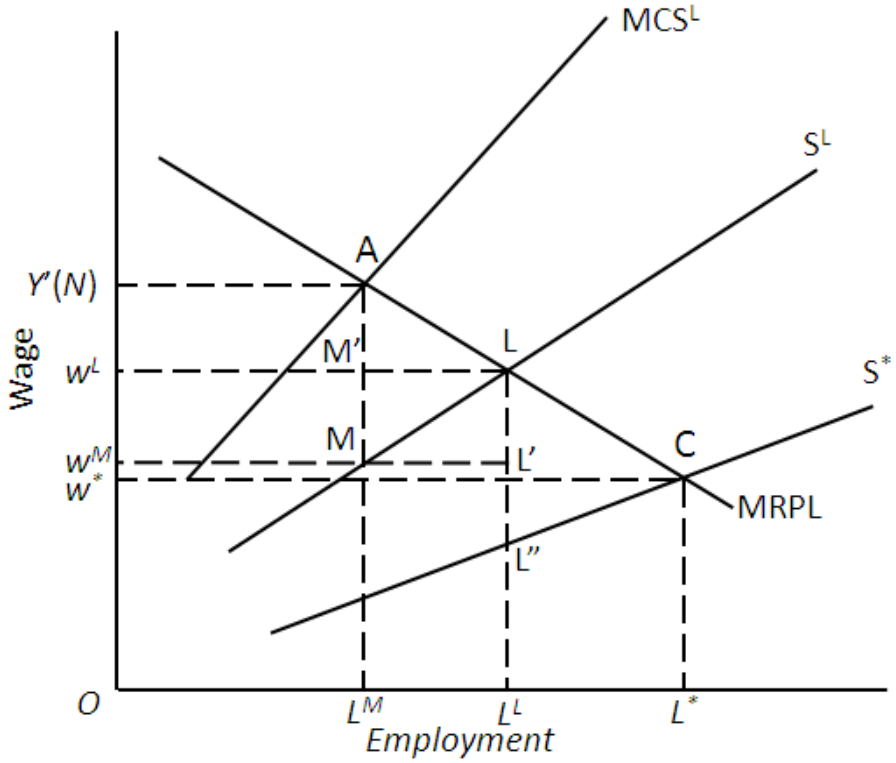


Panel B: Number of Tasks Permitted over 2001-2007



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

Panel A: Individual Sample Statistics	Dental Hygienists (*n*=5,854)		Dentists (*n*=7,159)		Total (*n*=13,013)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age	40.51	10.09	46.95	10.01	44.05	10.54
Schooling (in Years)	14.65	1.25	20.31	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	10.05	20.64	10.08	20.29	10.07
Experience-Squared(/1,000)	0.50	0.42	0.53	0.41	0.51	0.42
White (White: 1; Others: 0)	0.93	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	0.14
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
Hourly Earnings (in 2007 Dollars)	28.40	10.32	99.07	75.10		

Panel B: State Sample Statistics	*n*	Mean	S.D.	Source
DHPPI	357	46.80	20.02	Center for Health Workforce Studies (2004)
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	Occupational Employment Statistics
Growth in the number of Dentists	272	0.02	0.21	″
State Median Household Income	357	44,984.93	7,597.42	Current Population Survey
Percent of Uninsured (%)	357	13.67	3.76	″
State Median Price of Amalgam Restoration	336	112.66	19.73	Survey of Dental Fees (American Dental Association 2001, 2003, 2005, 2007)
State Median Price of Prophylaxis	343	49.47	8.54	″

Table 3: Pooled OLS Model of Log Hourly Earnings for Dental Hygienists Using the ACS, 2001-2007

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	0.000					
	(0.002)					
Tasks Permitted (Summated)		0.003				
		(0.007)				
Tasks Permitted (Rasch)			0.004			
			(0.009)			
Independence from Dentists (Summated)				0.012+		
				(0.006)		
Independence from Dentists (Rasch)					0.008+	
					(0.004)	
Self-Employment Allowed						0.106*
						(0.045)
Experience	0.017***	0.017***	0.017***	0.017***	0.017***	0.017***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Experience squared (/1,000)	-0.357***	-0.358***	-0.358***	-0.357***	-0.357***	-0.356***
	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)
Schooling (in Years)	0.040***	0.040***	0.040***	0.040***	0.040***	0.040***
	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
Gender	-0.043	-0.043	-0.043	-0.043	-0.043	-0.043
	(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	0.028	0.028	0.028	0.028	0.028	0.028
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Black	-0.070	-0.070	-0.070	-0.070	-0.070	-0.070
	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
Citizen	0.148**	0.148**	0.148**	0.148**	0.148**	0.148**
	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)
Working at For-Profit	0.163***	0.163***	0.163***	0.163***	0.163***	0.163***
	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)
Working at Not-for-Profit	0.099*	0.099*	0.099*	0.099*	0.099*	0.099*
	(0.048)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)
Self-employment	0.071	0.071	0.071	0.071	0.071	0.071
	(0.096)	(0.096)	(0.096)	(0.096)	(0.096)	(0.096)
Constant	1.483***	1.482***	1.487***	1.501***	1.568***	1.490***
	(0.252)	(0.260)	(0.261)	(0.265)	(0.268)	(0.260)
State Controls with State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.165	0.165	0.165	0.165	0.165	0.165
N	5,854	5,854	5,854	5,854	5,854	5,854

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 ***: $p<0.001$; state Controls include state median household income and the percentage of uninsured in the state.

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

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	-0.003					
	(0.003)					
Tasks Permitted (Summated)		-0.017				
		(0.022)				
Tasks Permitted (Rasch)			-0.030			
			(0.026)			
Independence from Dentists (Summated)				-0.016		
				(0.013)		
Independence from Dentists (Rasch)					-0.022***	
					(0.006)	
Self-Employment Allowed						-0.219***
						(0.046)
Experience	0.031***	0.031***	0.031***	0.031***	0.031***	0.031***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Experience squared(/1,000)	-0.595***	-0.595***	-0.595***	-0.595***	-0.596***	-0.596***
	(0.103)	(0.104)	(0.104)	(0.103)	(0.103)	(0.103)
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	0.246***	0.246***	0.246***	0.246***	0.246***	0.246***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Marital Status	0.102***	0.101***	0.101***	0.102***	0.102***	0.102***
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
White	0.100***	0.100***	0.100***	0.100***	0.100***	0.100***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Black	-0.020	-0.020	-0.020	-0.021	-0.021	-0.021
	(0.063)	(0.063)	(0.063)	(0.063)	(0.063)	(0.063)
Citizen	0.058	0.059	0.059	0.059	0.059	0.059
	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
Working at For-Profit	0.389***	0.389***	0.390***	0.389***	0.388***	0.389***
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
Working at Not-for-Profit	0.127*	0.127*	0.127*	0.127*	0.126*	0.126*
	(0.060)	(0.060)	(0.059)	(0.060)	(0.060)	(0.060)
Self-employment	0.505***	0.505***	0.505***	0.504***	0.504***	0.504***
	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
Constant	4.790***	4.758***	4.701***	4.731***	4.519***	4.735***
	(0.546)	(0.558)	(0.563)	(0.549)	(0.577)	(0.542)
State Controls with State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.108	0.108	0.108	0.108	0.108	0.108
N	7,159	7,159	7,159	7,159	7,159	7,159

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 ***: $p<0.001$; state controls include state median household income and the percentage of uninsured in the state.

Table 5: Models of Employment Growth for Dental Hygienists by State Using the ACS Data, 2001-2007

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	0.004					
	(0.003)					
Tasks Permitted (Summated)		-0.020				
		(0.034)				
Tasks Permitted (Rasch)			-0.037			
			(0.045)			
Independence from Dentists (Summated)				0.009+		
				(0.005)		
Independence from Dentists (Rasch)					0.006*	
					(0.003)	
Self-Employment Allowed						0.061+
						(0.034)
Dental Hygienist's Employment Growth Rate	-0.146*	-0.155*	-0.151*	-0.150*	-0.150*	-0.151*
	(0.064)	(0.061)	(0.063)	(0.064)	(0.064)	(0.064)
State Median Household Income (/1,000)	-0.015	-0.013	-0.014	-0.014	-0.014	-0.014
	(0.012)	(0.013)	(0.013)	(0.012)	(0.012)	(0.012)
Rate of Uninsured	-0.004	-0.001	-0.002	-0.004	-0.004	-0.003
	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
State Median Price of Prophylaxis	0.008	0.009	0.010	0.008	0.008	0.008
	(0.009)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
State Median Price of Amalgam Restoration	0.000	0.000	0.000	0.000	0.001	0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Constant	1.399	1.381	1.245	1.421	1.472	1.409
	(1.102)	(1.108)	(1.140)	(1.111)	(1.104)	(1.112)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.221	0.216	0.219	0.215	0.215	0.215
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 6: 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)		-0.022				
		(0.042)				
Tasks Permitted (Rasch)			0.022			
			(0.050)			
Independence from Dentists (Summated)				-0.036***		
				(0.005)		
Independence from Dentists (Rasch)					-0.024***	
					(0.003)	
Self-Employment Allowed						-0.255***
						(0.039)
Dental Hygienist's Employment Growth Rate	-0.282	-0.300	-0.293	-0.287	-0.287	-0.288
	(0.192)	(0.189)	(0.189)	(0.189)	(0.189)	(0.189)
State Median Household Income (/1,000)	-0.002	-0.004	-0.004	-0.003	-0.003	-0.003
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Rate of Uninsured	-0.002	-0.003	-0.005	0.000	-0.001	-0.001
	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)
State Median Price of Prophylaxis	0.007	0.010	0.006	0.006	0.006	0.006
	(0.015)	(0.013)	(0.013)	(0.014)	(0.014)	(0.014)
State Median Price of Amalgam Restoration	0.002	0.001	0.002	0.002	0.001	0.001
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)
Constant	0.817	0.772	0.911	0.792	0.607	0.847
	(1.774)	(1.762)	(1.688)	(1.738)	(1.736)	(1.748)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.243	0.239	0.238	0.247	0.246	0.246
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: 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).
- Labor costs accounts for 60% of health care spending (Schwieters and Harper, 2007).
- Dental hygienists account for approximately 22.3 percent of the total labor costs (from the ratio of the average hourly earnings of dentists and hygienists in Table 3).
- Therefore, labor costs for hygienists are approximately $12.88 billion (=$96.36 billion × 0.60 × 0.223), 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 0.106 for $(W^L - W^M)/W^M$ and 0.061 for $(L^L - L^M)/L^M$ (from Tables 4 and 6).
- Then, we are able to compute the reallocation from hygienists to dentists (rectangle $w^M w^L M'M$) as following:
  $(w^L - w^M) \times L^M = 0.106\ w^M \times L^M = 0.106 \times \$12.88$ billion $= \$1.34$ 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 monopsonitic employment restriction is
  $(w^L - w^M) \times (L^L - L^M) = 0.102\ w^M \times 0.061\ L^M = 0.102 \times 0.061 \times \$12.88$ billion $= \$0.08$ 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:
  $(L^L - L^M) \times w^M = 0.061\ L^M \times w^M = 0.061 \times \$12.88$ billion $= \$0.79$ billion.
- Then, hygienists' total revenue is $15.09 billion (=$12.88 billion + $1.34 billion +$0.08 billion +$0.79 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 $2.26 billion (=0.15*$15.09 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 $0.68 billion. If only 80 percent is deadweight (Carneiro, Heckman, and Vytlacil 2009), then $0.54 billion.

- The total output losses would be $0.54 billion to $0.68 billion due to licensing plus the monopsony effect of $0.08 billion which equals $0.62 billion to $0.75 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 Developed from the American Community Survey (ACS)

To generate our sample of dentists and dental hygienists, we started by dropping individuals who belong to the categories, "Working without pay in family business or farm" and "Unemployed." Thus, our sample includes individuals who belong to the classes of (1) Private wage and salary workers, (2) Government workers (who work in any local, state, or federal governmental unit), and (3) Self-employed both in own not incorporated business and in own incorporated business.

Next, 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 and individuals whose usual working hours in the past 12 months are less than 20 hours or more than 60 hours.

To compute the hourly earnings, we first computed annual hours worked (i.e., the usual working hours times the number of weeks for the past 12 months). Then we compute annual earnings by adding the wage (i.e., wagp) and salary income and the income from self-employment (i.e., semp), and then divide the annual earnings by annual hours worked.

In computing the hourly earnings, however, the ACS has two potential measurement problems: the topcoding (or censoring) of both incomes (i.e., wagp and semp), particularly for dentists, and the presence of outliers. To deal with the topcodings, as much of the literature does, 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 present empirical results in which hourly earnings were adjusted by a factor of 1.4.

As for the presence of outliers, we confirmed that 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. Since the income from self-employment of the ACS is reported in net after subtracting expenses, we deleted observations on the basis of implausibly low hourly wages. Specifically, we deleted these observations with measured hourly wages below the federal minimum wage of $5.15 during 2001–2007. To deal with the individuals with implausibly high hourly earnings, we trimmed down the top 1% of the sample.

Appendix Table B. Sample Selection from the ACS

	Dental Hygienists	Dentists
Initial observations	7,510	8,942
Selection rule 1: Unemployed or working without pay in family business or farm	-20	-11
Selection rule 2: Educational attainment Drop sample: Below associate for dentist; sample below 12th grade w/o diploma for dental hygienist	-48	-28
Selection rule 3: Age equal to or over 65	-142	-1,017
Selection rule 4: Experience = Age - years of schooling - 6	-8	-36
Selection rule 5: Less than 20 hours and more than 60 hours	-1,303	-534
Selection rule 6: Hourly wage less than the federal minimum of $5.15 during 2001–2007	-76	-75
Selection rule 7: Trim down the top 1% of the sample	-59	-82
Total observations	5,854	7,159

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

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	0.001					
	(0.008)					
Tasks Permitted (Summated)		-0.054				
		(0.043)				
Tasks Permitted (Rasch)			-0.053			
			(0.057)			
Independence from Dentists (Summated)				-0.067***		
				(0.010)		
Independence from Dentists (Rasch)					-0.049***	
					(0.006)	
Self-Employment Allowed						-0.534***
						(0.073)
Employment Growth Ratio	0.003	0.007	0.005	-0.005	-0.005	-0.005
	(0.037)	(0.038)	(0.038)	(0.036)	(0.036)	(0.036)
State Median Household	-0.070**	-0.066**	-0.069**	-0.065**	-0.065**	-0.065**
Income (/1,000)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
Rate of Uninsured	-0.034	-0.029	-0.032	-0.024	-0.024	-0.024
	(0.026)	(0.025)	(0.025)	(0.026)	(0.026)	(0.026)
Constant	5.227***	5.301***	5.240***	4.795***	4.346**	4.833***
	(1.307)	(1.322)	(1.312)	(1.330)	(1.362)	(1.324)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.354	0.357	0.356	0.361	0.362	0.362
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 ***: $p<0.001$.

Appendix D: Estimates of Hourly Earnings and Employment Growth for Hygienists and Dentists with Lagged Variables of Self-Employment

	Log Hourly Earnings for Dental Hygienists		Log Hourly Earnings for Dentists		Employment Growth for Dental Hygienists		Employment Growth for Dentists	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Self-Employment Allowed		0.091		-0.231***		0.064		-0.257***
		(0.065)		(0.044)		(0.039)		(0.044)
Self-Employment Allowed $_{t-1}$	0.051**	-0.009	-0.662***	-0.509***	0.023	-0.008	-0.124***	0.004
	(0.018)	(0.045)	(0.042)	(0.047)	(0.027)	(0.030)	(0.032)	(0.036)
R-squared	0.167	0.167	0.109	0.109	0.214	0.215	0.239	0.246
N	5,376	5,376	6,513	6,513	250	250	250	250
F-test		4.43*		125.71***		1.53		21.45***

Note: Models 1 to 4 and Models 5 to 8 contain the same control variables included in Tables 3 and 4 and in Table 5 and 6, respectively; robust standard errors clustered at the state level are reported in parentheses, † significant at $p<0.10$; * $p<0.05$; **: $p<0.01$; and ***: $p<0.001$.