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BATTLES AMONG LICENSED OCCUPATIONS:  
ANALYZING GOVERNMENT REGULATIONS ON LABOR MARKET OUTCOMES FOR DENTISTS AND HYGIENISTS

Morris M. Kleiner  
Kyoung Won Park

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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 to 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 10 percent higher earnings, and that dentists in those states have lower earnings and slower employment growth. Several sensitivity and falsification tests using other regulated and partially regulated occupations show that our licensing measures are generally robust to alternative specifications. Our estimates 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.

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

Kyoung Won Park  
Case Western Reserve University  
Weatherhead School of Management  
280 Peter B. Lewis Building  
11119 Bellflower Road  
Cleveland, Ohio 44106  
kwp17@case.edu

## **Introduction**

In this paper 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. It also gives an illustration of the kinds of issues that arise as more occupations become regulated and turf battles arise over who is legally allowed to do work for pay.

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 state regulations for dental hygienists 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 show how a monopsony relationship, where there are frictions in the market and employers have the ability to collude to set wages, 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 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 and earnings for dentists. These results are robust to sensitivity tests for similar partially licensed occupations and other

health-related occupations that are regulated. To the extent that these estimates suggest inefficiencies due to licensing and monopsonistic deadweight loss, we provide results of these estimated losses. The rest of the analysis presents how we developed these findings.

### **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, 2010). As recently as 1994, 9 states forbid the employment of more than two hygienists in a dental office fixing the scale effect for these two occupations (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, 2010).<sup>1</sup>

Initially, dental hygiene programs were one year long but have since been expanded; programs now take between two and four years to complete. 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

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<sup>1</sup> 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. In all the other states, dentists dominate the decision process of who gets to do the work.

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.<sup>2</sup> As of 2007, no state permitted reciprocity of the movement of dental hygienists from other states.

In the late 1970s, the American Dental Hygienists' 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 (Motley, 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, who also retained ownership and managerial authority (Beach, Shulman, Johns, and Paas, 2007). Over time, hygienists have been able to gain greater authority in state legislatures as their numbers have increased in overall dental practice, and consequently their influence in crafting licensing laws has grown. These policy provisions by both dental service organizations set the battlegrounds 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 spread of the regulation of hygienists over the period 2001–2007. Panel A shows the overall ranking of dental hygienists' professional practice environment that is allowed by statute or legal rulings. Panel B shows the number of dental tasks that hygienists are permitted to do,

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<sup>2</sup> 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 et. al., 2007). Montana and Nebraska adopted the provision to allow hygienists to be self-employed other than as 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. For example, in Colorado hygienists are allowed to clean teeth and do simple restorative work, independently of a dentist.

independently of dentists, by state law or administrative or court rulings in the state. We provide a full listing of the provisions in the table 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).<sup>3</sup> The results in panels A and B of Figure 1 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 shows 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 over 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

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<sup>3</sup> A report funded by the Kellogg Foundation Rasmuson Foundation and Bethel Community Services Foundation showed that dental hygienists performed as well as dentists in performing routine tasks such as the ones listed here (Wetterhall, Bader, Burrus, Lee, and Shugars, 2010).

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.<sup>4</sup>

When analyzing occupations that are licensed, we follow Shapiro (1986), who models a labor market where service output has two types of workers: high-skilled and lower-skilled. 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:

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<sup>4</sup> 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.



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

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 hygienists can be given by the following expression:

$$HL = B L_h^\gamma K_h^\delta, \quad (4)$$

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:

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

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

$$HL = (\theta L_d) L_h^\gamma K_h^\delta, \quad (6)$$

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 profit function for dental services can be written as

$$\rho B L_h^\gamma K_h^\delta - w_h L_h - r_h K_h \quad (7)$$

$$P_d A L_d^\alpha K_d^\beta + (1-\rho)(\theta L_d) L_h^\gamma K_h^\delta - w_d L_d - r_d K_d, \quad (8)$$

where  $\rho = 1$  is the case of no regulation and  $0 < \rho \leq 1$ , and  $P$  is the 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 determined by the decisions of the dentist to use of the hygienist's labor input and technology mix by the high-skilled provider,  $HH$ , and is exogenous. 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.<sup>5</sup>

### **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 that control low-skilled workers' tasks and their ability to do work only for certain types of employers have monopsonistic characteristics to 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, important frictions are assumed to be present. In the case of two universally licensed occupations, with one dominant, this requires the supervision of the other, and the assumption of frictions in the labor market is established. Second, employers have some ability to set wages. Since dental hygienists have no other major options for employment other than working for or under the supervision of a dentist, they can have significant market power to collude to set wages in a local market. This is consistent with one of the elements of monopsony (Lipscomb and Douglas, 1982).

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<sup>5</sup> The first-order condition shows that  $\rho B \gamma L_h^{\gamma-1} K_h^\delta - w_h = 0$ ,  $\rho B \delta L_h^\gamma K_h^{\delta-1} - r_h = 0$ ,  $P_d A \alpha L_d^{\alpha-1} K_d^\beta + (1-\rho)\theta L_h^\gamma K_h^\delta - w_d = 0$  and  $P_d A \beta L_d^\alpha K_d^{\beta-1} - r_d = 0$ . It implies that the hygienist's wage will go down and the dentist's wage will go up. Also, it implies that the employment of hygienists will go down and dentists' employment will go up (Varian, 1992).

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

$$\pi = Y(L) - w(L)L. \quad (9)$$

The first-order condition is

$$Y'(L) = w(L) + w'(L)L. \quad (10)$$

The value  $Y'(L)$  is the marginal revenue product of labor, and  $w(L) + w'(L)L$  is the marginal cost of labor. The latter increases 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, the law, when it favors dentists' control over the market structure, redistributes welfare away from workers (hygienists) and to their employer (dentists). Second, the market structure established by these two occupations reduces the aggregate (or social) welfare enjoyed by both groups taken together, since 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.

Figure 2 shows that 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  $A$ . The supply curve  $S^L$  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  $w^L w^M M M'$  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 range from major league baseball, where the impact has been large (100 to 600 percent), to teachers, nurses, and nurses assistants where the influence has been 5 percent or less (Scully, 1974; Zimbalist, 1992, Kahn; 2000; Matsudaira, 2010). 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, 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 50 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 facilities. 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.<sup>6</sup>
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 a less restrictive practice environment for dental hygienists.

For empirical analysis, we use the DHPPI as an overall index to capture the spread 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

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<sup>6</sup> We note that this component also includes other provisions, such as whether a 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.

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 affects the market outcomes. The table in Appendix A presents the operational definition of our regulatory variables.<sup>7</sup>

Table 1 shows the top and bottom five states ranked by their summated DHPPI. Although 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 also been considerable variation across states and over time.

## **Labor Market Analysis for Dentists and Hygienists with Occupational Licensing**

### **Regulations**

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<sup>7</sup> The correlations among the major components of the original DHPPI range from 0.56 to 0.96, and their intercorrelation (i.e., Cronbach's alpha) is 0.77. Although the correlations among the two summated ratings of the task permitted and self-employment range from 0.50 to 0.75 and their intercorrelation is 0.67, the correlations among the two Rasch indices and self-employment range from 0.41 to 0.73, and their intercorrelation is 0.51.

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).<sup>8</sup> Appendix B describes how we constructed the data used to analyze dentists and hygienists from the ACS. The values show that the average age of dentists is about six years higher than that for hygienists, and that dentists have six more years of schooling. Further, the dentistry profession tends to be male dominated, whereas 97 percent of hygienists are female. The average hourly earnings of dentists are more than three 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.

Our estimates in Tables 3 and 4 demonstrate the association between DHPPI and hourly earnings for dental hygienists and dentists, using individual-level data in the ACS. The basic general earnings equation can be stated as follows:

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

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 and its components in person  $i$ 's state  $s$  in time period  $t$ ; the vector  $\mathbf{X}_{ist}$  includes covariates measuring the characteristics of each person; the vector  $\mathbf{Z}_{st}$  includes time-varying state-level controls such as the state median household income and the percentage of

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<sup>8</sup> We choose to analyze the ACS as our main dataset over alternative datasets such as the CPS, because 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. For a detailed sampling framework of the ACS, see U.S. Census Bureau, American Community Survey, Data and Documentation, [http://www.census.gov/acs/www/data\\_documentation/data\\_main/](http://www.census.gov/acs/www/data_documentation/data_main/).



uninsured in the state;  $\delta_s$  and  $\eta_t$  are state and year fixed effects, respectively; and  $u_{ist}$  is the error term.<sup>9</sup>

In Table 3 we show the impact of the overall DHPPI index on the logarithm of hourly earnings of hygienists with all the controls for individual characteristics shown in Table 2 that were extracted from the ACS. Our results show that the DHPPI level is not a significant factor in determining hourly earnings. However, the legal ability either to be self-employed or to have tasks unsupervised is a key factor influencing wage determination. For example, having the ability to be self-employed raises hygienists' hourly earnings by approximately a statistically significant 10 percent, and working unsupervised measured by the summated score (the Rasch score) is associated with an 1.2 or 0.7 percent increase in earnings for hygienists.<sup>10</sup>

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 indicate that having state provisions that allow for hygienists to be self-employed is associated with approximately 16 percent lower hourly earnings for the dentists than for those members of the occupation who are generally required by law to supervise dental hygienists.<sup>11</sup> 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. 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 patients away

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<sup>9</sup> 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 suggests that our policy variables influence wages for each occupation beyond state or time varying characteristics.

<sup>10</sup> We also examined whether hygienists are directly reimbursed under the state government regulations with the same specifications. Although not shown in this paper, the direct reimbursement is associated with approximately 5.1 percent higher earnings for hygienists and 8.4 percent lower earnings for dentists, but is statistically significant at the 0.01 level only for hygienists. However, the direct reimbursement is not statistically significant in the employment growth models in Tables 5 and 6.

<sup>11</sup> We further examined the impact of 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 Tables 3 and 4, Appendix C shows that state regulations reduced the hourly earnings gap between these professions.

from full-service dentists and recommending fewer costly dental procedures.<sup>12</sup> To illustrate, there are powerful incentive effects for dentists to recommend more costly procedures. On average, sealants cost \$37, but most fillings cost more than \$100 and also need to be replaced periodically (Simonsen, 1991). Once fillings 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 protection from further tooth decay that is as good as or better than the protection from 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.

We also examined whether state provisions that allow for hygienists to be self-employed are associated with earnings dispersions for the two occupations.<sup>13</sup> The results in Table 5 show that the dispersion of the log of hourly earnings for hygienists in the states with the self-employment provisions was 15 percent higher than in the states without the provisions, and was statistically significant at the 0.05 level. But no statistically significant difference was found for dentists.

The employment effects of variations in state statutes for dental hygienists and dentists are given in Tables 6 and 7, respectively.<sup>14</sup> The general employment equation can be stated as follows:

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<sup>12</sup> 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 promotion opportunities.

<sup>13</sup> We computed the dispersions using a similar estimation procedure as in Kleiner and Krueger, 2010. Our first-stage estimates of the residual values for dental hygienists and dentists were from column 6 in Tables 3 and 4, respectively. We then computed the mean squared residuals for each occupation by whether self-employment was allowed. We compared the significance of the values generated in each category using the *t*-value.

<sup>14</sup> As a further test of the reliability of our employment data, we correlated the data from Occupational Employment Statistics (OES) with membership data from the ADHA by state for 2002–2006 and the number of active dentists in

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

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  $\mathbf{X}_{st}$  includes covariates measuring economic and dental characteristics within each state;  $\delta_s$  and  $\eta_t$  are state and year fixed effects, respectively; and  $\mu_{st}$  is the error term.

The estimates from our reduced form model in Table 6 show that the overall index is not significantly associated with employment growth of hygienists in equations that include state-level controls such as the growth in the number of dentists in the state, the state median household income, the percentage of 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 about 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 7 shows the relationship between the statutes and the growth of employment for dentists in the state. 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 dentists are

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2006 from the ADA. Their correlation was .92 and .96, respectively. This suggests that the OES is an appropriate measure of dentists' and hygienists' employment by state and year.

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.

In order to test for the robustness and sensitivity of our results, we show two cases in Table 8( Leamer, 2010).<sup>15</sup> In panel A we estimated the role of the DHPPI on the earnings of dental assistants who are not universally licensed and have different requirements than dental hygienists, and found no influence of the index to include market structure on their earnings in the ACS. In panel B, we performed another robustness check using data from the ACS for registered nurses, who have another set of statutes influencing the market structure for their occupation. We found that the DHPPI had no influence on the earnings of registered nurses. These results suggest that our results did not result from other factors that were not captured by the state fixed effects.

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 deadweight loss analysis can give the parameters to estimate potential losses to society from monopsony in the market (Kleiner and Kudrle, 2000). Using the parameters developed from the results from theory and our estimates, we show in Table 9 that the reallocation from hygienists to dentists is approximately \$1.34 billion per year. The output loss due to the monopsonistic restriction of employment is approximately \$0.08 billion per year. The output loss due to licensing is between \$0.54 and \$0.68 billion per year. Therefore, the total losses associated with overall occupational licensing

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<sup>15</sup> Further, Appendix D shows estimates using the lag of the self-employment policy variable for hourly earnings and employment growth. These results are consistent with those in Tables 3 through 6. We also performed additional robustness tests excluding self-employed dentists. The qualitative influence was robust. Specific sample selection procedures for dental assistants and registered nurses and full results are shown in Table 7 and Appendix D

and within-occupation regulation are between \$0.62 and \$0.75 billion annually. This results in approximately a 1 percent annual reduction in the output of dental services for those states that required dentists' supervision of dental hygienists using a basic deadweight loss analysis (Carneiro, Heckman, and Vytlačil, 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 result 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 2001–2007. 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 16 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 is delivered by hygienists in comparison to full-service dental offices. Using a simple deadweight loss analysis consistent with a monopsony model, we find that 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 architects and interior designers arising from the issue of 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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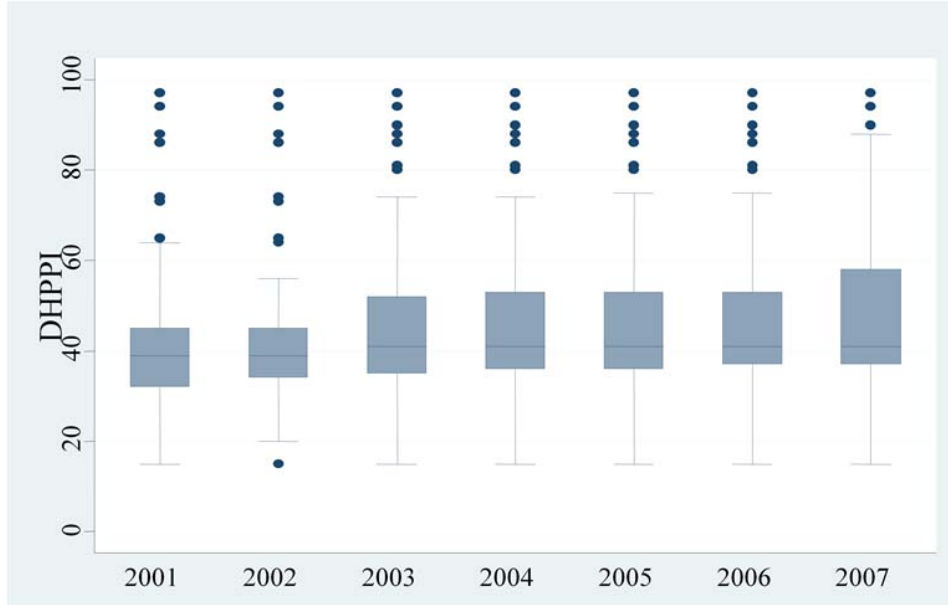
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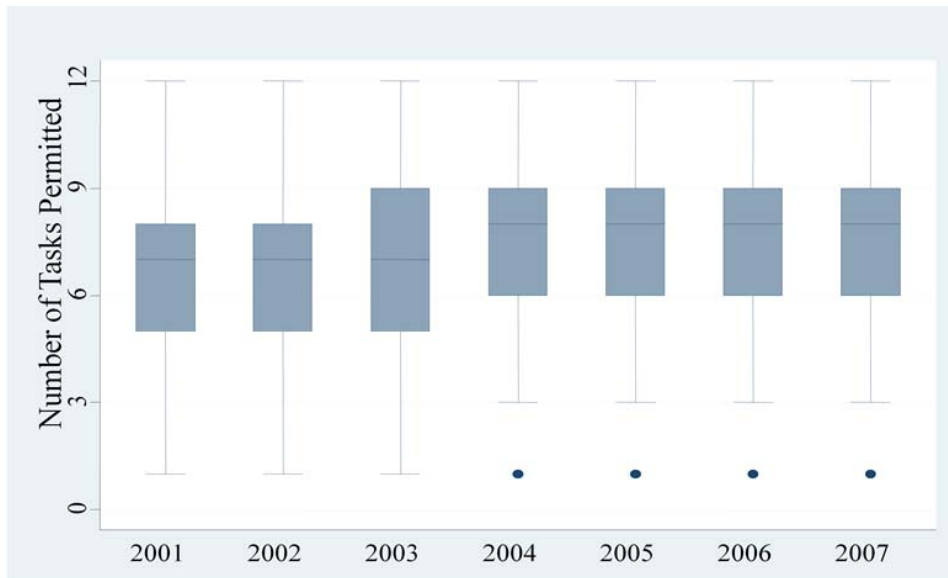
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Figure 1: Growth and Spread of State Regulations on Professional Practice Environment of Dental Hygienists (DHPPI) by State over Time

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

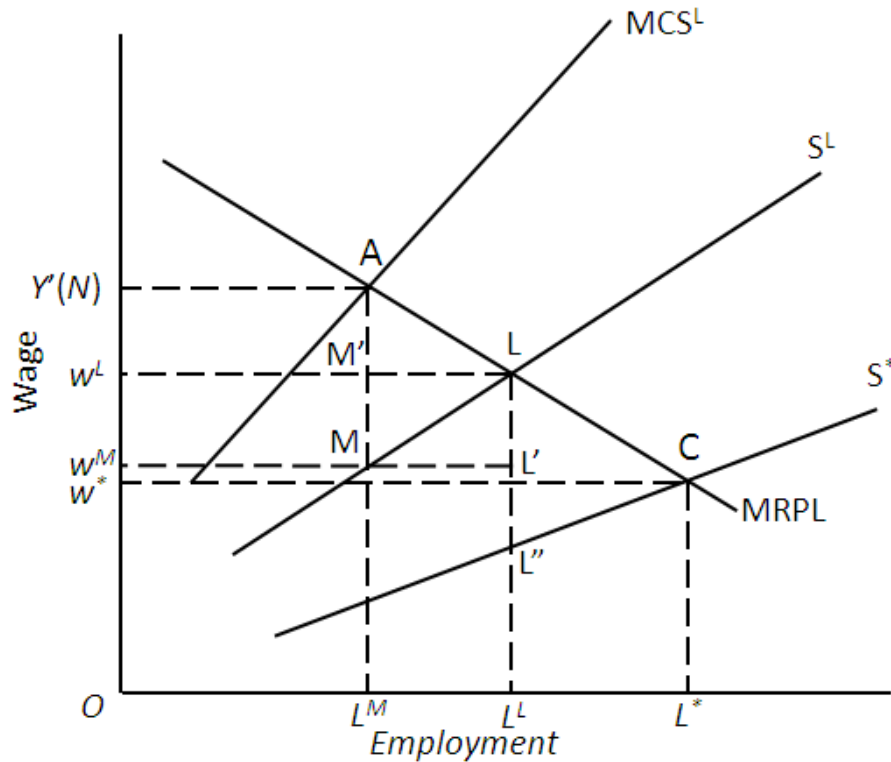


Panel B: Number of Tasks Permitted over 2001–2007



*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 (DHPPI) 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 quartiles, 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 quartiles). The remaining points represent outliers that do not fall within the range of the whiskers; for each definition of the variables, see Appendix A; and for detailed sample statistics, see panel B in Table 3.

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



Note: 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 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  $w^L w^M M M'$  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

Year	Top Five States		Bottom Five States	
	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 Five 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

<i>Panel A: Individual Sample Statistics</i>	Dental Hygienists ( <i>n</i> =5,886)		Dentists ( <i>n</i> =7,220)		Total ( <i>n</i> =13,106)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age	40.55	10.11	46.98	10.02	44.09	10.55
Schooling (in Years)	14.65	1.25	20.30	1.05	17.77	3.03
Gender (Male:1; Female: 0)	0.03	0.17	0.80	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)	19.90	10.07	20.67	10.09	20.33	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
Hourly Earnings (in 2007 Dollars)	28.81	11.93	95.46	67.66		

<i>Panel B: State Sample Statistics</i>	<i>n</i>	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
Percentage of Uninsured (%)	357	13.67	3.76	"
State Median Price of Amalgam Restoration	336	112.66	19.73	Survey of Dental Fees (American Dental
State Median Price of Prophylaxis	343	49.47	8.54	" Association 2001, 2003, 2005, 2007)

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)		0.005 (0.007)				
Tasks Permitted (Rasch)			0.005 (0.010)			
Independence from Dentists (Summated)				0.012* (0.006)		
Independence from Dentists (Rasch)					0.007+ (0.004)	
Self-Employment Allowed						0.100* (0.041)
Experience	0.017*** (0.003)	0.017*** (0.003)	0.017*** (0.003)	0.017*** (0.003)	0.017*** (0.003)	0.017*** (0.003)
Experience squared (/1,000)	-0.345*** (0.061)	-0.345*** (0.061)	-0.345*** (0.061)	-0.344*** (0.061)	-0.344*** (0.061)	-0.344*** (0.061)
Schooling (in Years)	0.043*** (0.007)	0.043*** (0.007)	0.043*** (0.007)	0.043*** (0.007)	0.043*** (0.007)	0.043*** (0.007)
Gender	-0.065+ (0.034)	-0.064+ (0.034)	-0.064+ (0.034)	-0.064+ (0.034)	-0.065+ (0.034)	-0.064+ (0.034)
Marital Status	0.008 (0.014)	0.008 (0.014)	0.008 (0.014)	0.008 (0.014)	0.008 (0.014)	0.008 (0.014)
White	0.002 (0.032)	0.002 (0.032)	0.002 (0.032)	0.002 (0.032)	0.002 (0.032)	0.002 (0.032)
Black	-0.080 (0.048)	-0.080 (0.048)	-0.080 (0.048)	-0.080 (0.048)	-0.080 (0.048)	-0.080 (0.048)
Citizen	0.142** (0.044)	0.142** (0.044)	0.142** (0.044)	0.143** (0.044)	0.143** (0.044)	0.143** (0.044)
Working at For-Profit	0.168*** (0.034)	0.168*** (0.033)	0.168*** (0.033)	0.167*** (0.033)	0.167*** (0.033)	0.167*** (0.033)
Working at Not-for-Profit	0.093+ (0.048)	0.093+ (0.048)	0.093+ (0.048)	0.093+ (0.048)	0.093+ (0.048)	0.093+ (0.048)
Self-employment	0.137+ (0.069)	0.137+ (0.069)	0.137+ (0.069)	0.137+ (0.069)	0.137+ (0.069)	0.137+ (0.069)
Constant	-3.087 (3.048)	-3.106 (2.998)	-3.256 (2.963)	-2.793 (3.078)	-2.981 (2.980)	-3.036 (2.968)
State Controls with State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.171	0.171	0.171	0.172	0.172	0.172
N	5,886	5,886	5,886	5,886	5,886	5,886

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	-0.002 (0.003)					
Tasks Permitted (Summated)		-0.005 (0.020)				
Tasks Permitted (Rasch)			-0.014 (0.023)			
Independence from Dentists (Summated)				-0.005 (0.017)		
Independence from Dentists (Rasch)					-0.014+ (0.008)	
Self-Employment Allowed						-0.162* (0.077)
Experience	0.031*** (0.005)	0.031*** (0.005)	0.031*** (0.005)	0.031*** (0.005)	0.031*** (0.005)	0.031*** (0.005)
Experience squared(/1,000)	-0.610*** (0.112)	-0.609*** (0.112)	-0.609*** (0.112)	-0.610*** (0.112)	-0.610*** (0.112)	-0.611*** (0.112)
Schooling (in Years)	-0.015 (0.011)	-0.015 (0.011)	-0.015 (0.011)	-0.015 (0.011)	-0.015 (0.011)	-0.015 (0.011)
Gender	0.244*** (0.018)	0.244*** (0.018)	0.244*** (0.018)	0.244*** (0.018)	0.244*** (0.018)	0.244*** (0.018)
Marital Status	0.115*** (0.020)	0.115*** (0.020)	0.114*** (0.020)	0.115*** (0.020)	0.115*** (0.020)	0.115*** (0.020)
White	0.097*** (0.017)	0.097*** (0.017)	0.097*** (0.017)	0.097*** (0.017)	0.097*** (0.017)	0.097*** (0.017)
Black	-0.036 (0.058)	-0.036 (0.059)	-0.036 (0.059)	-0.037 (0.058)	-0.037 (0.058)	-0.037 (0.058)
Citizen	0.067 (0.041)	0.067 (0.041)	0.067 (0.041)	0.067 (0.041)	0.067 (0.041)	0.067 (0.041)
Working at For-Profit	0.387*** (0.032)	0.387*** (0.032)	0.387*** (0.032)	0.387*** (0.032)	0.387*** (0.032)	0.387*** (0.032)
Working at Not-for-Profit	0.111+ (0.057)	0.111+ (0.057)	0.111+ (0.057)	0.111+ (0.057)	0.110+ (0.057)	0.110+ (0.057)
Self-employment	0.500*** (0.037)	0.500*** (0.037)	0.501*** (0.037)	0.500*** (0.037)	0.500*** (0.037)	0.500*** (0.037)
Constant	11.574+ (6.138)	11.848+ (6.065)	12.090+ (6.144)	11.727+ (6.095)	11.365+ (6.142)	11.511+ (6.046)
State Controls with State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.122	0.122	0.122	0.122	0.122	0.122
N	7,220	7,220	7,220	7,220	7,220	7,220

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: The Effect of the Self-Employment Provision and Hourly Earnings Dispersion for Dental Hygienists and Dentists Using the ACS, 2001–2007

Occupation	Mean within category squared residual		Coefficient (a–b)	<i>t</i> -value
	(a) No Self-employment Provision	(b) Self-employment Provision		
Dental Hygienists	0.13 ( <i>n</i> =4967)	0.15 ( <i>n</i> =919)	–0.02	–2.15*
Dentists	0.52 ( <i>n</i> =5,734)	0.50 ( <i>n</i> =1,486)	0.02	0.84

*Note:* The estimation procedure is described in footnote 13.

Table 6: Models of Employment Growth for Dental Hygienists by State Using the OES 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* (0.064)	-0.155* (0.061)	-0.151* (0.063)	-0.150* (0.064)	-0.150* (0.064)	-0.151* (0.064)
State Median Household Income (/1,000)	-0.015 (0.012)	-0.013 (0.013)	-0.014 (0.013)	-0.014 (0.012)	-0.014 (0.012)	-0.014 (0.012)
Rate of Uninsured	-0.004 (0.008)	-0.001 (0.009)	-0.002 (0.008)	-0.004 (0.008)	-0.004 (0.008)	-0.003 (0.008)
State Median Price of Prophylaxis	0.008 (0.009)	0.009 (0.010)	0.010 (0.010)	0.008 (0.009)	0.008 (0.009)	0.008 (0.009)
State Median Price of Amalgam Restoration	0.000 (0.004)	0.000 (0.004)	0.000 (0.004)	0.000 (0.004)	0.001 (0.004)	0.001 (0.004)
Constant	1.399 (1.102)	1.381 (1.108)	1.245 (1.140)	1.421 (1.111)	1.472 (1.104)	1.409 (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 7: Models of Employment Growth for Dentists by State Using the OES 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 (0.192)	-0.300 (0.189)	-0.293 (0.189)	-0.287 (0.189)	-0.287 (0.189)	-0.288 (0.189)
State Median Household Income (/1,000)	-0.002 (0.013)	-0.004 (0.013)	-0.004 (0.013)	-0.003 (0.013)	-0.003 (0.013)	-0.003 (0.013)
Rate of Uninsured	-0.002 (0.010)	-0.003 (0.010)	-0.005 (0.011)	0.000 (0.010)	-0.001 (0.010)	-0.001 (0.010)
State Median Price of Prophylaxis	0.007 (0.015)	0.010 (0.013)	0.006 (0.013)	0.006 (0.014)	0.006 (0.014)	0.006 (0.014)
State Median Price of Amalgam Restoration	0.002 (0.003)	0.001 (0.003)	0.002 (0.002)	0.002 (0.003)	0.001 (0.003)	0.001 (0.003)
Constant	0.817 (1.774)	0.772 (1.762)	0.911 (1.688)	0.792 (1.738)	0.607 (1.736)	0.847 (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 8: Falsification Tests of State Regulations on Professional Practice Environment of Dental Hygienists (DHPPI) Using Different Occupations from the ACS, 2001–2007

Panel A: Falsification Effects of Dental Hygienists Practices Index on Dental Assistants

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	-0.001 (0.002)					
Tasks Permitted (Summated)		0.014 (0.014)				
Tasks Permitted (Rasch)			0.017 (0.019)			
Independence from Dentists (Summated)				0.019 (0.016)		
Independence from Dentists (Rasch)					0.011 (0.009)	
Self-Employment Allowed						0.035 (0.031)
State Controls with State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.181	0.182	0.181	0.181	0.181	0.181
N	8,351	8,351	8,351	8,351	8,351	8,351

Panel B: Pooled OLS Model of Log Hourly Earnings for Registered Nurses Using the ACS, 2001–2007

	(1)	(2)	(3)	(4)	(5)	(6)
DHPPI	-0.007* (0.003)					
Tasks Permitted (Summated)		-0.038+ (0.019)				
Tasks Permitted (Rasch)			-0.030 (0.024)			
Independence from Dentists (Summated)				-0.034 (0.027)		
Independence from Dentists (Rasch)					-0.052 (0.046)	
Self-Employment Allowed						-0.055 (0.046)
State Controls with State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.401	0.401	0.401	0.401	0.401	0.401
N	105,738	105,738	105,738	105,738	105,738	105,738

Note: The same set of control variables in Table 3 were also included in Panel A and B; 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 9: A Static Simulation of the Effects of State Regulations on U.S. Dental Service Costs

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*Estimates of U.S. Dental Service Expenditures*

- U.S. dental service expenditures are approximately \$96.36 billion (U.S. Department of Health and Human Services, 2008).
- Labor costs account for 60 percent of health care spending (Schwieters and Harper, 2007).
- Dental hygienists account for approximately 23.2 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 \$13.40 billion ( $=\$96.36 \text{ billion} \times 0.60 \times 0.232$ ), which is rectangle  $w^M OL^M M$  ( $=w^M \times L^M$ ) in Figure 2.

*Analysis of Monopsonistic Exploitation and Deadweight Loss Using Basic Demand Analysis*

- Monopsonistic exploitation (rectangle  $w^L w^M M M'$  in Figure 2)
    - We substitute the estimates of 0.100 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 follows:  
 $(w^L - w^M) \times L^M = 0.100 w^M \times L^M = 0.100 \times \$13.40 \text{ billion} = \$1.34 \text{ billion}$
    - 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 monopsonistic employment restriction is  
 $(w^L - w^M) \times (L^L - L^M) = 0.100 w^M \times 0.061 L^M = 0.100 \times 0.061 \times \$13.40 \text{ billion} = \$0.08 \text{ billion.}$
  - Licensing Effect
    - To compute the 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 follows:  
 $(L^L - L^M) \times w^M = 0.061 L^M \times w^M = 0.061 \times \$13.40 \text{ billion} = \$0.82 \text{ billion.}$
    - Then, hygienists' total revenue is \$15.64 billion ( $=\$13.40 \text{ billion} + \$1.34 \text{ billion} + \$0.08 \text{ billion} + \$0.82 \text{ billion}$ ).
    - Given that the licensing premium is 15 percent economy-wide (Kleiner and Krueger, forthcoming), then the reallocation from consumers to hygienists' services is \$2.35 billion ( $=0.15 \times \$15.64 \text{ billion}$ ).
    - Also, given that the mean value of demand elasticity of labor is 0.3 (Hamermesh, 1993), the deadweight loss due to licensing (i.e., triangle  $LL''C$  in Figure 2) should be about \$0.70 billion. If only 80 percent is deadweight (Carneiro, Heckman, and Vytlačil, 2009), then \$0.56 billion.
  - The total output losses would be \$0.56 billion to \$0.70 billion due to licensing plus the monopsony effect of \$0.08 billion, which equals \$0.64 billion to \$0.78 billion.
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## 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: Dentist's 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 is 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 12<sup>th</sup> 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 and salary income (i.e., *wagp*) 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 presence of outliers and the topcoding (or censoring) of both incomes (i.e., *wagp* and *semp*), particularly for dentists. First, a few individuals report implausibly high earnings relative to their hours of work, which would affect the estimated mean and variance of hourly earnings. We deleted observations whose hourly earnings were in the top 0.5 percent for each occupation. As a result, the highest hourly earnings were in the range of two times of the top coded hourly earnings. We computed the top coded hourly earnings (also top coded hourly *wagp*

and semp) assuming that the top coded individuals worked for 40 hours and 52 weeks in a given year. For individuals who had wagp (semp) only, we assigned the top coded hourly wagp (semp) as their hourly earnings. For individuals who had both wagp and semp and the sum of hourly wagp and hourly semp was greater than the higher of the top coded hourly wagp and the top coded hourly semp, we assigned the higher of the top coded hourly wagp and the top coded hourly semp as their hourly earnings.

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 using hourly earnings adjusted by a factor of 1.4.

For individuals who reported implausibly low earnings, we deleted these observations with measured hourly wages below the federal minimum wage of \$5.15 during 2001–2007.

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: Drop individuals whose hourly earnings belong to the top 0.5%.	-30	-37
Selection rule 7: Hourly earnings less than the federal minimum of \$5.15 during 2001–2007	-73	-59
Total observations	5,886	7,220



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 (0.037)	0.007 (0.038)	0.005 (0.038)	-0.005 (0.036)	-0.005 (0.036)	-0.005 (0.036)
State Median Household Income (/1,000)	-0.070** (0.022)	-0.066** (0.022)	-0.069** (0.022)	-0.065** (0.022)	-0.065** (0.022)	-0.065** (0.022)
Rate of Uninsured	-0.034 (0.026)	-0.029 (0.025)	-0.032 (0.025)	-0.024 (0.026)	-0.024 (0.026)	-0.024 (0.026)
Constant	5.227*** (1.307)	5.301*** (1.322)	5.240*** (1.312)	4.795*** (1.330)	4.346** (1.362)	4.833*** (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		0.095 (0.065)		-0.105** (0.035)		0.064 (0.039)		-0.257*** (0.044)
Self-Employment Allowed $_{t-1}$	0.024 (0.021)	-0.039 (0.044)	-0.597*** (0.040)	-0.528*** (0.045)	0.023 (0.027)	-0.008 (0.030)	-0.124*** (0.032)	0.004 (0.036)
<i>R</i> -squared	0.173	0.173	0.121	0.121	0.214	0.215	0.239	0.246
<i>N</i>	5,406	5,406	6,571	6,571	250	250	250	250
<i>F</i> -test		1.48		111.88***		1.53		21.45***

*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 \*\*\*  $p < 0.001$ .