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ABSTRACT

We examine the labor market impact of states easing occupational license requirements by expanding the scope of practice (SOP) for nurse practitioners (NPs), allowing them to practice without physician oversight. Using data on job postings, we find that employers increase their demand for NPs when states expand NP SOP. We then show that SOP laws also increase NP earnings and reallocate NPs across the healthcare sector, including increasing self-employment. The laws only mildly increase employment, however. Therefore, expanding NP SOP has the potential to increase access to primary care, but inelastic NP labor supply has largely prevented this from occurring.

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1 Introduction

Approximately one-quarter of all U.S. workers are employed in occupations that require them to obtain a government-issued occupational license.[1] Despite the high prevalence of licensing, the effect of occupational licensing on market efficiency and outcomes remains unclear and likely varies across settings. Occupational licenses may harm market outcomes because obtaining a license is costly and thus, they create barriers to entry that limit the supply of workers—raising workers' wages, limiting output, and increasing consumer prices. However, occupational licenses could improve market outcomes because the requirements associated with obtaining a license help ensure some minimum level of service quality, which could increase consumer demand if there is customer uncertainty about service quality (Kleiner 2000).[2] In this regard, the benefits of licensing will be larger when service quality varies a lot across providers, when informational asymmetries about quality are high, or when the costs/benefits of service quality are substantial. Thus, the debate about occupational licensing often boils down to comparing the service quality improvements associated with licensing with the distortions created in the labor and product markets that result (Cramer and Krueger 2016).

Occupational licensing is particularly common in the healthcare sector, where more than 70 percent of health care practitioners are required to be licensed.[3] The ubiquity of licensing in the healthcare sector likely stems from the importance of providing quality healthcare services, the potential for large differences in service quality across providers, and the high degree of patient uncertainty about provider quality. Indeed, there is evidence that requiring healthcare providers to be licensed improves patient safety (Anderson et al. 2020). That said, excessive licensing in the healthcare sector could unnecessarily limit access to medical

[1] An occupational license is a license that allows an individual to engage in paid employment in their particular profession. This statistic on the prevalence of occupational licenses in the U.S. labor market comes from the authors' analysis of the 2019 Basic Monthly Current Population Survey (Flood et al. 2022).

[2] Certifications are another way that the government can offer some quality control in a marketplace. Occupational licenses differ from certifications in that only licensed workers can be employed in occupations that require licenses while anyone can work in an occupation that has certifications (whether they have the certification or not). From a consumer's point of view, licensing requires the consumer to purchase the service from a licensed provider while certification gives consumers the option of buying from a certified provider or not. See Kleiner (2000) for more details on this distinction.

[3] This statistic comes from the authors' analysis of the 2019 Basic Monthly Current Population Survey.

care and contribute to rising healthcare costs (Kleiner and Park 2010; Wing and Marier 2014; Timmons 2017)—two problems that continue to plague the sector. Occupational licenses in the healthcare sector are also characterized by a clearly delineated "scope of practice" (SOP), which describes the set of actions that an occupational license allows the relevant healthcare provider to legally perform. Indeed, the debate regarding occupational licenses in the healthcare sector is rarely about whether these professions should be licensed or not, but more often about where the lines associated with SOP rules should be drawn—balancing patient safety concerns with the broader goal to expand healthcare access and lower healthcare costs.

In this paper, we study the healthcare labor market impacts of states expanding nurse practitioners' (NPs) scope of practice and allowing them to provide care without direct physician oversight ("full NP SOP").[4] This paper fits into a broad literature evaluating the costs and benefits of restrictive occupational licensing rules and their impact on outcomes in the healthcare sector. This literature can be broken up into two lines of inquiry: (a) the impact of restrictive SOP rules on health outcomes and (b) the impact of restrictive SOP rules on healthcare costs and access. Both are important when considering whether to ease or tighten SOP rules. However, this study analyzes the latter.

In terms of health outcomes, physician organizations, in particular, have championed restricting the scope of practice for non-physician healthcare occupations and argue that expanding the scope of practice of non-physician providers harms patients' health.[5] However, the evidence for this assertion with respect to full NP SOP is mixed. Most studies find that the adoption of full NP SOP either improved or did not impact patient outcomes. Alexander and Schnell (2019) find that full NP SOP is associated with improvements in self-reported mental health and decreases in mental health-related mortality; Traczynski and Udalova (2018) find that full NP SOP is associated with improvements in self-reported health and decreased emergency room usage; and Kleiner et al. (2016) find that full NP

[4]Oversight in this context can take a variety of forms ranging from the co-provision of a given service to periodic reviews of NP care delivery and decision-making.

[5]For example, see "Why Expanding APRN Scope of Practice Is Bad Idea," by American Medical Association (AMA) reporter Andis Robeznieks, posted to AMA website on 10/30/20.

SOP did not impact the quality and safety of health services.[6] That said, Chan and Chen (2022) find that NPs in Veteran Health Administration emergency departments increase resource utilization and achieve worse health outcomes for their patients than physician providers.[7] Thus, the impact of full NP SOP on patient outcomes remains an open and important question for future research, where the impact could differ by the type of care provided, e.g. primary care versus emergency care.

The literature on the impact of full NP SOP on healthcare costs and access is more consistently supportive of the policy in terms of lowering healthcare costs and increasing healthcare access. In terms of impacts on costs, studies find that expanded NP SOP decreased the transaction price of well-child visits by 3-16 percent (Kleiner et al. 2016) and outpatient care costs for Medicaid recipients by 17 percent (Poghosyan et al. 2019). Relatedly, Perry (2009) and Kleiner et al. (2016) both find that expansion of NP SOP lowered physician earnings and raised NP earnings, suggesting that restraining NP substitutability raises demand for costly physicians, leading to elevated physician salaries and potentially higher primary care spending. In terms of impacts on healthcare access, some studies find that broadening SOP laws for NPs led to increased healthcare access in terms of increased frequency of check-ups (Traczynski and Udalova 2018); greater intensity of care for Medicaid patients (Poghosyan et al. 2019); and increased hours worked for NPs (Luo et al. 2021, Markowitz and Adams 2022).[8] However, none of these effects are particularly large and some studies find no measurable impact on access. For example, Smith (2022) examines services provided by NPs in primary care practices and finds no effect of full NP SOP on the volume of patients seen or the types of services provided by NPs. Thus, the estimated impacts of easing SOP rules on access are somewhat more muted than what one might expect.

[6]Expanded SOP for other healthcare occupations has also shown no negative effects on health outcomes. For example, Markowitz et al. (2017) find that expanding SOP laws for certified nurse midwives did not impact maternal or infant health outcomes.

[7]An important difference between Chan and Chen (2022) and the existing literature is that they do not evaluate the impact of changes in SOP laws, but instead compare outcomes across providers in a setting with full SOP for NPs.

[8]Alexander and Schnell (2019) find that the positive mental health effects associated with expanded NP SOP tend to be stronger in areas (and among populations) traditionally underserved by physicians, which is suggestive of increases in access to healthcare.

Our paper examines the impact of full NP SOP on healthcare costs and access through the lens of the healthcare labor market. We advance the literature by exploring the underlying causes of the equilibrium labor market outcomes observed in much of the existing literature. In particular, we examine both theoretically and empirically the extent to which the equilibrium adjustments are being driven by changes in labor demand and/or labor supply. This distinction is important because it allows us to better understand the market for primary care and why easing SOP rules affects some equilibrium outcomes but not others. For example, the relatively small and at times non-evident impact of full NP SOP on healthcare access could be because consumers or firms do not view NPs as actual substitutes for primary care physicians (small increase in NP labor demand), because NP labor supply is slow to respond to the policy change (either small increases in NP labor supply or an inelastic NP labor supply curve), or because the increased usage of NPs cannibalizes the usage of other healthcare professionals (either decreased labor demand or supply of other healthcare professions). Any of the above are possible, but they imply different policy remedies if SOP rules are going to achieve their full potential and help increase healthcare access and lower costs.

We first develop an equilibrium model of primary care to examine how SOP changes impact the labor demand and labor supply for NPs and other healthcare professionals. The model highlights that the equilibrium labor market adjustment stems from a resulting increase in labor demand for NPs and an ambiguous effect on NP labor supply, where the magnitudes of the equilibrium effects may differ across place of service and may change as one moves from the short-run to the long-run. Using a difference-in-differences research design over the period 2010-2019, we then test the empirical implications of the model and assess the magnitudes of the labor market adjustment using data on job openings from Burning Glass Technologies (BGT) and data on equilibrium labor market outcomes from the American Community Survey (ACS). Following many studies, we interpret the BGT job posting data as a measure of labor demand.[9] Therefore, our analysis of the BGT data allows us to assess how full NP SOP affects labor demand for NPs and other healthcare

[9]See Lazear and Spletzer (2012), Faberman and Mazumder (2012), Deming and Kahn (2018), Hershbein and Kahn (2018), and Dillender (2022), among others

occupations. We are then able to back out the likely labor supply response given our BGT results and the changes in equilibrium outcomes we estimate in the ACS.

We find that full NP SOP increases the number of job postings for NPs without affecting the number of job postings for primary care physicians (PCPs), physician assistants (PA), registered nurses (RN), or licensed practical nurses (LPN). The estimated effect is quite large with job postings for NPs increasing by about 30 percent. However, the effect occurs with a lag and only becomes evident beginning two years after SOP adoption. Interestingly, demand for NPs increases by similar proportions in both health professional shortage areas (HPSA) and non-HPSAs. Moreover, we do not find that expanded SOP substantively changes the skill demands listed in NP job postings. Thus, the more favorable regulatory environment did not lead to different types of NPs being desired by employers or alter employers' expectations about the tasks NPs would perform. Rather, the increase in job postings simply appears to reflect an overall increase in demand for NPs.

We then examine how this change in labor demand manifests into equilibrium outcomes for healthcare workers in the ACS including earnings, total employment, and other employment outcomes such as hours worked and employment across place of service. We find that the adoption of full NP SOP increases NP earnings but has only a small effect on NP employment: not changing total NP employment but causing relatively small increases in hours worked for NPs that are most evident when we examine the full-time/part-time margin. Expanded NP SOP also appears to reallocate NP employment across the healthcare industry, increasing self-employment among NPs and shifting the employment of NPs away from hospitals and towards outpatient care centers. This reallocation could be associated with an increase in the number of NPs engaged in primary care, but we do not have the relevant data to make this case definitively. We find no impact on the earnings and employment outcomes for any other adjacent healthcare occupations.

Equipped with estimates of both the labor demand response and the equilibrium outcomes for NPs, we infer the labor supply effects. We find both increases in NP labor demand (from the BGT data) and sustained increases in NP earnings (from the ACS data). We also observe no significant changes in overall NP employment and relatively small increases in hours worked. If full NP SOP led to substantial increases in NP labor supply, the persistent

earnings gains would be much less evident. Moreover, the timing of the employment effects in the ACS—with hours worked and the reallocation of workers across the healthcare sector largely occurring more than two years after full SOP adoption—line up well with the increased job posting in the BGT data. Thus, little in our equilibrium results (when analyzed relative to the demand effects) suggests a large increase in labor supply. Moreover, the sustained increase in earnings with relatively small changes in employment suggests that NP labor supply is highly inelastic, at least in the short-run when the high time costs to become an NP largely limit the employment response to intensive margin adjustments.[10]

Our work makes important contributions to the literature on occupational licensing in the healthcare industry—further highlighting that it is not just the license itself but also restrictions within the license that matter, affecting labor and product market outcomes. We expand upon the analysis in Kleiner et al. (2016) and other studies exploring the labor market effects of full NP SOP by disentangling equilibrium outcomes into effects on labor demand and labor supply. This allows us to better understand why some equilibrium outcomes occur but others do not. Our results imply that expanding SOP for NPs increases labor demand for NPs (without affecting the demand for other healthcare occupations) and thus, has the potential to increase the number of primary care providers and increase access to primary care. However, we find that inelastic labor supply for NPs is largely preventing this from occurring. Therefore, states that want to use expanded SOP to increase healthcare access should think about combining this policy, which substantially increases the demand for NPs, with other workforce promoting policies that help produce a larger supply of NPs such as expanding training programs or subsidizing tuition for NPs that agree to practice within the state for a specified period of time.

2 Scope of Practice Laws for NPs

The nurse practitioner profession began with a certificate program in the 1960s that aimed to provide nurses with the training to perform more healthcare tasks in response to concerns

[10] All newly licensed NPs have at least a master's degree and advanced clinical training beyond their initial professional RN training.

about healthcare capacity that arose as the creation of Medicaid and Medicare increased demand for medical care (IOM 2010). Since the 1960s, the number of NPs in the United States has grown. As of 2017, there were about 200,000 practicing NPs (in terms of full-time equivalents) and NPs represented the fastest growing type of primary care provider in the United States (Auerbach et al. 2020).

As with many healthcare professions, NPs must obtain a license to practice. Thus, NP licensure rates are extremely high. According to 2015 to 2019 Basic Monthly Current Population Survey data (Flood 2022), roughly 91% of workers employed as NPs report having a license with little variation in rates across states.[11] NP occupational licenses are also governed by SOP laws that describe the set of actions that their license allows them to legally perform. SOP laws for NPs vary across states and largely govern the types of tasks for which NPs need physician oversight to perform. States with restrictive NP SOP laws require NPs to have formal agreements with physicians to oversee the care NPs provide. Depending on the state, NPs may need some version of physician involvement to prescribe medications, to order tests, and/or to admit patients to the hospital. In contrast, states with full practice authority for NPs allow NPs to practice without any degree of formal physician oversight or involvement in NP care delivery.

State legislatures have recently taken greater interest in NP SOP rules, with several states eliminating the need for any physician oversight. Specifically, from 2013 to 2017,

[11]Reported licensure rates are 87% for MDs, 84% for RNs, 68% for LPNs, and 84% for PAs. Moreover, the variation in licensure across states also tends to be smaller for healthcare occupations than for non-healthcare occupations. While the mean of the coefficients of variation in licensure rates across states for all occupations is 0.70, the coefficient of variation across states is 0.08 for NPs, 0.05 for MDs, 0.05 for RNs, 0.14 for LPNs, and 0.14 for PAs. Thus, licensure is extremely common in all states.

nine states implemented laws to grant NPs full practice independence ("full SOP").[12] Table 1 shows the states expanding SOP for NPs to full SOP during our study period along with the dates the laws became effective. Our analysis of SOP policy changes draws from multiple sources, including our own reading of the laws as well as McMichael and Markowitz (2021). As of 2020, nearly half of all states have granted full SOP to NPs.[13] Purported reasons for the expansion of SOP include: meeting increased healthcare demand due to the Affordable Care Act's (ACA) insurance expansions, reducing healthcare costs, and aligning NPs' capabilities with their SOP.[14]

3 Theoretical Model

We next model the ways in which a state expanding NP SOP to allow NPs to practice without physician oversight can alter the labor demand and labor supply for NPs and other healthcare professionals.[15] We then trace out how these changes in supply and demand could alter equilibrium outcomes for impacted workers.

[12]Three other states adopted full SOP over the 2011-2019 period. North Dakota and Vermont adopted full NP SOP in 2011. Thus, they are considered "always treated" in our analysis. Illinois adopted full SOP on January 1, 2018. However, there was a 1.5 year delay while the state finalized its administrative rules (https://www.americanmedspa.org/news/456401/Illinois-Adopts-Rules-for-Full-Practice-Authority-for-APRNs.htm, last accessed 11/3/21). Thus, Illinois is considered a control state for the job posting analysis, which runs through June 2019, and a treatment state in the ACS, which runs through 2019. Four other states had NP SOP rule changes over the sample period. Oregon and Rhode Island had a small policy changes in 2013, but both have long been full SOP states. Utah experienced a small change in 2016 but did not adopt full NP SOP until March 2023 (https://nurse.org/articles/utah-nurse-practitioner-full-practice-authority/, last accessed 7/28/23). Lastly, Virginia adopted legislation allowing NPs to work without a collaborative practice agreements in 2019, but the rule change falls short of full NP SOP as evidenced by the American Association of Nurse Practitioners continued classification of Virginia NP SOP rules as "restricted" (https://www.aanp.org/advocacy/state/state-practice-environment, last accessed 7/28/23).

[13]Prior to 2013, the following states had already adopted NP Full SOP: Alaska, Arizona, Colorado, the District of Columbia, Hawaii, Idaho, Iowa, Maine, Montana, New Hampshire, New Mexico, North Dakota, Oregon, Rhode Island, Vermont, Washington, and Wyoming.

[14]In response to healthcare needs arising from COVID-19, a majority of the states that had not already granted nurse practitioners full practice authority temporarily expanded nurse practitioners' SOP. Some stakeholders have since pushed for these temporary expansions of nurse practitioner SOP to become permanent (National Academies of Sciences, Engineering and Medicine 2021).

[15]See Markowitz and Adams (2022) for an alternative discussion of the ways in which expanded NP SOP could impact labor supply for NPs.

3.1 Labor Demand

Suppose that primary care (Y) is produced using three kinds of labor that are differentiated by the degree of formal training—low, medium, and high—required to be licensed for and work in the position. In this set-up, NPs would represent healthcare workers with a medium level of formal training (H_M) while physicians would represent workers with a high level of formal training (H_H) and other healthcare professions such as LPNs would represent workers with a low level of formal training (H_L). If we then abstract from capital in the production process, we can express the primary care production function using the following general expression: $Y = f(H_H, H_M, H_L)$.

Prior to full SOP adoption, NPs require physician oversight, which implies at least some degree of complementarity between NPs and physicians in the production of primary care. If we model this relationship as perfect complements and further differentiate between physicians engaged in primary care (H_H^p) and physicians engaged in NP oversight (H_H^o), we can rewrite the production function as: $Y = f(H_H^p, \min(H_M, \alpha H_H^o), H_L)$, where α represents the number of NPs a physician can oversee in any given time period.[16] Under this set-up, the firm's profit is:

$$\pi = p_Y f(H_H^p, \min(H_M, \alpha H_H^o), H_L) - w_H H_H - w_M H_M - w_L H_L,$$

where p_Y is the price of primary care, w_k is the wage paid to worker in job k, and $H_H = H_H^p + H_H^o$. Because a profit maximizing firm always sets $H_M = \alpha H_H^o$, we can rewrite the profit function as:

$$\pi = p_Y f(H_H^p, H_M, H_L) - w_H H_H^p - w'_M H_M - w_L H_L$$

where $w'_M = w_M + \frac{1}{\alpha} w_H$ is the full cost of hiring a nurse practitioner, i.e. the NP wage rate plus the costs associated with physician oversight.

To solve for the labor demand expressions, we simply take the three first order conditions,[17] and then substitute the expression for w_H from $\frac{\partial \pi}{\partial H_H^p}$ into $\frac{\partial \pi}{\partial H_M}$. The inverse labor demand expression for NPs becomes:

[16] It is assumed $\alpha > 1$ or else nobody would ever use NPs for primary care. This production function is similar to the production function in Aaronson and Phelan (2019).

[17] (1) $\frac{\partial \pi}{\partial H_M} = p_Y f_{H_M} - w_M - \frac{w_H}{\alpha} = 0$; (2) $\frac{\partial \pi}{\partial H_H^p} = p_Y f_{H_H^p} - w_H = 0$; and (3) $\frac{\partial \pi}{\partial H_L} = p_Y f_{H_L} - w_H = 0$.

$$w_M = p_Y(f_{H_M} - \frac{f_{H_H^p}}{\alpha}),$$

where f_{H_k} represents the partial derivative of the production function with respect to labor type k. Thus, prior to the adoption of full SOP, the marginal revenue product (MRP) of hiring a NP is the MRP associated with the new production from the new NP minus the lost productivity of pulling a physician out of primary care (for $\frac{1}{\alpha}$ units of time) and requiring them to oversee the NP.[18] After states adopt full SOP, however, NPs no longer need to be overseen by physicians, which can be expressed in the existing framework as $\alpha \to \infty$. Then, under full SOP the labor demand function becomes: $w_M = p_Y f_{H_M}$. Thus, labor demand for NPs unambiguously increases when states adopt full SOP.[19]

In the model, the magnitude of this increase in demand for NPs is an increasing function of the lost productivity of having physicians engage in oversight ($\frac{f_{H_H^p}}{\alpha}$). This lost productivity and thus, increased demand for NPs following the adoption of full NP SOP could vary across place of service and geographic areas if the cost of physician oversight systematically varies across these dimensions. For example, physician oversight may be easier and thus, cheaper (i.e. high α) when physicians are more plentiful because an ample supply of physicians could ensure that one was always available to provide oversight. Physician oversight might also be cheaper when employers employ numerous NPs as this would allow a physician to specialize in oversight.[20] In both of these scenarios, larger employers would experience lower costs of physician oversight and thus smaller increases in demand from full SOP adoption. For the opposite reasons, smaller employers likely experience larger increases in NP demand following full SOP adoption. The extreme example is NP self-employment. Prior to expanded SOP, NPs interested in self-employment fully bear the additional costs

[18] Another way to interpret $P_Y \frac{f_{H_H^p}}{\alpha}$ is that it is the "collaborative practice agreement fee" that NPs frequently have to pay to compensate a physician supervisor. Under that scenario, NPs would be paid w'_M and they would remit $\frac{1}{\alpha} w_H$ to their supervising physician. However, it is also possible that the employer pays for the cost of physician oversight. In that instance, NPs would be paid w_M and the employer pays the supervising physician $\frac{1}{\alpha} w_H$ for providing oversight. In terms of the analysis that follows, it doesn't matter who pays the supervising physician, NP or employer, as it implies the same impact on NP labor demand.

[19] Interestingly, the model implications are similar if the NP labor market is monopsonistic. However, the increase in demand from full NP SOP ($w'_M - w_M$) will be smaller if firms have market power. See Appendix B for a more complete derivation.

[20] A final way in which α might differ across place of service is if NPs differ in the extent to which they engage in providing primary care (as opposed to other RN-type services) across place of service. For example, if NPs are less likely to provide primary care at hospitals than at physician offices, then the labor demand effect will be smaller at hospitals.

to establish a formal arrangement with one or more physicians to satisfy the oversight requirements under restrictive SOP laws. Thus, we would expect full SOP adoption to lead to sizable increases in self-employment among NPs, but also larger increases in demand at smaller employers.

The production function also implies that this increase in demand for NPs from full SOP is likely to spillover and alter the labor demand for other healthcare occupations including both H_H and H_L. This spillover comes from the change in NP wages (w_M) that occurs when NP labor demand increases. However, the net effect on demand for H_H and H_L depends on the magnitude of the equilibrium labor market change for NPs and the extent to which H_H and H_L are gross substitutes or gross complements with H_M. Thus, the signs and magnitudes of these spillover effects are an empirical question.

3.2 Labor Supply

Easing SOP rules can also affect NP labor supply. Suppose individuals maximize utility, which is a function of market consumption (C) and leisure time (L), subject to both a budget and a time constraint. In the model, individuals choose how to allocate their time endowment (T) between labor (H) and L, where the choice of H implies some level of C given wages, preferences, and T. We then extend this neoclassical model in two ways. First, we incorporate occupational choice into the model where workers can choose between three healthcare occupations, which differ in the degree of formal training (low, medium, and high) required to be licensed in these professions. This allows healthcare workers to trade-off licensing costs (I_k) to enter occupation k against the wages associated with employment, where $w_H > w_M > w_L$ but also $I_H > I_M > I_L$. Second, we alter the utility function, allowing workers to experience disutility from work, where the disutility, $v(H_k, \gamma_k)$, is increasing in hours of work (H_k) and the level of oversight (γ_k) at occupation k. This set-up implies the following utility function and time and budget constraints:

$$\text{Utility Function: } U(L, C) = g(L, C) - v(H_k, \gamma_k)$$
$$\text{Time Constraint: } H_k + L = T$$
$$\text{Budget Constraint: } C = w_k * H_k - I_k.$$

To solve the optimization problem, first recognize that utility maximizing workers will specialize in one of the three occupations because there is is no benefit to occupational variety that offsets the cost of becoming licensed in separate occupations. Thus, one can write down the Lagrangian for each occupation after substituting the time constraint into the budget constraint and the utility function:

$$\max \mathcal{L}(L, C, \lambda) = g(L, C) - v(T - L, \gamma_k) + \lambda[w_k T + N - I_k - C - w_k L].$$

Then, one can solve for optimal L and C associated with each occupation, where optimal L for each occupation implies an optimal H_k from the time constraint. The individual then chooses the occupation with the highest utility among the three occupations. This set-up implies that the labor supply H_k for occupation k is:

$$H_k = z(w_k, \gamma_k, I_k, w_{-k}, \gamma_{-k}, I_{-k}, T, g(), v()),$$

where w_{-k},γ_{-k},I_{-k} represent the wages, level of oversight, and licensing costs at other healthcare occupations.

Given this set-up, the adoption of full NP SOP could alter the labor supply curve for NPs in three distinct ways. The primary mechanism is through the level of oversight γ_M. Suppose the level of oversight, γ_k, is an increasing function of general managerial oversight, which is necessary for all professions (ξ_k), and the degree of direct clinical oversight, which is only necessary for NPs. From the labor demand analysis above, we know that prior to full SOP physicians oversee NPs for $\frac{1}{\alpha}$ of each unit of time, with $\alpha > 1$. Thus, the level of oversight at each occupation can be expressed as the sum of managerial oversight and clinical oversight, i.e. $\gamma_k = \xi_k + \mathbb{1}[H_M > 0]\frac{1}{\alpha}$, where $\mathbb{1}[H_M > 0]$ is an indicator for working as an NP. As in the labor demand analysis, the adoption of full SOP can be expressed as $\alpha \to \infty$. As a result, γ_M falls, decreasing the disutility of being an NP and increasing NP labor supply.[21]

[21]Interestingly, γ_M and γ_L are unchanged by full SOP adoption as only NPs experience clinical oversight in the model. Moreover, the impact on physicians, who no longer have to oversee NPs would represent a labor demand effect as there is nothing in the utility function that says physicians prefer clinical tasks to oversight/managerial tasks. That said, there could be spillover effects on the labor supply for other healthcare professions, but this would come via w_{-k}, γ_{-k}, and I_{-k}. Like the labor demand spillover effects, the spillover labor supply effects are ambiguous.

Full SOP can also alter the labor supply of NPs via its effect on licensing costs (I_k) and wages at other professions (w_{-k}). States that adopt full SOP for NPs often increase the hours of supervised work NPs need to be licensed and practice independently.[22] This represents an increase in NP licensing costs (I_M) and could actually decrease NP labor supply. The adoption of full NP SOP can also impact the labor supply curve for NPs via its effect on wages for other healthcare occupations. While the equilibrium wage effects at other occupations are ambiguous (see demand discussion above), if wages decrease at other healthcare occupations, then labor supply for NPs will increase and vice versa.

Taken together, the overall impact of full NP SOP on the NP labor supply curve for NPs is ambiguous. Moreover, the impact might differ in the short-run and long-run. For example, eliminating physician oversight might cause existing NPs to increase hours worked (intensive margin) via its impact on γ_M. However, if prospective NPs value working independently, it might also increase the number of people who enter the NP profession (extensive margin). Since the time costs of becoming a NP are substantial (requiring a masters degree and advanced clinical training), the extensive margin labor supply adjustment may not occur for several years. However, extensive margin adjustments could also come about via interstate migration.

3.3 Equilibrium

The theoretical model laid out above describes various channels through which the adoption of full NP SOP alters the labor demand and supply for NPs. Full SOP causes an unambiguous increase in NP labor demand and an ambiguous impact on NP labor supply. The overall equilibrium impacts will depend on which channels dominate. NP employment would be expected to rise so long as any increased licensing costs for NPs are small. The wages of NPs would be expected to rise as long as NPs' disutility of physician oversight is of second order importance. The equilibrium effects on the wages and employment of other

[22]For example, with the adoption of full NP SOP, Connecticut now requires NPs to work under the supervision of a physician for at least three years and at least 2000 hours before they can gain full independence. Virginia's law in 2018 went even further and required NPs to obtain 9000 hours of supervised work before they could practice without a collaborative practice agreement. Another way in which these law changes could impact NP labor supply is that some employers that previously used NPs may now be hesitant to hire new NPs as they expect many will leave once they are fully trained and able to practice independently.

occupations depend on whether these occupations are net complements or substitutes of NPs as well as the equilibrium impacts on NPs.

Arriving at the new equilibrium may take several years. This slow adjustment process comes from different short-run and long-run impacts on NP labor supply. As discussed above, obtaining the education and licensing to be an NP takes several years. Therefore, extensive-margin supply responses to expanded NP SOP—regardless of whether they stem from shifts in the labor supply curve or movements along the supply curve—may be slow to manifest. Additionally, new entry into the NP workforce may be largely limited to new career entrants as many non-NP healthcare workers will have already paid the fixed costs of entering other occupations (in terms of obtaining training and licenses) and have fewer years of work left to benefit from a costly occupational transition. However, some more-immediate labor supply responses are possible if full SOP adoption induces NPs to move across states (extensive margin) or causes existing NPs to work additional hours (intensive margin).

The slow equilibrium adjustment process could also come from delayed changes in labor demand. While NPs are no longer required to have physician oversight once full NP SOP is adopted, patients may not immediately accept NPs as equivalent providers and thus, employers may be slow to embrace full NP SOP. Additionally, even if employers want to use NPs to expand their practice, it may take time to build up the patient demand to justify a new hire.

This uncertainty about equilibrium outcomes for NPs and other healthcare professionals—with full NP SOP potentially affecting both labor demand and labor supply—suggests that a deeper empirical exploration of the topic and its impacts on labor demand and supply is warranted, including examining variation in effects over time, across place of service, and across geographic areas.

4 Data

Our empirical analyses use data from two different sources: data on job vacancy postings collected and distributed by Burning Glass Technologies (BGT) and data on the labor mar-

ket outcomes of healthcare workers from the American Community Survey (ACS). Below, we describe each of these data sources.

4.1 Burning Glass Technologies

Burning Glass Technologies (BGT) collects data on job posting from approximately 40,000 online job boards as well as company websites using a proprietary web-scraping procedure that removes duplicate job postings. For each job posting, BGT collects information about the occupation, desired applicant qualifications including skills, employer characteristics, the job location, and a precise calendar date associated with the posting (among other job characteristics). As such, the BGT database aims to be a near-universe of online job postings, with the company advertising that the data can be used to provide real time analysis on job growth, skill demands, and labor market trends. The BGT data, which are increasingly used in contemporary studies to capture important elements of labor demand (Lazear and Spletzer 2012; Faberman and Mazumder 2012; Deming and Kahn 2018; Hershbein and Kahn 2018; Dillender 2022), are an excellent data source to assess how expanding NP SOP affects the labor demand for NPs and other healthcare occupations.[23]

We use the BGT data on all vacancies posted online from January 2011 through June 2019 with a work location in one of the 50 US states or the District of Columbia. We then limit the data to job postings for the following healthcare occupations using the Standard Occupation Classification (SOC) codes: nurse practitioners (NPs), primary care physicians (PCPs), registered nurses (RNs), licensed practical and licensed vocational nurses (LPNs), and physician assistants (PAs).[24]

Our empirical analysis of the BGT data focuses on two main outcomes: the total number of job postings and the share of job postings that mention specific skills (both of which we aggregate to the state-quarter-year level for each occupation). These variables allow us to assess whether expanding NP SOP impacts overall labor demand for different healthcare occupations and whether employers respond to expanded NP SOP by demanding workers

[23]As of 2016, BGT estimates that it captures roughly 85 percent of job openings (Hershbein and Kahn 2018). Because most healthcare employers post job advertisements on their websites, this share is even higher for the healthcare sector (Lancaster et al. 2019).

[24]PCPs include family and general practitioners, general internists, and general pediatricians.

with different types of skills. While the skills included in the BGT data are too numerous to analyze individually, we group the skills into the following eight skill groupings: general healthcare skills, specialized healthcare skills, emergency healthcare skills, mental healthcare skills, healthcare support skills, leadership skills, office support skills, and other skills. Appendix Table A1 presents the mapping between the 574 BGT skills, which BGT refers to as skill clusters, and our eight derived "skill groupings."

Table 2 presents occupation-specific summary statistics for the average number of job postings per quarter as well as the growth in the number of postings from 2011 to 2018 (i.e., the full-year endpoints for our analytic window). As shown, while NPs are one of the smaller healthcare occupations (of those included in our analysis), they are one of the fastest growing over the most recent decade in terms of the number of job postings. This is consistent with Auerbach et al. (2020). The table also presents summary statistics on the skills demanded in these job postings using our skill groupings. For NPs, the most frequently mentioned skills in job postings include general care skills (62 percent of postings), healthcare support skills (47 percent of postings), and specialized care skills (41 percent of postings).[25] Reassuringly, the skills demanded for other healthcare occupations are largely in line with what one would expect. For example, general care skills are the most frequently mentioned skill for PCPs (74 percent of postings) while healthcare support skills are the most frequently mentioned skills for RNs and LPNs, 59 and 69 percent, respectively.

4.2 American Community Survey

We also analyze the effect of SOP laws on the labor market outcomes of NPs and other healthcare professionals using the American Community Survey (ACS). The ACS is a household-based survey administered by the US Census Bureau that collects economic and demographic information on one percent of the US population each year. While the survey is not specifically designed to analyze outcomes of healthcare workers, the large sample size and extensive labor market information make it a good data source to study the impact

[25]This description excludes "Other Skills," which are largely composed on an unspecified skill ("na") in the BGT database. For example, "na" makes up 56 percent of all "Other Skills" for NPs and an identical percentage for PCPs.

of NP SOP.[26] Our ACS analysis complements the analyses of the BGT data because it allows us to assess how the change in labor demand (evident in job postings) manifests itself in terms of equilibrium labor market outcomes, including earnings, hours worked, overall employment, self-employment, and employment across the healthcare sector.

Table 3 presents summary statistics by occupation on the sample of healthcare workers aged 25-60 over the 2010-2019 analysis period from the ACS.[27] The specific occupations we analyze are very similar to the BGT analysis and include NPs, physicians, RNs, LPNs, and PAs. However, the SOC codes used by the Census Bureau in the ACS are slightly more aggregated for NPs and physicians than in the BGT data.[28] The sample includes 12,182 NPs as well as 68,755 physicians (MDs), 244,231 RNs, 63,050 LPNs, and 9,298 PAs.[29] Relative to MDs, NPs are more likely to be female, non-immigrants, and white. They are also much less likely to be self-employed than physicians (three versus 18 percent). When we classify healthcare workers' place of employment using Census Industry Codes, we see that the industrial employment of NPs (like MDs, PAs, and RNs) is highly concentrated in hospitals (40 percent) and physicians' offices (26 percent). One difference is that NPs are much more likely to work in outpatient care centers than MDs or RNs (16 percent versus six and five percent, respectively). After these three industries, the employment of NPs is fairly dispersed with colleges and universities representing the next most common place of employment at two percent.

[26]Kleiner et al. (2016) also use the ACS to examine the impact of full NP SOP (over an earlier period 2001-2013) on the earnings of healthcare workers. In pre-2010 ACS data, the occupations were more aggregated than they currently are—with NPs combined with RNs, nurse anesthetists, and nurse midwives. Auerbach et al. (2020) also use the ACS to document trends in NP employment over 2010-2017.

[27]Following Goodman-Bacon (2021), we exclude observations from those states that had previously expanded their NP SOP prior to the start of the 2010-2019 period including the two states that adopted in 2011: Vermont and North Dakota. Thus, our control group represents states without expanded NP SOP. See footnote 13 for a complete list of these 17 "always treated" states.

[28]The nurse practitioner occupation code in the publicly available ACS data also includes nurse midwives. Additionally, the physician and surgeon occupation codes are combined in the ACS. The inclusion of nurse midwives and surgeons is unlikely to have a large effect on our estimates. According to the 2019 Occupation Employment and Wage Statistics (OEWS), nurse practitioners made up almost 97 percent of the combined nursing SOCs and non-surgeon physicians made up more than 95 percent of the combined physician SOCs nationally.

[29]Physicians can be doctors of medicine (MDs) or doctors of osteopathic medicine (DOs). We use the term MD as shorthand for physician for simplicity and because more than 90 percent of physicians are MDs rather than DOs.

Table 3 also provides summary statistics on employment and earnings by occupation. In terms of employment, 86 percent of NPs are employed full-time while 12 percent are employed part-time and 2 percent have not worked in the previous year.[30] Looking at weekly hours worked, the average NP worked 39.9 hours per week, with full-time employed NPs working an average of 42.7 hours and part-time employed NPs working an average of 26.5 hours. These numbers do not appreciably differ across full SOP adopting and never adopting/control states. Thus, a vast majority of NPs are already working full-time and the scope for intensive margin employment adjustments for NPs (following full NP SOP adoption) is limited.

Lastly, we present several earnings statistics to show the impact of top-coding and winsorizing of the ACS sample. Earnings data in the ACS are top-coded, where the largest two percent of earners in each state in each year have their actual earnings replaced with the average earnings of the highest two percent in the state-year. Top-coding rarely impacts NPs, RNs, PAs, or LPNs, but 29 percent of physicians have top-coded earnings. In our empirical analysis of earnings, we exclude top-coded earnings observations from the analytic sample because the average earnings levels (associated with top-coded values) may be driven by large earnings levels for other (non-healthcare) occupations. We also winsorize the earnings data, excluding the observations with the highest and lowest two percent of earnings within each occupation-state.[31] As shown in Table 3, this trimming of the sample does not significantly change the average earnings for NPs. Average earnings for full-time, non-top-coded, and winsorized NPs are $93,100. PAs are paid similarly, but physicians are paid about a third more and RNs are paid about a third less.

[30] We define a full-time worker as a worker who worked at least 40 weeks over the past year and averaged at least 30 hours worked per week. A part-time worker worked some hours in the past year. The ACS allows us to identify individuals that have not worked in the previous year because it reports the last occupation employed for non-employed individuals as long as they have worked in the past five years

[31] We later present robustness estimates that include both topcoded and winsorized earnings.

5 Empirical Methodology

5.1 Empirical Approach for Job Vacancies & Skill Demands

We analyze the effects of expanding NP SOP on job vacancies and skill demands in the BGT data using a two-way fixed effects generalized difference-in-differences estimation strategy, which we also adapt to an event study model. We first estimate:

$$Y_{st} = \alpha OneYrPre_{st} + \beta ZeroToTwoYrsPost_{st} + \gamma TwoPlusYrsPost_{st} + \lambda_s + \nu_t + \epsilon_{st}, \quad (1)$$

where $OneYrPre$ represents the period one year prior to policy adoption, $ZeroToTwoYrsPost$ represents the period from adoption up to two years post SOP implementation, and $TwoPlusYrsPost$ represents the period two or more years following SOP implementation. Our regression models, which we estimate separately for our five healthcare occupations, also control for state (λ_s) and quarter-year (ν_t) fixed effects. Information from job listings, which is our outcome Y_{st}, is aggregated to quarter-years by state, where the specific outcomes we examine include the natural logarithm of the total number of job postings, the average number of skills/skill groupings per job posting, and the share of postings mentioning a specific skill grouping. That said, because expanded NP SOP can affect relative demand as well as absolute demand, we also use the ratio of the number of postings for other related healthcare occupations to job postings for nurse practitioners as an outcome variable. This relative-posting approach will also help control for other trends affecting healthcare employment, such as the ACA. The coefficients α, β, and γ are the parameters of interest, where α helps assess the parallel trends assumption and β and γ describe the impact of expanding NP SOP over time.

We then adapt our two-way fixed effects estimation to a full event study framework:

$$Y_{st} = \sum_{j=1}^{J} \alpha_j 1[t - T_s^* = j] + \lambda_s + \nu_t + \epsilon_{st}, \quad (2)$$

where T_s^* represents the time period that state s enacts the full NP SOP policy, $1[.]$ is the indicator function, and the α coefficients are the parameters of interest. The model is

otherwise identical to Equation 1, where we cluster our standard errors at the state level in both sets of estimates.

We are sensitive to the concerns raised in Goodman-Bacon (2021) regarding the potential biases associated with differences in treatment timing. Thus, we drop the always treated states, i.e. those states that had enacted full NP SOP prior to 2011, from our empirical analysis.[32] Moreover, of the nine states that changed their SOP laws during our time period, most did so within a fairly narrow window, five in 2015 alone and seven within the two year period between the middle of 2014 and the middle of 2016 (see Table 1). Later in the paper, we present robustness tests showing the sensitivity of our results to using different subsets of full NP SOP adopting states—including when imposing that our treatment group states implement their policy changes within a common time window.

5.2 Empirical Methods for Labor Market Outcomes

Our empirical approach analyzing labor market outcomes of healthcare workers in the ACS is almost identical to Equation 1 and Equation 2, except that the data are annual and at the individual level. Thus, the time fixed effects are year dummy variables and we include basic demographic controls (X_{ist}) in the regressions. The specific control variables included in X are: a cubic in age and indicators for sex, race, ethnicity, education groupings, and immigrant status.[33] The outcomes we analyze in the ACS are intentionally different and complementary to the insights offered from the BGT data in that they allow us to assess how changes in labor demand inherent in the BGT analysis manifest themselves into equilibrium earnings and employment outcomes for healthcare workers. Specifically, we analyze the effect of full NP SOP on individual earnings, total occupational employment, annual hours worked, full-time/part-time employment probabilities, migrating across state lines, working across state lines, self-employment probabilities, and employment across industries. We weight regressions using the ACS sample weights and, like the BGT analysis, we exclude always treated states and cluster our standard errors at the state-level. We also implement

[32]See footnote 13 for a complete list of these 17 "always treated" states. In robustness estimates, we show that the results are very similar if we include these states in the control group.

[33]In the earnings regression, we also include indicators for weeks employed. The indicators follow the ranges of weeks that are reported in the ACS, where weeks worked is a categorical variable.

the same series of robustness checks for the ACS data (e.g., assessing any influence from differential timing in treatment).

6 Results

6.1 BGT Analysis

Table 4 presents our estimates of Equation 1 when the outcome is the natural logarithm of the number of job postings (per quarter). Looking first at NPs in column (1), we see that in the year prior to expanding NP SOP, jobs postings for NPs in full SOP adopting states tended to be somewhat less common than in non-adopting states, although the coefficient is not statistically different than zero. In the first seven quarters after full SOP adoption, there was no measurable change in the demand for NPs (measured as the number of online job postings). However, beginning two years after full NP SOP adoption, the number of job postings for NPs in full SOP adopting states increased by 0.27 (se=0.12) log points, representing a large increase in demand for NPs. Interestingly, this increase in demand for NPs occurs without any corresponding change in the demand for other healthcare occupations including PCPs (column 2), RNs (column 3), LPNs (column 4), and PAs (column 5).[34] Thus, the estimates imply that states that adopted full NP SOP experienced stronger demand for NPs without any subsequent weakening in demand for other credentialed healthcare professionals—suggesting that NPs are not simply replacing other healthcare workers. The results also imply that none of these other healthcare occupations appear to be gross substitutes or complements to NPs, at least over the time frame we analyze.

We also estimate Equation 1 using the ratio of total other healthcare job postings to total NP job postings as our outcome variable. These estimates, which we present in Table 5, will help address the negative (although statistically insignificant) leading coefficients across all occupations in Table 4 and better assess changes in relative demand. Under this approach, if the adoption of full NP SOP increases the relative demand for NPs compared

[34]While all of the $TwoPlusYrsPost$ coefficients in Columns 2-5 are negative, almost all are actually larger than the pre-trend, i.e. the coefficient associated with job posting levels in the year prior to full SOP adoption, and none are statistically different than zero.

to other healthcare occupations, then the coefficients on the policy adoption variable should be negative, i.e., that this ratio falls. Indeed, this is precisely what we see. We again see no measurable differential between adopting and never adopting states prior to the deregulation event or in the first two years after the policy change, but the relative number of job postings for each of these occupations (compared to NPs) falls beginning two-years after full NP SOP adoption. Importantly, because we see no significant change in job postings for other healthcare occupations in Table 4, the decline in relative postings clearly comes from increases in NP job postings. Moreover, to help assess the magnitudes of these changes in relative demand, we also include the average ratio at the bottom of each column. The coefficients combined with the average ratio value imply that relative demand for each of these other occupations decreased by about 30 percent—an estimated effect that is almost identical to the change in the number of NP job postings in Table 4. Therefore, the changes in the ratio of job postings in Table 5 confirm our results in Table 4 that expanding NP SOP to allow NPs to practice independently has increased the relative demand for NPs.

To better understand the timing of these effects on labor demand for NPs, we next estimate the event study model in Equation 2, where we continue to use the ratio of job postings (total occupation job postings/total NP job postings) as our outcome variable. These results—estimated at the half-year level to reduce noise—are presented in Figure 1.[35] The first dashed vertical line in each figure indicates the time period just prior to policy adoption, while the second dashed vertical line is just before the period two-years after full NP SOP adoption. One thing to note across all figures is that the ratio of job postings is fairly steady in the quarters leading up to full NP SOP adoption offering additional support for the parallel trends assumption. This is especially the case in Panel B, which presents effects on the ratio of RN job postings to NP job postings. We again see that there is no immediate change in this ratio in the first year after adoption, but the ratio generally starts to decline after a year, and becomes statistically different than zero after two years. Appendix Figure A1 presents analogous event study estimates of the effect of full NP SOP adoption on the natural log of NP job postings. In all of these estimates, the increase in

[35]The data on the ratio of postings are still summed to the state-quarter-year, but we estimate the effects at the half-year level using half-year dummies that take the value of one for each of the two relevant quarters.

demand materializes with a lag, which likely reflects underlying frictions in healthcare labor markets (e.g., if employers cannot instantaneously adjust clinical staffing and roles across labor types) and that it takes time for patients and healthcare providers to learn that NPs can indeed provide quality healthcare services without physician oversight.[36]

Lastly, we examine geographic heterogeneity in the effect of full NP SOP adoption on the number of NP job postings. Previous research has shown that NPs are an important healthcare provider in traditionally underserved areas (Barnes et al. 2018). This analysis allows us to assess whether expanded SOP increases NP labor demand and thus, could improve access to primary care providers in Health Professional Shortage Areas (HPSAs).[37] Interestingly, we see that full SOP adoption increases demand for NPs among employers located in HPSA as well as non-HPSA counties, with the magnitudes and the timing of the growth quite similar across areas (see Table A2).[38]

We turn next to the impact of full NP SOP adoption on the skills demanded of NPs, which we present in Table 6. Column (1) and (2) show our estimates of full NP SOP adoption on the average number of BGT skills listed per job posting and the average number of skill groupings listed per job posting, where the difference between a "BGT skill" and a "skill grouping" is that a BGT skill includes any of the 574 skills included in the BGT job postings (based on BGT's own proprietary algorithm for classifying skills) and a skill grouping is one of our eight aggregated skill groupings. We find that NP SOP adoption is not changing the average number of BGT skills or skill groupings among NP jobs posting (or PCP jobs postings, see Appendix Table A3). The effects of full NP SOP adoption on the proportion of jobs mentioning specific skill groupings are presented in Columns 3-10 of Table 6. Interestingly, we see essentially no change in the composition of skill demands in job

[36]The Zero to Two Years Post SOP and Two Plus Years Post SOP coefficients are jointly statistically significant when we compare total job posts for NPs with PAs and LPNs, i.e. for columns 3 and 4 of Table 5, but not when we compare total NP postings to PCPs or RNs (i.e. columns 1 and 2 in Table 5) or for the natural logarithm of total NP postings in Table 4.

[37]To implement this analysis, we simply limit observations to those occurring in HPSA or non-HPSA counties. We then sum all posting within HSPA counties (or non-HPSA counties) within the state and perform analogous regressions.

[38]Thus, we find that the proportion of the state population living within a HSPA has no effect on job postings, which contrasts with the findings of Traczynski and Udalova (2018).

postings.[39] Thus, full NP SOP adoption does not appear to be changing the specific skills employers are seeking out for their prospective NP hires. This is somewhat surprising since one might expect that full NP SOP adoption would cause NPs to focus more on tasks related to primary care services. These estimates, however, imply that full NP SOP adoption is not associated with any greater degree of skill specialization among NPs. Instead, employers are simply demanding more NP clinical labor. These results also suggest that skill mismatch should not hamper the ability of existing NPs to practice independently under full SOP.

6.2 ACS Analysis

We now present results describing how full NP SOP affects the equilibrium labor market outcomes of healthcare workers in the ACS. We first present overall effects on earnings and employment. We then show how NP SOP affects NP employment across the healthcare sector.

6.2.1 Earnings

Table 7 presents the effects of adopting full NP SOP on full-time labor market earnings for NPs. As shown in column (1), the earnings of NPs are very similar in the year prior to policy adoption in states that adopt full NP SOP (compared to NPs in states that never adopt full NP SOP). However, earnings for NPs in states that adopt full SOP increase by about 6 percent in the year-of and one-year after adoption and remain about 7 percent higher two or more years after adoption. Figure 2 presents our estimates of the event study coefficients, which confirm that the adoption of full NP SOP has an immediate, persistent, and positive impact on NP earnings. Indeed, the stability of the earnings effect over time—evident even four or more years after SOP adoption—implies that the employment response of NPs may be quite limited, at least in the initial few years following the removal of NP SOP restrictions.

[39] A notable exception is that the estimates suggest some decreased frequency of job postings mentioning mental health skills. While we do not place a lot of weight on this result given the multiple hypotheses that we are testing (Savin 1984), it is possible that this reflects a movement away from skills not associated with providing primary care.

Table 7 and Figure 2 also present the estimated effects of full NP SOP adoption on full-time labor market earnings for MDs, RNs, LPNs, and PAs. While the estimates of Equation 1 in Table 7 suggest a potential short-term impact on MD earnings,[40] these effects are not evident in the full event study estimates in Figure 2. This null effect on physician earnings contrasts with Kleiner et al. (2016), who find that the earnings of physicians decline when NPs are granted full SOP when examining earlier policy changes. We also find no evidence that the earnings of RNs, LPNs, or PAs are affected by the policy change, which is especially evident in Figure 2. Thus, we find no evidence that the adoption of full NP SOP is spilling over and affecting the earnings of other healthcare occupations. Additionally, we show in Appendix Figure A2 that the earnings effects on NPs and MDs are unaffected if we use total labor market income, which is the sum of labor market earnings and self-employment income, as the outcome variable or if we expand the sample to include part-time employed workers.[41]

6.2.2 Employment

Panel A of Table 8 presents the impact of expanded NP SOP on the natural log of equilibrium employment levels for NPs and other healthcare workers in the ACS (where occupational employment has been summed to the state-year level). Total employment could increase in response to full NP SOP adoption due to full NP SOP influencing the labor force participation decisions among currently trained NPs, the number of NPs being trained, and NPs' location decisions. In this way, the estimates in Panel A, capture extensive margin employment effects. Surprisingly, we find no evidence that the adoption of full NP SOP is increasing equilibrium employment levels for NPs or affecting overall employment at any of the healthcare occupations we examine within the first four years post-deregulation.[42] We

[40]The change in earnings for physicians in the short-run relative to the leading effect is -0.04 (se=0.03), but entirely disappears in the long-run.

[41]This rules out an impact of full NP SOP on physician self-employment income. However, the ACS does not allow us to distinguish between outcomes for primary care physicians and other types of doctors. Thus, it is possible that the earnings of primary care physicians have been affected by the adoption of full NP SOP even if the earnings of all physicians have not.

[42]If anything, the estimates in column (1) of Panel A imply that NP employment may be declining. The long-run effect minus the one-year before effect is -0.22 (se=0.12). That said, the estimates are noisy and seem to suggest declining employment trends for other healthcare occupations. For example, the long-run effect minus the one-year before effect is -0.10 (0.06) for physicians and -0.06 (0.03) for RNs.

also find no differential trends in overall employment for NPs compared to other healthcare occupations. As shown in Figure 3, which plots the event study estimates from regressions where the outcome is the ratio of total employment (e.g., total RN employment divided by total NP employment), the adoption of full NP SOP is not decreasing this ratio or changing it in any significant way. That said, these results do not rule out small effects or indicate that there will be no effect after additional years. Instead, they highlight that the stock of NPs following the adoption of full NP SOP has been slow to adjust—suggesting that high shares of the current workforce are inframarginal to the policy.

Healthcare workers may also change their hours worked when states adopt full NP SOP. Panel B of Table 8 presents estimates of the impact of full NP SOP on the natural log of individual annual hours worked from Equation 1. The full event study estimates from Equation 2 are presented in Figure 4 and Appendix Figure A3. While less evident in the difference-in-differences estimates in Table 8 due to the leading effect, the event study estimates in Panel A of Figure 4 show that NPs indeed work more hours on average when states adopt full NP SOP. Beginning three years after adoption, the estimates imply that NPs increase their annual hours worked by about 100 hours (or about five percent for a full-time worker). This increase in hours worked is most evident when looking at the full-time/part-time margin in Panels B and C of Figure 4, with full-time employment increasing by 9-11 percentage points beginning three years after adoption and part-time employment falling by a similar amount.[43] Thus, the adoption of full NP SOP induces part-time employed NPs to become full-time employed, representing an important intensive margin adjustment. It also provides a channel through which full NP SOP can improve health outcomes and health care access, as found in Alexander and Schnell (2019) and Traczynski and Udalova (2018). This result is also consistent with other studies that find impacts of full NP SOP on NP hours worked (Luo et al. 2021, Markowitz and Adams 2022), but differs in that we find that these increases occur with a lag. Indeed, the timing of the hours increase is notable and lines up well with the increase in job postings observed in the BGT data.

[43]Somewhat surprisingly, full NP SOP also tends to increase NP full-time employment just prior to full NP SOP adoption. This may reflect NPs wanting to complete the requisite number of supervised hours before they are allowed to practice independently.

The remaining results in Figure 4, show that full NP SOP is not increasing the number of NPs by inducing NPs to reenter the labor force (Panel D), to move across state lines (Panel E), or to commute and work across state lines (Panel F).[44] Lastly, Table 8 and Appendix Figure A3 show that the adoption of full NP SOP is not affecting hours worked at other healthcare occupations. This lack of an equilibrium impact on the earnings or employment at other healthcare occupations is consistent with the BGT results and suggests that these other healthcare occupations are neither major complements nor substitutes to NP labor over our period of analysis.[45]

6.2.3 Place of Service

Full NP SOP could also increase access to primary care by reallocating NPs across different types of healthcare employers—moving NPs to employers where they are more-likely to engage in primary care.

Table 9 presents linear probability model estimates of the impact of full NP SOP adoption on NP self-employment and place of service in the ACS. Looking at column (1), we find that there is no measurable difference between NP self-employment in adopting and non-adopting states in the year prior to adoption, but self-employment increases by 1.4 (se=0.8) percentage points in the year-of and one-year after adoption and remains 1.8 (se=0.6) percentage points higher two or more years after adoption. This rise in self-employment is unique to NPs, with no other healthcare occupations experiencing any changes (see Appendix Table A4). Moreover, the effect is quite persistent and grows slightly over time. As we show in the event study estimates in Figure 5, NPs are 2.9 (se=0.9) percentage points more likely to be self-employed four or more years after full SOP adoption. These percentage point increases

[44]These effects on mobility differ from those found in Shakya and Plemmons (2020), who find that NPs are 0.4 percent less likely to move states if they live in full SOP states.

[45]This contrasts with Kleiner et al. (2016) who finds some evidence that NPs substitute for physicians. However, we cannot rule out NP/physician complementarities discussed in Traczynski and Udalova (2018), where full NP SOP frees up physician time and allows them to spend more time on primary care.

are quite substantial as the self-employment rate of NPs across the entire sample is 3.0 percent.[46]

The adoption of full NP SOP also appears to affect NP place of service with NPs reallocating their employment away from hospitals and towards outpatient care centers, which include clinics and urgent care centers. Ignoring the leading coefficient, the estimates imply that two or more years after full SOP adoption, NP employment at hospitals decreases by 4.8 (se=4.2) percentage points and increases at outpatient care centers by 3.2 (se=1.5) percentage points.[47] If we account for the leading effect, this employment realignment is magnified and suggests that NPs may also be reallocating into physician offices.[48] These changes in place of employment indicate that the need for physician oversight (before full SOP is adopted) was a binding constraint for employers contemplating hiring NPs and NPs making decisions about how to practice.

The movement of NPs away from hospitals and towards self-employment and employment at outpatient care centers could increase the number of primary care providers (and thus, access to primary care) even if total NP employment remains fixed. For example, when we look at the place of service for self-employed NPs, the most commonly observed location is "Office of Other Health Practitioner." Thus, much of the movement of NPs into self-employment appears to reflect the opening of new primary care practices. Additionally, it is not unreasonable to think that NPs employed at outpatient care centers and physician offices may be more likely to be engaged in providing primary care than NPs employed at hospitals.[49] This again points to the idea that the reemployment pattern among NPs is

[46]These findings are consistent with the findings in Markowitz and Adams (2022) and DePriest et al. (2020). Interestingly, our earnings results differ from DePriest et al. (2020), who also estimates the impact of full NP SOP on NPs' earnings using the ACS. That said, they do not control for unobserved state and year differences (i.e., state and year fixed effects) in their empirical analysis, suggesting that accounting for these confounding factors is important.

[47]The coefficients in columns (2)-(5) sum to zero in each row because all NPs are employed at one of the four places of employment.

[48]The long-run coefficient minus the leading coefficient is -12.5 (se=6.5) for hospitals, 5.2 (se=2.4) for outpatient care centers, and 7.1 (se=3.7) for physician offices.

[49]One potential concern with this interpretation is that many outpatient care centers and physician offices are associated with hospitals. Many NPs in the ACS that report working in a hospital may be employed in these hospital affiliated physician offices and outpatient care centers, as opposed to working in inpatient or emergency care units.

consistent with full NP SOP increasing the number of primary care providers, even if it has been unsuccessful at increasing the aggregate number of NPs over our period of analysis.[50]

6.3 Robustness

We perform numerous robustness tests of our BGT and ACS analysis to test the sensitivity of our results to minor perturbations to our empirical specification. These estimates are presented in Appendix Tables A5 and A6, which include the robustness estimates of the BGT and ACS analysis, respectively. Generally speaking, our results are quite robust to these alternative specifications.

Our main empirical specifications excluded states that allowed NPs to practice independently (i.e., full NP SOP states) over the entire sample period. The exclusion of these "always treated" states from the control group addresses potential biases associated with variation in treatment timing in the two-way fixed effects difference-in-differences empirical approach (Goodman-Bacon 2021; Callaway and Sant'Anna 2021). We examine the sensitivity of our results to these exclusions by presenting estimates that use all states. We also investigate whether the differential timing of SOP law changes is distorting our estimates by limiting our treatment sample to the seven states that adopted full NP SOP over the two year time frame between the middle of 2014 and the middle of 2016. As we show in columns 2-3 of Table A5 and columns 4-5 of Table A6, neither the BGT nor the ACS results are sensitive to these further restrictions placed on the analytic samples.

We also estimate additional specifications that test the sensitivity of our results to variation in ACA adoption, changes in the skill grouping variables, and small changes to the ACS empirical specification. We find that excluding states that did not adopt Medicaid expansion (under the ACA) does not materially affect our results (see column 4 on Table A5 and column 6 of Table A6); that small changes in our skill grouping variables have no material

[50]For both self-employment and earnings, the Zero to Two Years Post SOP coefficient and the Two Plus Years Post SOP coefficients are jointly statistically significant. For all other outcomes, only the Two Plus Years Post SOP coefficients are statistically significant.

effects on our results;[51] and that small changes to our ACS empirical specification—such as including top-coded and winsorized earnings, including hours worked in the earnings regressions, excluding sample weights, or adding in additional time-varying covariates—also do not substantially change our estimates (see columns 2-3 and 7-8 of Table A6).

7 Disentangling Supply and Demand

The question remains: what can we infer about labor supply given our empirical results? As described in the theoretical model, the adoption of full NP SOP is likely to increase labor demand for NPs but has an ambiguous effect on NP labor supply, where the net effect depends upon the importance of preferences for independence, which would increase NP labor supply, and increased licensing costs to become an NP, which would decrease NP labor supply. Empirically, we find that full NP SOP adoption is associated with sizably increases in job postings for NPs, which we interpret to reflect increased labor demand. However, this increase occurs with a lag, largely becoming evident two years after full SOP adoption. To separate out the labor supply response from this labor demand response, we contrast our labor demand results with the equilibrium labor market results we observe in the ACS.

Generally speaking, increased demand would be associated with rising wages and rising employment while increased supply would be associated with falling wages and rising employment. Thus, a key determinant to disentangling the labor supply response from the labor demand response is simply to examine what happens to equilibrium wages (since we show that labor demand has increased). As we described above, full-time earnings for NPs (and other measures of NP earnings that control for hours worked) increase substantially and remain persistently higher in states that adopt full NP SOP. Thus, if labor supply is shifting, the labor demand shift must be substantially larger. Moreover, the timing of the employment response in the ACS analysis is also consistent with the increase in employment

[51] In results not shown, we have tried several reconfigurations of our skills groupings to test the sensitivity of our results to alternative skill groupings. These include: combining healthcare support and office support skills, breaking our "na" from other skills, and creating an "education skills" grouping from the other skills. None of these changes had a material impact on our skills analysis estimates in Table 6.

largely being due to the increase in demand that we observe in the BGT. While we see no change in overall employment, we see an increase in hours worked/full-time employment and a reallocation of workers away from hospitals and towards outpatient care centers that both occur about the same time that we observe an increase in job postings—beginning two years after full NP SOP adoption. Therefore, this increase in equilibrium employment and reallocation of workers also appears to be driven by changes in labor demand. However, we cannot fully rule out that a small shift in labor supply is occurring.

The one equilibrium adjustment that is less clearly driven by changes in labor demand is the increase in self-employment. Theoretically, the growth in self-employment could be due to either an increase in labor demand (associated with increased NP marginal revenue product when physician oversight is no longer needed) or labor supply (because the utility gains of working independently would be largest in self-employment). The BGT analysis offers no insights into this distinction because nobody places a job posting for themselves. For these reasons, it is not entirely clear whether the increase in self-employment reflects increased labor demand or supply. Regardless, the immediate increase in self-employment evident in the ACS analysis likely spurs the immediate increase in NP earnings, which are then buttressed by the lagged increase in NP labor demand.[52]

8 Conclusion

Our paper fits into a broad literature that seeks to understand the impact of occupational licensing and its effect on labor and product markets. Occupational licenses could help provide some quality control in an industry, but they may unnecessarily restrict labor supply increasing consumer prices and limiting output. Evaluating this tradeoff in the healthcare market is especially valuable given the importance of providing high-quality service to consumers but also long-standing concerns around limitations in healthcare access and rising healthcare costs.

[52]Two other potential explanations for the immediate increase in earnings is that NPs now face lower operating costs from not having to maintain collaborative agreements or that self-employed NPs simply earn more than they did as employees.

In this paper, we study the labor market effects of states expanding the scope of practice for nurse practitioners allowing them to practice without physician oversight. We show that this policy change is likely to increase the labor demand for NPs but has an ambiguous effect on the labor supply curve. We then set out to assess empirically whether the adoption of full SOP indeed affects labor demand and equilibrium outcomes in the healthcare labor market. The empirical analysis then allows us to back out the likely impacts of full NP SOP on labor supply. This comprehensive approach allows us to assess why we observe the equilibrium outcomes we do and more broadly analyze whether expanded SOP has the potential to increase access to primary care and lower healthcare costs.

Using Burning Glass Technologies data, which represents the near universe of job postings, we find that full NP SOP adoption substantially increased labor demand for NPs in the form of a 31 percent increase in job postings, but did not affect the number of job postings for other primary care providers, including PCPs and RNs. Thus, healthcare patients and providers do not appear to believe that physician oversight is necessary for NPs to provide quality care and the increased demand for NPs is not displacing employers' demand for other healthcare workers. At the same time, we also find that this increase in demand for NPs is not associated with any changes in the specific skills among NPs being sought after by employers. This implies that employers are not seeking different types of NPs but simply more NPs.

We then show how this increase in labor demand (associated with full NP SOP) affects equilibrium labor market outcomes in the ACS. We find that full NP SOP increases equilibrium earnings for NPs but has only limited effects on equilibrium employment—not increasing total NP employment but increasing hours worked of existing NPs by about five percent. This combination of results, combined with the timing of the estimated effects, suggests that the adoption of full NP SOP is unlikely to have had a substantial impact on the labor supply curve for NPs. Additionally, the persistent earnings gains combined with the relatively small increases in total employment imply that the short-run labor supply curve for NPs is fairly inelastic. We also see that full NP SOP is changing the allocation of NPs across the healthcare industry—with NPs moving into self-employment, away from hospitals, and into outpatient care centers. This reallocation of NPs suggests that while full

NP SOP is not increasing the overall number of NPs, it may be increasing the number of primary care providers as NPs in self-employment and at outpatient care centers may be more likely to provide primary care than NPs employed at hospitals. The impact of this reallocation on healthcare costs is unclear. However, to the extent that there is substitution of care previously provided by physicians to lower cost NPs (notwithstanding demand-driven increases in their earnings) overall healthcare spending could be decreased.

Given the continued efforts to "bend the cost curve" in healthcare, expanding non-physician provider scope of practice laws is an appealing tool for both lowering cost of care and expanding access to care. In this study, we find evidence that NP SOP can help achieve both objectives. However, a large expansion in the number of primary care providers is being held back by the short-term inelastic labor supply of NPs. States that want to use expanded SOP to substantially increase healthcare access should think about combining this policy, which substantially increases the demand for NPs, with other workforce promoting policies that help produce a larger supply of NPs such as expanding training programs or subsidizing tuition for NPs that agree to practice within the state.

This study also makes important contributions to the broader literature on occupational licenses. First, we show that it is not simply the presence of an occupational license that matters but that the restrictions within the license also affect labor and product market outcomes. We also show that occupational licenses can impact the industrial organization within a market, reallocating workers across employers and geographic markets, encouraging self-employment, and possibly increasing overall competition. Lastly, the increase in self-employment reveals the potential negative effects of tighter regulations on the entrepreneurial activity of licensed professionals.

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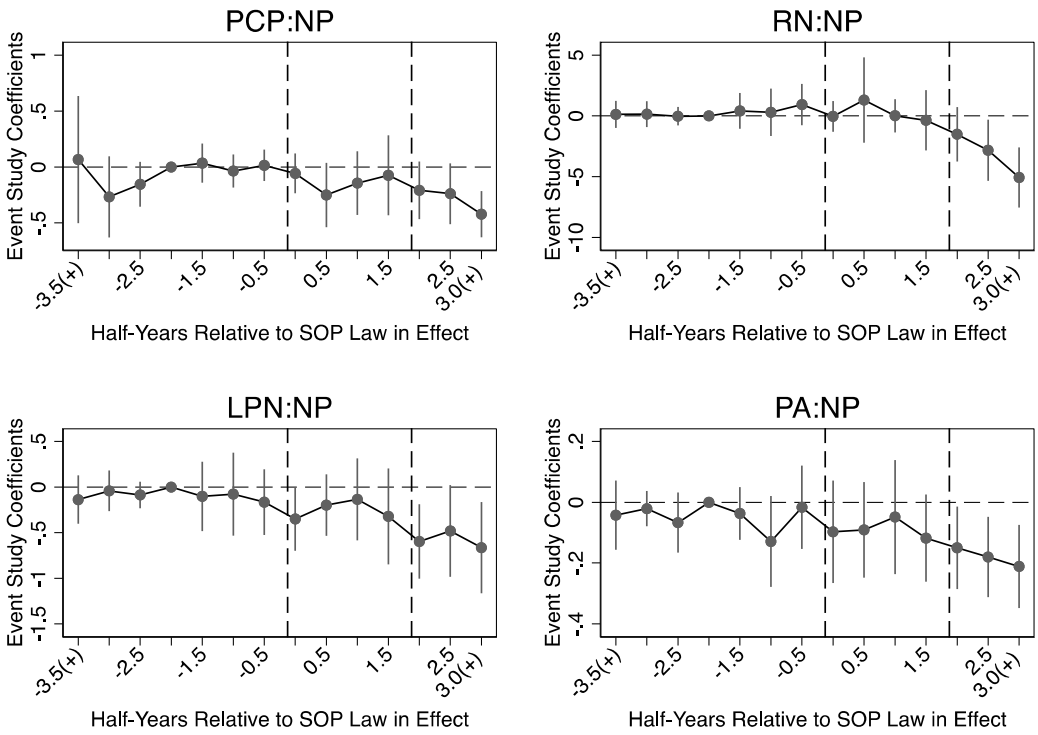
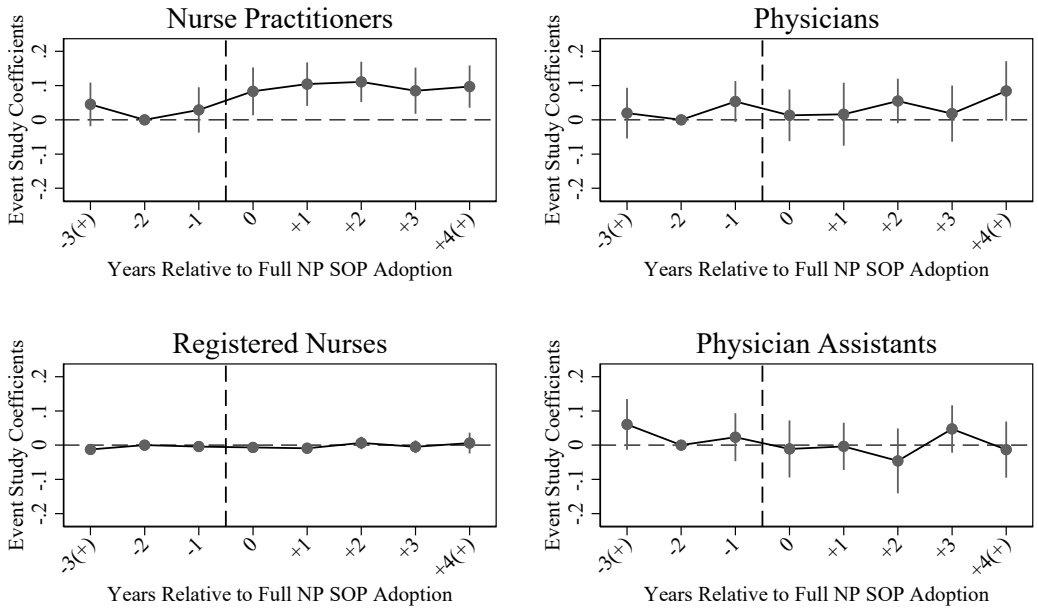
Figure 1: Effect of Full NP SOP on Relative Job Postings



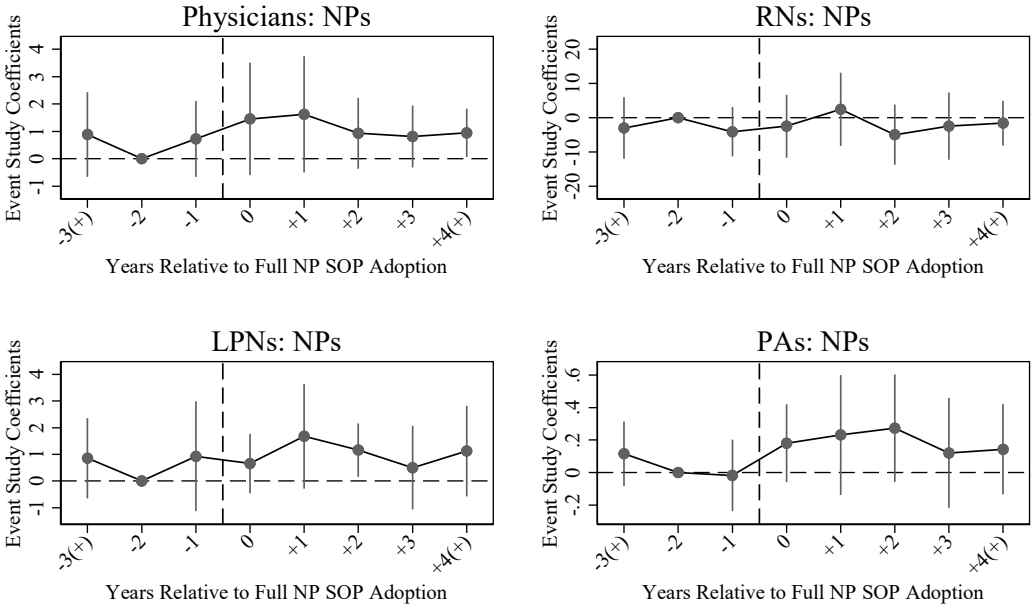
Notes: This figure plots the coefficients and 95 percent confidence intervals of the event study estimates showing the effect of Full NP SOP adoption on the relative number of NP job postings (at the state-quarter-year level) in the BGT data. All coefficients are relative to the effect two years prior to adoption. The first dashed vertical line is just prior to adoption, the second one is two years after adoption.

Figure 2: Effect of Full NP SOP Adoption on Natural Log of Full-Time Earnings



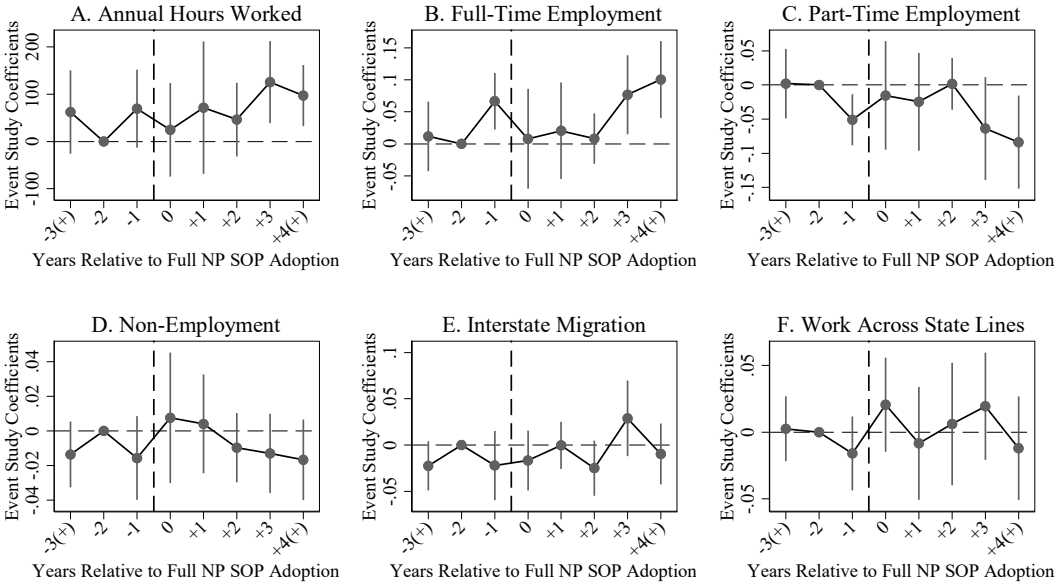
Notes: This figure plots the coefficients and 95 percent confidence intervals of the event study estimates showing the effect of Full NP SOP adoption on the natural log of earnings for full-time employed workers in different health care occupations in the ACS. All coefficients are relative to the effect two years prior to adoption.

Figure 3: Effect of Full NP SOP Adoption on Relative NP Employment



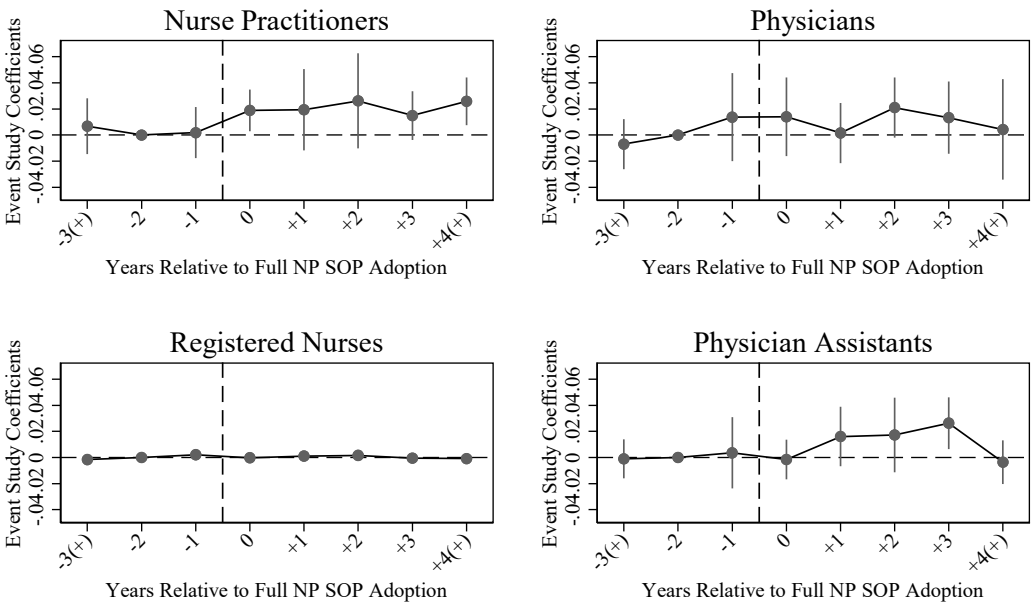
Notes: This figure plots the coefficients and 95 percent confidence intervals of the event study estimates showing the effect of Full NP SOP adoption on relative employment for different health care occupations in the ACS. All coefficients are relative to the effect two years prior to adoption.

Figure 4: Effect of Full NP SOP Adoption on NP Employment



Notes: This figure plots the coefficients and 95 percent confidence intervals of the event study estimates on NPs showing the effect of Full NP SOP adoption on annual hours worked (panel A), full-time employment (panel B), part-time employment (Panel C), non-employment (panel D), migrating across state lines (panel E), and working across state lines (panel F). All coefficients are relative to the effect two years prior to adoption.

Figure 5: Effect of Full NP SOP Adoption on Self Employment



Notes: This figure plots the coeffiecients and 95 percent confidence intervals of the event study estimates showing the effect of Full NP SOP adoption on self-employment for different health care occupations in the ACS. All coefficients are relative to the effect two years prior to adoption.

Table 1: Full Nurse Practitioner Scope of Practice Adoption, 2013-2017

State	**Full NP SOP Effective Date**
Connecticut	7/1/2014
Delaware	9/1/2015
Maryland	10/1/2015
Minnesota	1/1/2015
Nebraska	3/1/2015
Nevada	7/1/2013
New York	1/1/2015
South Dakota	7/1/2017
West Virginia	6/1/2016

Notes: SOP effective date information was compiled from state legislation documents, state nursing licensing information, media reports, and existing NP SOP literature. We cross-referenced this information with McMichael and Markowitz (2021).

Table 2: Summary Statistics for Burning Glass Technologies Healthcare Job Postings, 2011Q1-2019Q2

	Nurse Practitioners	**Primary Care Physicians**	**Registered Nurses**	**Licensed Practical Nurses**	**Physician Assistants**
Average Quarterly Job Postings	23,545	23,177	214,330	34,140	10,153
Growth in Job Postings, 2011-2018	97.6%	49.9%	150.5%	111.1%	16.9%
Avg Number of Skills per Posting	6.5	4.1	6.8	7.1	5.8
Avg Number of "Skill Groupings" per Posting	3.1	2.1	3.3	3.5	2.8
% of Postings for Specific Skill Groupings					
General Care Skills	62.0	74.0	58.1	64.5	53.1
Specialized Care Skills	40.9	35.4	38.1	27.5	46.4
Mental Health Skills	18.9	3.3	7.7	6.9	5.9
Emergency Care Skills	28.0	11.3	43.2	42.4	35.3
Healthcare Support Skills	47.2	21.2	58.8	69.4	35.6
Office Support Skills	32.8	18.2	31.6	37.5	28.7
Leadership Skills	8.9	3.6	12.4	10.0	7.2
Other Skills	75.5	47.0	83.3	90.2	67.6
N	800,545	788,010	7,287,228	1,160,759	345,197

Notes: Not all BGT job postings include skills, but these omissions are rare (typically 1% or less of postings for a given provider type). "Skill Groupings" are our combined skill measurements, grouping the individual BGT skills into more aggregated combinations of skills. The specific BGT skills included in each "skill grouping" are presented in Appendix Table A1. "Other Skills" include unspecified skills, designated "na" by BGT. Indeed, unspecified skills make up a majority of "Other skills," including 56 percent for nurse practitioners.

Table 3: Summary Statistics from American Community Survey, Sample of Healthcare Workers Aged 25-60, 2010-2019

	Nurse Practitioners	**Physicians**	**Registered Nurses**	**Licensed Practical Nurses**	**Physician Assistants**
Age	42.7	42.8	42.6	42.5	38.5
Female	0.91	0.40	0.89	0.89	0.70
Immigrant	0.11	0.30	0.16	0.15	0.13
Hispanic	0.05	0.07	0.07	0.11	0.09
Asian American	0.06	0.24	0.10	0.05	0.09
Black	0.09	0.07	0.13	0.28	0.08
White	0.83	0.68	0.74	0.63	0.80
College Degree	0.98	1.00	0.60	0.05	0.84
Full-time Employment	0.86	0.91	0.80	0.76	0.83
Part-time Employment	0.12	0.08	0.16	0.17	0.14
Not Employed (over past year)	0.02	0.01	0.04	0.07	0.03
Weekly Hours Worked	39.9	51.9	36.4	35.4	40.3
Self Employed	0.03	0.18	0.01	0.02	0.03
Topcoded Earnings	0.01	0.29	0.00	0.00	0.01
Earnings ($1000s)					
All Individuals	88.1	197.5	58.6	34.6	85.3
Full-time Employed	95.8	210.5	66.8	41.6	96.6
Full-Time and Non-topcoded	93.5	117.2	65.6	40.7	90.6
Full-time, Non-topcoded, and Winsorized	93.1	118.7	64.5	39.5	89.0
Industry					
Hospitals	0.39	0.47	0.62	0.24	0.42
Physicians Offices	0.25	0.33	0.04	0.07	0.30
Outpatient Care Centers	0.16	0.06	0.05	0.06	0.10
Other Industry	0.20	0.14	0.29	0.62	0.18
N	12,182	68,755	244,231	63,050	9,298

Notes: Nurse Practitioners include nurse midwives because the ACS combined the two occupations into a single occupation. According to the 2019 Occupation Employment Statistics (OES), Nurse Practitioners made up almost 97 percent of this combination nationally. Full time employed is defined as working at least 40 weeks over the past year, averaging at least 30 hours per week, and reporting positive earnings. The ACS topcodes the highest two percent of earnings in each state in each year. The winsorized sample excludes the observations with the highest and lowest two percent of earnings within each occupation grouping.

Table 4: Effects of Full NP SOP on Job Postings, BGT Data, 2011Q1 - 2019Q2

	Nurse Practitioners	**Primary Care Physicians**	**Registered Nurses**	**Licensed Practical Nurses**	**Physician Assistants**
	(1)	(2)	(3)	(4)	(5)
1 Year Pre	–0.10	–0.06	–0.07	–0.13	–0.20
	(0.10)	(0.11)	(0.04)	(0.07)	(0.11)
SOP Zero to Two Years Post	0.01	–0.03	–0.02	–0.12	–0.10
	(0.11)	(0.14)	(0.08)	(0.10)	(0.16)
SOP Two Plus Years Post	0.27	–0.07	–0.07	–0.08	–0.04
	(0.12)	(0.17)	(0.05)	(0.09)	(0.13)
State FE	Yes	Yes	Yes	Yes	Yes
Yr-Qtr FE	Yes	Yes	Yes	Yes	Yes
N	1,156	1,156	1,156	1,156	1,156

Notes: Outcome is the natural log of the total number of job postings for a given occupation in each state-quarter-year. *SOP Zero to Two Years Post* is defined as the quarters associated with the year of adoption and one year after adoption. *SOP Two Plus Years Post* is defined as the quarters associated with two or more years after adoption. Always treated SOP states are excluded from the analyses. Standard errors are clustered at the state level.

Table 5: Effects of Full NP SOP on Relative Job Postings, BGT Data, 2011Q1-2019Q2

	Total Occupation Job Postings: NP Job Postings			
	Primary Care Physicians	**Registered Nurses**	**Licensed Practical Nurses**	**Physician Assistants**
	(1)	(2)	(3)	(4)
1 Year Pre	0.02	0.50	–0.03	–0.04
	(0.14)	(0.77)	(0.14)	(0.05)
SOP Zero to Two Years Post	–0.10	0.11	–0.16	–0.05
	(0.19)	(1.05)	(0.14)	(0.06)
SOP Two Plus Years Post	–0.29	–3.79	–0.52	–0.15
	(0.15)	(1.15)	(0.18)	(0.05)
State FE	Yes	Yes	Yes	Yes
Yr-Qtr FE	Yes	Yes	Yes	Yes
N	1,156	1,156	1,156	1,156
Sample Mean	1.1	9.8	1.8	0.4

Notes: The outcome is the ratio of the number of job postings for different healthcare occupations to the number of nurse practitioner postings in each state-quarter-year. *SOP Zero to Two Years Post* is defined as the quarters associated with the year of adoption and one year after adoption. *SOP Two Plus Years Post* is defined as the quarters associated with two or more years after adoption. Always treated SOP states are excluded from the analyses. Standard errors are clustered at the state level.

Table 6: Effects of Full NP SOP on Skills in BGT Job Postings for Nurse Practitioners, BGT Data, 2011Q1 - 2019Q2

			Skill Groupings							
	Number of BGT Skills	**Number of Skill Groupings**	**General Care Skills**	**Specialized Care Skills**	**Mental Health Skills**	**Emergency Care Skills**	**Healthcare Support Skills**	**Office Support Skills**	**Leadership Skills**	**Other Skills**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 Year Pre	0.47	0.08	0.01	–0.03	0.01	0.03	0.05	0.02	–0.01	–0.00
	(0.42)	(0.12)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.01)	(0.02)
SOP Zero to Two Years Post	0.18	–0.03	–0.02	–0.00	–0.02	0.02	–0.00	0.00	0.01	–0.01
	(0.37)	(0.11)	(0.02)	(0.02)	(0.01)	(0.02)	(0.03)	(0.03)	(0.01)	(0.02)
SOP Two Plus Years Post	–0.26	–0.09	–0.02	0.00	–0.04	0.02	–0.01	–0.02	–0.00	–0.00
	(0.45)	(0.14)	(0.03)	(0.02)	(0.01)	(0.03)	(0.03)	(0.03)	(0.01)	(0.02)
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,156	1,156	1,156	1,156	1,156	1,156	1,156	1,156	1,156	1,156
Sample Mean	6.8	3.2	0.62	0.40	0.18	0.29	0.49	0.34	0.09	0.78

Notes: The outcome is either the average number of skills per job posting (columns 1 and 2) or the probability that a job posting includes a skill associated with a specific skill grouping (columns 3-10) – both computed at the state-quarter-year level. *SOP Zero to Two Years Post* is defined as the quarters associated with the year of adoption and one year after adoption. *SOP Two Plus Years Post* is defined as the quarters associated with two or more years after adoption. Always treated SOP states are excluded from the analyses. Sample means differ slightly from the means in Table 2 because these means are based on a straight average of state-quarter-year averages and the means use only the analytic sample. Standard errors are clustered at the state level.

Table 7: Effects of Full NP SOP on Full-Time Earnings, ACS Data, 2010-2019

	Nurse Practitioners	**Physicians**	**Registered Nurses**	**Licensed Practical Nurses**	**Physician Assistants**
	(1)	(2)	(3)	(4)	(5)
1 Year Pre	0.00	0.04	0.01	0.00	-0.02
	(0.03)	(0.02)	(0.01)	(0.02)	(0.04)
SOP Zero to Two Years Post	0.06	0.00	0.00	0.01	-0.05
	(0.02)	(0.02)	(0.01)	(0.01)	(0.03)
SOP Two Plus Years Post	0.07	0.04	0.01	-0.03	-0.05
	(0.03)	(0.02)	(0.01)	(0.02)	(0.03)
State FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	9,697	33,095	185,385	45,084	7,108

Notes: The outcome is the natural log of individual earnings and each column presents results from a separate regression on full-time aged 25-60 workers in a specific occupation. *SOP Zero to Two Years Post* is defined as the year of adoption or one year after adoption. *SOP Two Plus Years Post* is defined as two-years or more after adoption. Always treated SOP states are excluded from the analyses. Standard errors are clustered at the state level.

Table 8: Effects of Full NP SOP on Employment, ACS Data, 2010-2019

	Nurse Practitioners	**Physicians**	**Registered Nurses**	**Licensed Practical Nurses**	**Physician Assistants**
	(1)	(2)	(3)	(4)	(5)
Panel A: Natural Log of State-Level Total Employment					
1 Year Pre	0.17	0.15	0.02	0.02	-0.08
	(0.09)	(0.07)	(0.01)	(0.08)	(0.08)
SOP Zero to Two Years Post	0.01	0.11	-0.02	0.05	0.12
	(0.12)	(0.09)	(0.03)	(0.06)	(0.10)
SOP Two Plus Years Post	-0.05	0.05	-0.04	0.09	0.09
	(0.09)	(0.05)	(0.02)	(0.06)	(0.11)
N	340	340	340	340	338
Panel B: Natural Log of Individual Annual Hours Worked					
1 Year Pre	0.04	0.02	0.01	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)
SOP Zero to Two Years Post	0.02	0.02	0.00	0.03	0.02
	(0.03)	(0.01)	(0.01)	(0.02)	(0.03)
SOP Two Plus Years Post	0.03	-0.01	-0.01	-0.01	-0.01
	(0.02)	(0.02)	(0.01)	(0.02)	(0.04)
N	11,935	67,680	23,3701	57,963	8,977

Notes: The outcome in Panel A is the natural log of total occupational employment at the state-year level. All employment totals are limited to workers aged 25-60 who are employed either full or part-time. The outcome in Panel B is the natural log of individual annual hours worked. Non-employed workers are excluded from the latter analysis. All specifications include state and year fixed effects as well as individual covariates (averaged to the state-year level Panel A). *SOP Zero to Two Years Post* is defined as the year of adoption or one year after adoption. *SOP Two Plus Years Post* is defined as two-years or more after adoption. Standard errors are clustered at the state level.

Table 9: Effects of Full NP SOP on NP Place of Service, ACS Data, 2010-2019

		Employer Type Among Non-Self Employed			
	Self-Employment	**Hospitals**	**Physicians Offices**	**Outpatient Care Centers**	**Other**
	(1)	(2)	(3)	(4)	(5)
1 Year Pre	-0.003	0.077	-0.064	-0.021	0.008
	(0.015)	(0.090)	(0.064)	(0.034)	(0.039)
SOP Zero to Two Years Post	0.014	0.026	-0.034	-0.020	0.029
	(0.008)	(0.054)	(0.030)	(0.021)	(0.028)
SOP Two Plus Years Post	0.018	-0.048	0.007	0.032	0.009
	(0.006)	(0.042)	(0.044)	(0.015)	(0.029)
State FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Sample Mean	0.03	0.40	0.26	0.16	0.19
Observations	12,182	11,798	11,798	11,798	11,798

Notes: The outcome is an indicator for being self-employed (column 1) or for being employed at a different employer type (column 2-5). The sample includes all NPs aged 25-60, where columns 2-5 exclude self-employed NPs. *SOP Zero to Two Years Post* is defined as the year of adoption or one year after adoption. *SOP Two Plus Years Post* is defined as two-years or more after adoption. Always treated SOP states are excluded from the analyses. Standard errors are clustered at the state level.

ONLINE APPENDIX A

Figure A1: Event Study for Full NP SOP on Natural Log Total NP Job Postings

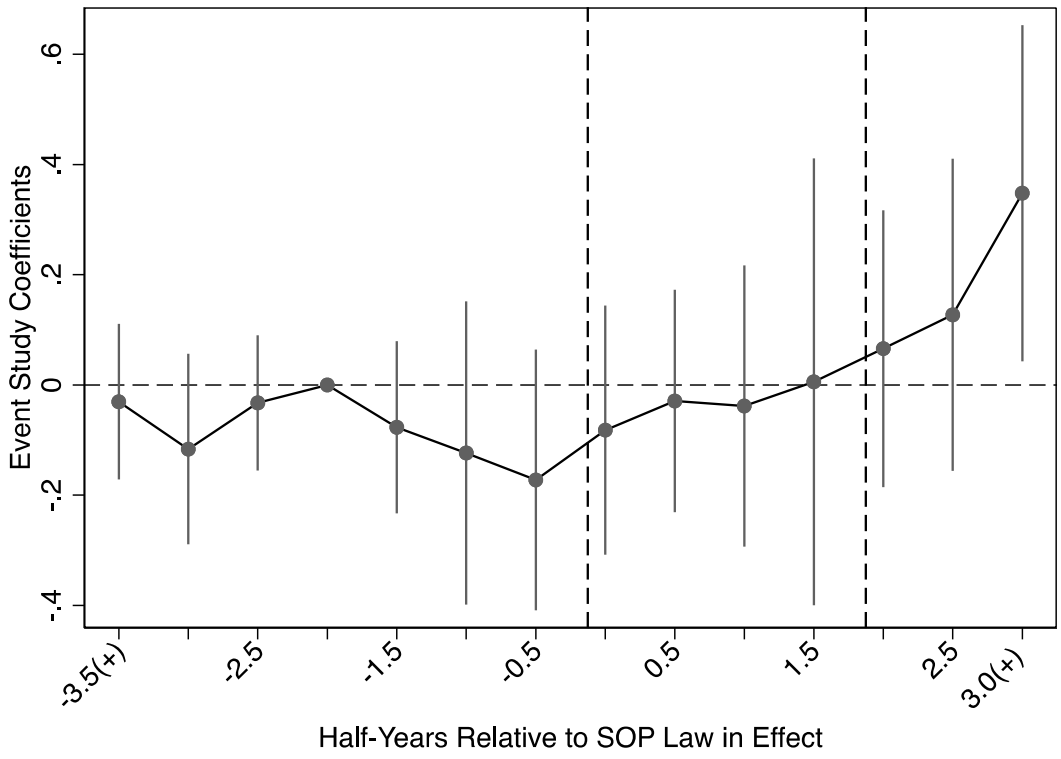
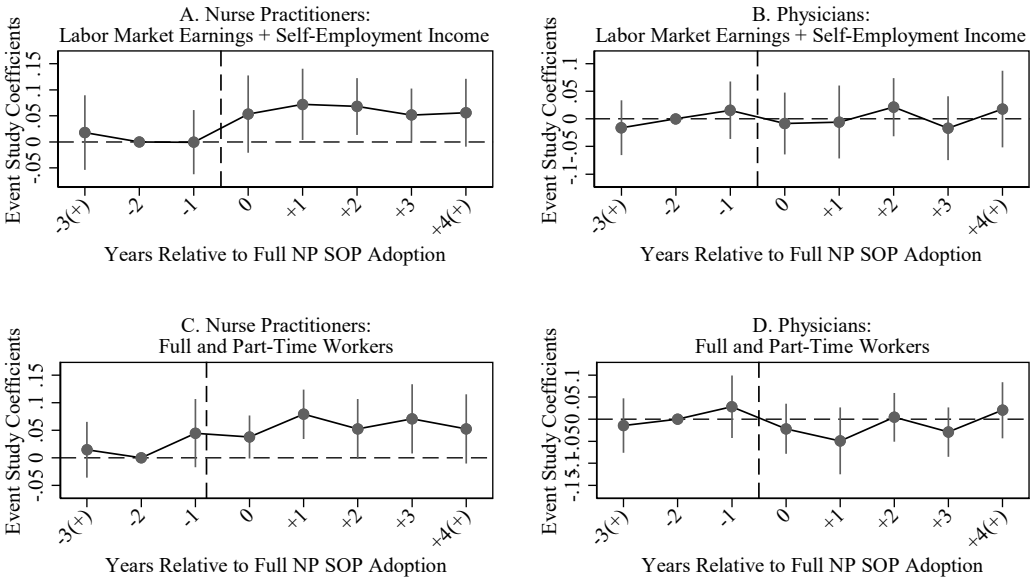
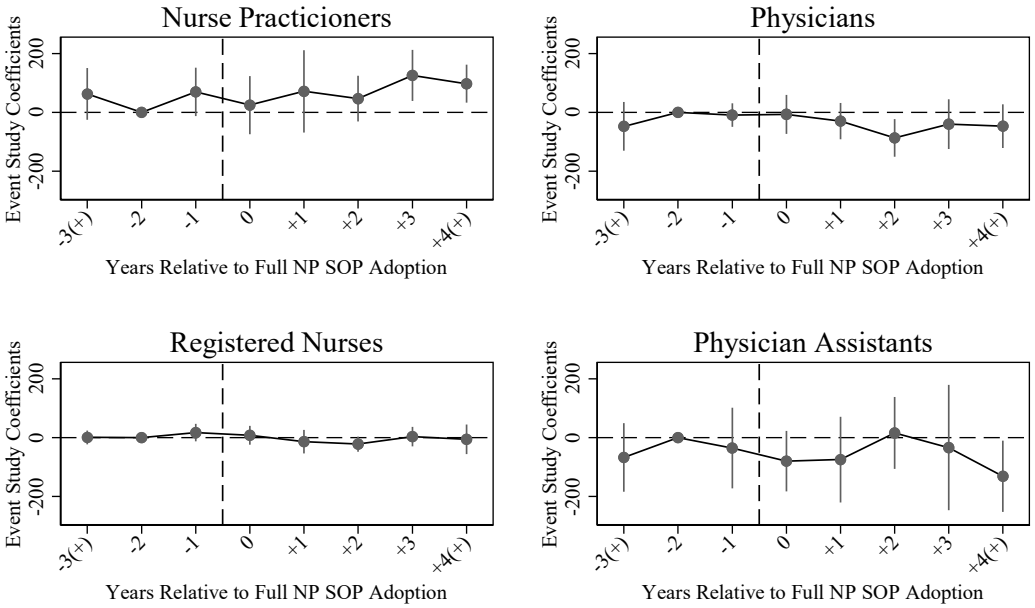


Figure A2: Effect of Full NP SOP Adoption on Earnings II



Notes: This figure plots the coefficients and 95 percent confidence intervals of the event study estimates showing the effect of Full NP SOP adoption on earnings for nurse practicioners and physicians. Panels A and B include self-emnployment income for full-time employed workers. Panels C and D include annual earnings for full and part-time workers. All coefficients are relative to the effect two years prior to adoption.

Figure A3: Effect of Full NP SOP Adoption on Annual Hours Worked



Notes: This figure plots the coefficients and 95 percent confidence intervals of the event study estimates showing the effect of Full NP SOP adoption on annual hours worked for different health care occupations in the ACS. All coefficients are relative to the effect two years prior to adoption.

Table A1: BGT Skills Included in our Skill Groupings

General Care Skills
Advanced Patient Care
Basic Patient Care
General Medical Tests and Procedures
General Medicine
Geriatrics
Healthcare Procedure and Regulation
Injury Treatment
Pediatrics
Routine Examination Tests and Procedures

Specialized Care Skills
Allergies
Anesthesiology
Cardiology
Cellular Biology
Dental Care
Dermatology
Ear, Nose, and Throat
Endocrinology
Eye Care
Gastroenterology
Genetics
Infectious Diseases
Nephrology
Neurology
Neuroscience
Nuclear Medicine
Obstetrics and Gynecology (OBGYN)
Oncology
Orthopedics
Pathology
Pharmacy
Pulmonology
Radiology
Speech Language Pathology
Surgery
Urology

Emergency Care Skills
Emergency and Intensive Care
Emergency Services

Mental Healthcare Skills
Mental and Behavioral Health Specialties
Mental Health Diseases and Disorders
Mental Health Therapies

Healthcare Support Skills
Alternative Therapy

Healthcare Support (continued)
Basic Living Activities Support
Blood Collection
Exercise Training
First Aid
Healthcare Procedure and Regulation
Medical Procedure and Regulation
Medical Support
Mobility Assistance
Nutrition and Diet
Occupational Health and Safety
Patient Education and Support
Patient Physical Measurements
Physical Abilities
Physical Therapy
Public Health and Disease Prevention
Rehab Therapy
Rehabilitation
Social Work

Office & Business Support Skills
Administrative Support
Advanced Customer Service
Auditing
Basic Customer Service
Billing and Invoicing
Brand Management
Budget Management
Business Communications
Business Process and Analysis
Business Solutions
Claims Processing
Clinical Data Management
Compensation and Benefits
Computer and Information Technology Industry Knowledge
Contract Management
Customer Relationship Management (CRM)
Cybersecurity
Data Management
Data Techniques
Database Administration
Dictation
Employee Relations
Enterprise Resource Planning (ERP)
Financial Advisement
Financial Management
Financial Reporting
Financial Risk Management
General Accounting
General Administrative and Clerical Tasks

Office & Business Support (continued)
General Marketing
General Networking
General Sales
General Sales Practices
General Shipping and Receiving
Graphic and Visual Design Software
Health Information Management and Security
Housekeeping
Human Resource Management and Planning
Labor Compliance
Management Information System (MIS)
Market Analysis
Marketing Management
Marketing Strategy
Medical Billing and Coding
Medical Documentation and Abstraction
Medical Records
Microsoft Development Tools
Microsoft Office and Productivity Tools
Office Machines
Operations Management
Order Management
Patient Reception
PHP Web
Process Improvement
Procurement
Product Development
Project Management
Public Relations
Quality Assurance and Control
Recruitment
Regulation and Law Compliance
Sales Management
Scheduling
Social Media
Software Development Principles
Specialized Sales
System Design and Implementation
Web Development

Leadership Skills
Business Development
Business Management
Business Strategy
Employee Training
Leadership and Management
Office Management
People Management
Performance Management

Leadership (continued)
Program Management

Other Skills
Art and Illustration
Biologics Industry Knowledge
Biology
Broadcasting Industry Knowledge
Chemical Analysis
Chemistry
Child Care
Child Development
Civil and Architectural Engineering
Clinical Informatics
Clinical Research
Construction Management
Data Analysis
Drug Development
Education Administration
Environmental Work
Equipment Repair and Maintenance
Food and Beverage Service
Foreign language skills
Hazardous Waste Management
Instructional and Curriculum Design
Laboratory Research
Law Enforcement and Criminal Justice
Lean Manufacturing
Litigation
Mathematics
Medical Research
Molecular Biology
Music
na
Peer Review
Physics
Research Methodology
Retail Industry Knowledge
Robotics
Simulation
Social Services Industry Knowledge
Surveillance
Talent Management
Teaching
Technical Support
Telecommunications
Training Programs
Writing

Notes: This figure excludes any BGT skill (called "skill clusters" in the BGT data) comprising less then 0.01 percent of all skills mentioned in the BGT postings, in terms of frequency. This (includes three "Specialized Care" skills together comprising 0.018 percent of skills mentioned), three "Healthcare Support" skills (together comprising 0.004 percent of all skills mentioned), (133 "Office and Business Support" skills together comprising 0.382 of all skills mentioned), and 246 "Other" skills (together comprising 0.301 percent of all skills mentioned). Thus, this table lists more than 99 percent of all skill mentioned in the BGT data, in terms of frequency of being mentioned. BGT Skills within skill groupings are organized alphabetically.

Table A2: Full NP SOP on NP Job Postings
Effects by HPSA Designation

	Full HPSA Counties	**Other Counties**
	(1)	(2)
1 Year Pre	–0.11	–0.21
	(0.10)	(0.19)
SOP Zero to Two Years Post	0.05	–0.12
	(0.12)	(0.17)
SOP Two Plus Years Post	0.31	0.30
	(0.14)	(0.17)
State FE	Yes	Yes
Yr-Qtr FE	Yes	Yes
N	1,089	1,156

Notes: See notes from Table 4.

Table A3: Effects of Full NP SOP on Skill in BGT Job Postings for Primary Care Physicians
BGT Data, 2011Q1 - 2019Q2

			Skill Groupings							
	Number of BGT Skills	**Number of Skill Groupings**	**General Care Skills**	**Specialized Care Skills**	**Emergency Care Skills**	**Mental Health Skills**	**Healthcare Support Skills**	**Office Support Skills**	**Leadership Skills**	**Other Skills**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 Year Pre	0.19	–0.06	–0.00	–0.02	–0.01	–0.00	–0.01	–0.01	–0.01	–0.01
	(0.18)	(0.06)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)
SOP Zero to Two Years Post	–0.07	–0.09	–0.02	0.00	–0.00	–0.01	–0.02	–0.01	–0.01	–0.03
	(0.14)	(0.06)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.00)	(0.03)
SOP Two Plus Years Post	0.01	–0.02	–0.00	–0.02	–0.01	–0.01	–0.02	–0.00	0.01	0.02
	(0.17)	(0.08)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.02)	(0.01)	(0.04)
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Mean	4.2	2.2	0.73	0.36	0.03	0.12	0.22	0.18	0.04	0.48
N	1,156	1,156	1,156	1,156	1,156	1,156	1,156	1,156	1,156	1,156

Notes: The outcome is either the average number of skills per job posting (columns 1 and 2) or the probability that a job posting includes a skill associated with a specific skill grouping (columns 3-10) – both computed at the state-quarter-year level. *SOP Zero to Two Years Post* is defined as the quarters associated with the year of adoption and one year after adoption. *SOP Two Plus Years Post* is defined as the quarters associated with two or more years after adoption. Always treated SOP states are excluded from the analyses. Sample means differ slightly from the means in Table 2 because these means are based on a straight average of state-quarter-year averages and the means use only the analytic sample. Standard errors are clustered at the state level.

Table A4: Effects of Full NP SOP on Self-Employment
ACS Data, 2010 - 2019

	Physicians	**Nurse Practitioners**	**Licensed Practical Nurses**	**Physician Assistants**
	(1)	(2)	(3)	(4)
1 Year Pre	0.019	0.003	0.002	0.004
	(0.016)	(0.002)	(0.005)	(0.011)
SOP Zero to Two Years Post	0.014	0.002	-0.003	0.008
	(0.009)	(0.001)	(0.003)	(0.006)
SOP Two Plus Years Post	0.018	0.001	-0.004	0.013
	(0.013)	(0.001)	(0.005)	(0.007)
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Sample Mean	0.180	0.008	0.016	0.028
N	68,755	244,231	63,050	9,298

Notes: The outcome is an indicator for being self-employed. *SOP Zero to Two Years Post* is defined as the year of adoption or one year after adoption. *SOP Two Plus Years Post* is defined as two-years or more after adoption. Always treated SOP states are excluded from the analyses. Standard errors are clustered at the state level.

Table A5: Robustness Estimates for NPs in BGT Analysis

	Preferred Specification	All States	Common Adoption Period	Exclude No ACA Exp. States
	(1)	(2)	(3)	(4)
Panel A: Effect on Natural Log of NP Job Postings				
1 Year Pre	–0.104	–0.105	–0.009	–0.122
	(0.10)	(0.10)	(0.13)	(0.11)
SOP Zero to Two Years Post	0.01	–0.033	0.10	–0.034
	(0.11)	(0.01)	(0.09)	(0.12)
SOP Two Plus Years Post	0.27	0.20	0.30	0.21
	(0.12)	(0.12)	(0.15)	(0.13)
N	1,156	1,734	1,054	816
Panel B: Effect on Relative Number of Job Postings (RNs : NPs)				
1 Year Pre	0.49	0.46	–0.60	0.56
	(0.77)	(0.74)	(0.71)	(0.82)
SOP Zero to Two Years Post	0.11	0.25	–1.13	0.44
	(1.05)	(1.01)	(0.67)	(1.18)
SOP Two Plus Years Post	–3.79	–3.34	–3.96	–3.20
	(1.15)	(1.13)	(1.28)	(1.28)
N	1,156	1,734	1,054	816

Notes: See notes for Tables 4-5. Column (2) presents estimates that use always treated states as control states. Column (3) presents estimates when we limit our treatment sample to Full NP SOP adopting states over the two-year period (7/1/14 - 6/1/16) as the treated states. Column (4) presents estimates when we exclude states that did not expand Medicaid from the control sample. *SOP Zero to Two Years Post* is defined as the year of adoption or one year after adoption. *SOP Two Plus Years Post* is defined as two-years or more after adoption. Standard errors are clustered at the state level.

Table A6: Robustness Estimates for NPs in ACS Data

	Preferred Specification	No Earnings Restrictions	Include Hours Worked	All States	Common Adoption Period	Exclude No ACA Exp. States	No Sample Weights	Include Extra Covars
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Effect on Natural Log of Earnings for NPs working Full-Time								
1 Year Pre	0.00	0.00	-0.01	-0.01	-0.01	-0.01	0.00	0.00
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.01)	(0.03)
SOP Zero to Two Years Post	0.06	0.05	0.05	0.05	0.05	0.05	0.03	0.06
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
SOP Two Plus Years Post	0.07	0.06	0.05	0.05	0.06	0.06	0.04	0.06
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
N	9,697	9,697	11,022	11,022	9,250	6,188	9,697	9,697
Panel B: Effect on Self-Employment								
1 Year Pre	0.00			0.00	0.01	-0.01	0.00	0.00
	(0.02)			(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
SOP Zero to Two Years Post	0.01			0.02	0.02	0.01	0.01	0.01
	(0.01)			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
SOP Two Plus Years Post	0.02			0.02	0.02	0.02	0.02	0.02
	(0.01)			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	12,182			13,916	11,616	7,772	12,182	12,182
Panel C: Effect on Relative Employment (RNs : NPs)								
1 Year Pre	-1.91			-0.18	-2.69	-1.06	-2.18	-1.73
	(2.77)			(2.82)	(3.00)	(2.82)	(2.73)	(2.81)
SOP Zero to Two Years Post	1.83			1.73	1.30	1.28	1.81	2.11
	(2.55)			(2.63)	(2.68)	(3.09)	(2.49)	(2.69)
SOP Two Plus Years Post	-1.19			-1.20	-1.68	1.23	-1.55	-0.51
	(2.65)			(2.35)	(2.87)	(1.42)	(2.65)	(3.01)
N	331			486	231	302	331	331

Notes: See notes for Tables 7-9. Column (2) presents estimates when we include topcoded and winsorized earnings levels. Column (3) presents estimates where we also include hours worked and hours squared as covariates. Column (4) presents estimates that use always treated states as control states. Column (5) presents estimates when we limit our treatment sample to Full NP SOP adopting states over the two-year period (7/1/14 - 6/1/16) as the treated states. Column (6) presents estimates when we exclude states that did not expand Medicaid from the control sample. Column (7) presents results when we do not use the sample weights as weights in our estimates. Column (8) presents estimates where we include the state-level unemployment rate and state-level share of individuals aged 65+. *SOP Zero to Two Years Post* is defined as the year of adoption or one year after adoption. *SOP Two Plus Years Post* is defined as two-years or more after adoption. Standard errors are clustered at the state level.

ONLINE APPENDIX B

Suppose the labor market for NPs is monopsonistic with $W_M = g(H_M) = \lambda H_M$. Then, the profit maximization expression becomes:

$$\pi = p_Y f(H_H^p, H_M, H_L) - w_H H_H^p - (\lambda H_M + \tfrac{1}{\alpha} w_H) H_M - w_L H_L$$

and our three first order conditions are

1. $\frac{\partial \pi}{\partial H_M} = p_Y f_{H_M} - 2\lambda H_M - \frac{w_H}{\alpha} = 0$
2. $\frac{\partial \pi}{\partial H_H^p} = p_Y f_{H_H^p} - w_H = 0$
3. $\frac{\partial \pi}{\partial H_L} = p_Y f_{H_L} - w_H = 0.$

From (2) above, we know $w_H = f_{H_H^p}$. We also know that $W_M = \lambda H_M$ by definition. Thus, we can plug these two expressions into (1) and rewrite it as:

$$W_M = \tfrac{1}{2}[P_Y(f_{H_M} - \tfrac{f_{H_H}}{\alpha})].$$

After full SOP adoption, $\alpha \to \infty$ and this expression reduces to $W_M = \frac{1}{2}(P_Y f_{H_M})$. Thus, the increase in labor demand is $\frac{P_Y f_{H_H}}{2\alpha}$ with full SOP adoption, which is exactly half of the increase compared to when the market is competitive, which was $\frac{P_Y f_{H_H}}{\alpha}$. Taken together, this analysis shows that monopsony would weaken the equilibrium response to changes in NP SOP.