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ABSTRACT

The H-1B program allows skilled foreign-born individuals to work in the United States. The annual quota on new H-1B visa issuances fell from 195,000 to 65,000 for employees of most firms in fiscal year 2004. However, this cap did not apply to new employees of colleges, universities, and non-profit research institutions. Additionally, existing H-1B holders seeking to renew their visa were also exempt from the quota. Using a triple difference approach, this paper demonstrates that cap restrictions significantly reduced the employment of new H-1B workers in for-profit firms relative to what would have occurred in an unconstrained environment. Employment of similar native workers in for profit firms did not change, however, consistently with a low degree of substitutability between H1B and native workers. The restriction also redistributed H-1Bs toward computer-related occupations, Indian-born workers, and firms using the H-1B program intensively.

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1 Introduction

The H-1B program provides a pathway for foreign-born skilled professionals to work in the United States. Proponents argue that the H-1B program increases the skilled labor force, boosts innovation and productivity, and generates long-run economic gains. Opponents instead argue that H-1B workers displace Americans and reduce wages, especially in the Information Technology (IT) sector. Economists and policy-makers continue to debate these issues and several other important aspects of the H-1B program such as whether the program actually selects workers of high ability or what are their characteristics. The program's design might unintentionally favor some firms, workers, or occupations. This paper informs these issues by examining how a large reduction in the number of H-1B visas available beginning in fiscal year 2004 affected the employment and characteristics of new H-1B workers in for-profit firms, whether any effect was observed in the employment of similar native in for-profit firms and how this affected the types of firms that hired them.

In fiscal year (FY) 2004 the annual quota (or cap) on H-1B visas available for new foreign-born employees of most firms fell drastically from 195,000 to 65,000 per year.[1] While the reduction was substantial, it was not applied uniformly. In particular, two groups of H-1B workers were unaffected by this policy change. First, employees of colleges, universities, and non-profit research institutions were exempted from the cap in 2001 (hereinafter, "non-profit" or "cap-exempt" firms). Second, the quota only applied to new H-1B applicants. Established H-1B workers seeking to extend their employment or move from one for-profit firm to another were not subject to any cap. Thus, the quota reduction in 2004 generated a quasi-experiment by creating a sudden discontinuity in the maximum supply of H-1B workers in the "treated" group of newly-hired employees of for-profit firms, relative to those in the "control" groups of newly-hired non-profit employees and experienced H-1B workers.

We empirically study the effects of the H-1B quota reduction using a triple difference strategy. We compare the hiring of new and established H-1B workers, across for-profit and non-profit sectors, before and after 2004. The extent to which the cap affects potential employment depends on the difference between H-1B demand and the cap. For this reason fiscal years 2008 and 2009 are particularly notable as aggregate demand for H-1B visas spiked and more than 150,000 applications were received within the first week of the filing period in each year. The US government responded by distributing all cap-subject permits with a lottery for these years. We examine whether the heightened intensity of rationing during the lottery years had stronger impacts on employment and other outcomes.

[1]The current quota includes these 65,000 general visas, plus 20,000 permits for new H-1B workers who have obtained an advanced degree from a US university.

Our analysis exploits a unique dataset on approved H-1B applications acquired through a Freedom of Information Act (FOIA) request. Individual-level information allows us to ascertain the education, experience, and occupation of each approved H-1B worker. We utilize variation in H-1B hiring within nationally-defined skill cells from FYs 2002 through 2009. These cells group workers according to education, experience, and occupation. Following in the tradition of Borjas (2003) and Ottaviano and Peri (2012), we consider each cell as a somewhat separate labor market since workers are closer competitors within rather than across cells. Information on the hiring firm and applicant allow us to parse H-1B approvals and skill cells into four groups defined by whether employers were for-profit or non-profit, and whether the application was for a new or established H-1B worker.

Our regressions address two broad issues. First, we quantify the decline in new H-1B employment in for-profit firms relative to what would have occurred in the absence of hiring restrictions. We find that cap-subject skill cells experienced an approximate 20-50% decline in H-1B employment relative to what it would have been if firm demand – rather than a legislative limit – determined hiring outcomes. H-1B employment fell by an additional 3-8% relative to its demand-driven level during fiscal years 2008 and 2009. Thus, the binding cap combined with the surge in applications led to a tremendous rationing in skilled, foreign-born labor market entry through the H-1B program.

Key to the identification, our triple difference design effectively removes differential pre-trends between for-profit and non-profit sectors and between new and existing hires for each skill-specific labor market. Furthermore, our results remain stable across a variety of specifications that progressively add more controls. We also perform an additional test demonstrating that other contemporaneous shocks were unlikely to have generated our central results and that the employment effects on new-H1B were not offset by employment effects for natives. Namely, we analyze the market for native-born workers using the same triple difference framework and find no evidence for a change in new native-born employment, in occupations similar to those of H1B workers, at for-profit firms after 2004. These results have an important implication. Since the reduced cap caused H-1B employment to fall without generating an offsetting rise in native employment, the results find no evidence for short-run native and H-1B labor substitutability.

Second, we assess whether the quota affected the selection of new H-1B employees and the types of firms participating in the H-1B program. We find evidence of a decline in H-1B recipients at the tails of the wage-offer distribution. This is particularly concerning at the high end of the wage distribution as it indicates that the cap reduced the inflow of foreign workers most likely to be highly productive and innovative. We also show that the reduced cap shifted the composition of workers toward computer-related occupations and Indian-born

workers. Moreover, the policy change redistributed H-1B labor toward firms that employ 50 or more H-1B workers each year and away from employers that use the program less extensively, thus increasing the concentration of H-1B workers in fewer firms. These results could be an indication that past experience and existing networks became more relevant in securing a share of the constrained supply of new H-1B workers.

The results help to inform both economic and policy debates. In terms of the economics literature, this paper is most directly related to the growing research on the economic impacts of the H-1B program. Several papers have shown that H-1B workers bring positive benefits to innovation, productivity, and labor markets (e.g. Kerr and Lincoln 2010, Peri, Shih and Sparber 2015, Ghosh, Mayda, and Ortega 2016). In contrast, Doran, Gelber, and Isen (2014) provide recent evidence from H-1B pilot lotteries showing that H-1B workers do not increase firm productivity or innovation.

By estimating how the cap has affected the inflow of H-1B workers, native employment and the types of workers and firms participating in the program, this paper can improve our understanding of the economic impact of this program. In this way we complement past work utilizing the change in the H-1B cap to examine unintended consequences on the international undergraduate student population. For example, Kato and Sparber (2013) show that applicant quality declined after the quota was reduced. Shih (2016) finds that the fall in the cap led to a decline in undergraduate enrollment that was especially pronounced among students from countries with higher expected returns to working in the United States. Amuedo-Dorantes and Furtado (2016) show that the cap altered the career choices of foreign students as they substituted away from private sector firms and toward research institutes.

Beyond direct questions about immigration, the H-1B quota also provides a rare opportunity to understand how labor markets respond to quantity constraints. Much work has been done on limits in the form of a minimum wage floor (e.g. Card and Krueger 1994, 2015), but since the US government does not normally impose limits on the types of workers firms may hire, there is little empirical evidence on the impact of quantity restrictions, and in particular, how they affect wages and the selection of workers. Our work improves understanding about the effects of quantity restrictions in the labor market.

In terms of policy debates, H-1B reform is part of the US government's current agenda. Concerns over skilled immigrants' potential to negatively affect American workers have been heightened by several cases receiving significant media attention in which companies replaced their domestic IT staff with foreign H-1B workers.[2] Descriptive statistics indicate an increasingly large share of H-1B visas are awarded to a very small subset of IT firms.[3] These IT

[2]High profile cases include Southern California Edison, Disney, and University of California – San Francisco. See Anderson (2015), Preston (2016), and Fernandez Campbell (2016) for press coverage.

[3]In a testimony to Congress on February 25, 2016, Ron Hira cites that 30% of new visas subject to

firms have been accused of using the H-1B program to outsource American jobs by hiring Indian computer workers at low wages. Our analysis evaluates whether changes in the cap ameliorate or exacerbate such issues. Moreover, the H-1B quota has changed quite dramatically over its history, and currently-competing proposals have called for both increases and decreases in the quota.[4] Given the regular use of the quota as a policy lever, it is important to evaluate its efficacy and consequences. Fortunately – and unlike other policy proposals[5] – prior experience provides the empirical means to study implications of changing the cap.

The rest of the paper is organized as follows. Section 2 describes the H-1B program in greater detail, including the drop in its quota that provides the natural experiment of interest. Section 3 provides the simple theory on how demand for H-1B workers is derived and how a binding supply constraint would affect the employment of specific groups of workers. Section 4 describes the data. Section 5 discusses our empirical specification and its identification, while Section 6 shows the empirical results. Section 7 concludes.

2 Skilled Workers and The H-1B Program

Since its inception in 1990, the H-1B visa program has been the primary channel for foreign-born college-educated professionals to enter the US workforce. Its dual intent allows foreign workers to petition for permanent residence, and therefore many who have entered on an H-1B visa have remained permanently in the country. Among skill-intensive sectors, the H-1B program has mostly affected science, technology, engineering, and mathematics (STEM) occupations: roughly 50% of the growth in the college-educated STEM workforce since 1990 is attributable to H-1B workers (Peri, Shih, and Sparber 2015).

Though the program has always been subject to an annual quota on new issuances, the limit has changed over time, sometimes quite significantly. While the limit of 65,000 H-1B permits annually had prevailed since 1990, this cap was not binding until 1997 and 1998. Congress increased the cap to 115,000 for 1999 and 2000, then to 195,000 in 2001. Moreover, 2001 marked the beginning of cap exemptions for employees of higher-education, non-profit, and government-research organizations. The high quota in 2001 was set to be renewed in

the quota were distributed to only 10 large IT services firms. Transcripts of the testimony are available at`https://www.judiciary.senate.gov/`.

[4]Proposed quota expansions include the SKILLS Visa Act – which would raise the cap to 155,000 – and S.744 – which would have allowed the cap to fluctuate according to market conditions within the 115,000-180,000 band. Proposed contractions include H.R. 3163 – which would have created additional restrictions for large employers – and the S.2365 Protecting American Jobs Act – which sought to reduce the quota by 15,000.

[5]Aside from the quota, other policy proposals have included enforcing a minimum wage for H-1B workers, increasing application fees, auctioning off visas, or intensifying monitoring for compliance.

late 2003. By October 2003, however, Congress declined to issue a renewal and the policy expired, reducing the quota back to the original limit of 65,000. A small expansion occurred under the H-1B Visa Reform Act in December 2004, which allotted an additional 20,000 permits to workers who earned a master's degree or Ph.D. from a US institution. However, the general H-1B quota has been reached before the end of each fiscal year since 2004.

Several steps are required for an individual to acquire an H-1B. First, she must obtain an employment offer from a US firm. This firm must file a Labor Condition Application (LCA) with the Department of Labor outlining the nature of the job and attesting compliance with H-1B regulations. After receiving LCA approval from the Department of Labor, the employer and worker combine efforts to complete the H-1B application. This application includes evidence of a formal job offer, the firm's approved LCA, an I-129 form that documents further information about the individual and the job, and other supporting documents. If awarded an H-1B, the foreign applicant may then move to the United States and begin work on the start date indicated in the H-1B application for a duration of 3 years. H-1B status can be renewed for a total duration of 6 years. Further stay in the United States beyond 6 years requires either a successful petition for permanent residency or a transfer to a different visa.

US Citizenship and Immigration Services (USCIS) oversees the H-1B adjudication process. Each April USCIS begins accepting H-1B applications from foreign individuals seeking permits that count toward the following fiscal year's cap (i.e., new applicants seeking employment at for-profit employers). For example, April 1, 2007 marked the opening of the filing period for H-1B applicants to submit H-1B petitions under the fiscal year 2008 cap. October 1st, 2007 was the earliest date on which an H-1B recipient could begin work. Traditionally, USCIS has used a first-come first-served approach to allocate permits, allowing H-1B applications to be filed and considered after April 1st until available permits were exhausted. The end of the application period is demarcated by the "final receipt date," which USCIS defines as the date on which they receive enough applications to fill the remaining available permits under the cap. Applications submitted after the final receipt date are not processed.

Figure 1 shows the evolution in the duration of the application period (i.e. days elapsed between the April 1 and the final receipt date) for each fiscal year. The final receipt dates are marked in red. Note that the cap was not binding prior to FY 2004 so there was no final receipt date during that period. A decrease in the application period implies that demand for the visa is growing relative to its supply. Importantly, the figure shows that the number of H-1B application days became progressively shorter after FY 2004, reaching its minimum in FYs 2008 and 2009 when USCIS faced overwhelming demand for H-1B permits within

just the first week of the application period. USCIS awarded all cap-subject H-1Bs by a computerized random lottery for FYs 2008 and 2009.

Our paper will empirically assess the consequences of the H-1B cap reduction. We will use a national-level approach that groups workers into different labor markets defined by skill. One difference from previous papers using this approach is that we add dimensions separating groups according to employer type (for-profit versus non-profit) and H-1B issuance type (new versus established H-1B workers). We assume that demand for comparably skilled workers evolves similarly across sectors and is driven by technological change. We also allow for overall productivity and demand to differ across sectors. We track the evolution in demand for new H-1B workers and evaluate the effect of introducing a binding cap in 2004 in for-profit firms by comparing them to similar non-profit hires. Before turning to the empirical analysis, we provide a brief theoretical sketch illustrating the determinants of demand for skilled foreign-born workers across experience groups and sectors. The framework allows us to justify the empirical specification.

3 Theoretical Framework

To motivate our empirical design and its assumptions, we present a simple model of production and relative labor demand. We consider two sectors (j): one made of firms producing goods and services for-profit (PR), and the other made of non-profit firms (NP). Each of these sectors produces one good or service with price p_j. Prices can change over time in response to demand. Non-profit firms earn a profit margin equal to zero, but this need not be true at for-profit firms. In the long-run, firms compete for workers of each skill type and experience level. Workers earn a wage equal to their marginal productivity. As workers are mobile, the wage for each specific type of worker is equalized across sectors.

Consider the following production function for output (Y) in sectors j and year t:[6]

$$Y_{jt} = A_{jt} \left(K_{jt}\right)^{\eta} \left(\sum_{k} \delta_{jkt} \left[\left(L_{jkt}^{New}\right)^{\gamma} + \theta_{jkt}^{Exp} \left(L_{jkt}^{Exp}\right)^{\gamma} \right]^{\frac{\rho}{\gamma}} \right)^{\frac{1-\eta}{\rho}} \tag{1}$$

In Equation (1) A_{jt} is total factor productivity (TFP) and K_{jt} is a combination of factors (such as physical capital, unskilled labor, and US-born skilled workers) used in production. The summation term in parenthesis, henceforth represented by Γ_{jkt}, is a nested CES combining foreign-born workers (L) of different skills k defined by occupation, education, and potential work experience. These workers are distinguished by their work experience in the

[6]Note this can be considered as an extension of the production function adopted in Ottaviano and Peri (2012) or Card and Lemieux (2001)

United States. Let L_{jkt}^{New} denote the labor input of foreign-born workers with no previous US working experience. In our context, these workers are on their first H-1B term and hence have 0 to 3 years of working experience in the US. The coefficients δ_{jkt} capture the skill-specific relative productivity for workers in sector j, while θ_{jkt}^{Exp} captures the productivity of experienced workers relative to new ones within a skill group. The parameter ρ determines the elasticity of substitution between workers of different skill groups, $\sigma = 1/(1-\rho)$. The parameter γ determines the elasticity of substitution between new and experienced workers, $1/(1-\gamma)$.

The key to our empirical strategy is that employment of each skill group is determined by relative demand when the H-1B quota is large and non-binding (as it was prior to 2004). Utility maximizing workers will arbitrage away wage differences by moving between the for-profit and non-profit sectors. Employment of new workers of each skill type satisfies the equalization of wages between for-profit and non-profit firms, $w_{kt}^{New,NP} = w_{kt}^{New,PR} = \omega_{kt}^{New}$, in each period [7]. Equalization of wages for experienced H-1B workers also occurs since they are not subject to any quota: $w_{kt}^{Exp,NP} = w_{kt}^{Exp,PR} = \omega_{kt}^{Exp}$. Wages equal to marginal productivity implies:

$$\omega_{kt}^{New} = (1-\eta) p_t^j A_t^j \left(K_t^j\right)^{\eta} \Gamma_{jkt}^{\frac{1-\eta-\rho}{\rho}} \delta_{jkt} \left[\left(L_{jkt}^{New}\right)^{\gamma} + \theta_{jkt}^{Exp}\left(L_{jkt}^{Exp}\right)^{\gamma}\right]^{\frac{\rho-\gamma}{\gamma}} \left(L_{jkt}^{New}\right)^{\gamma-1} \tag{2}$$

$$\omega_{kt}^{Exp} = (1-\eta) p_t^j A_t^j \left(K_t^j\right)^{\eta} \Gamma_{jkt}^{\frac{1-\eta-\rho}{\rho}} \delta_{jkt} \left[\left(L_{jkt}^{New}\right)^{\gamma} + \theta_{jkt}^{Exp}\left(L_{jkt}^{Exp}\right)^{\gamma}\right]^{\frac{\rho-\gamma}{\gamma}} \theta_{jkt}^{Exp}\left(L_{jkt}^{Exp}\right)^{\gamma-1} \tag{3}$$

To obtain the basic estimating equation when quotas do not bind, we first take the logarithm of both sides of (2) and (3) in each sector. Then we calculate the difference in log-wages and rearrange to obtain:

$$\ln\left(L_{jkt}^{New}\right) - \ln\left(L_{jkt}^{Exp}\right) = \frac{1}{\gamma-1}\left(\ln\theta_{jkt}^{Exp} + \ln(\omega_{kt}^{New}) - \ln(\omega_{kt}^{Exp})\right) \tag{4}$$

Finally, we difference Equation (4) across sectors $j = \{FP, NP\}$. Since new-workers' and experienced-workers' wages are common across the for-profit and non-profit sectors, this

[7] Wages for a type of workers may be different between profit and non-profit sector, due to a percentage premium or differential. The main results from this model follow even in the presence of such differential, as long as it does not change over time

difference simplifies to:

$$\begin{aligned} & \left[\ln\left(L_{PR,kt}^{New}\right) - \ln\left(L_{PR,kt}^{Exp}\right)\right] - \left[\ln\left(L_{NP,kt}^{New}\right) - \ln\left(L_{NP,kt}^{Exp}\right)\right] \\ = \; & \frac{1}{\gamma - 1}\left(\ln\left(\theta_{PR,kt}^{Exp}\right) - \ln\left(\theta_{NP,kt}^{Exp}\right)\right) \end{aligned} \tag{5}$$

Equation (5) holds if firms are on their demand curve and workers are free to move across sectors. We allow the experience-specific productivity for each skill group, $\ln\left(\theta_{jkt}^{Exp}\right)$, to have a component that is unique to the NP or PR sector. This is separable from a skill-specific component common between sectors that evolves over time and varies across skills due to differences in relative demand, relative prices, or TFP. The double differencing removes skill- and sector-specific productivity (and prices). Only the relative productivity of new and experienced workers remains. If we assume that experience-specific productivity can be decomposed into $\ln\left(\theta_{jkt}^{Exp}\right) = \ln\left(\theta_{kt}^{Exp}\right) + \ln\left(\theta_{j}^{Exp}\right)$, then the double difference in relative demands expressed in equation (5) will be represented by a constant factor common to all skills, $\alpha = \frac{1}{\gamma-1}\left(\ln\theta_{PR}^{Exp} - \ln\theta_{NP}^{Exp}\right)$.

Combining the above assumptions, allowing for classical measurement error in the employment variables, and rearranging equation (5) provides us with Equation (6).

$$\left[\ln\left(L_{PR,kt}^{New}\right) - \ln\left(L_{PR,kt}^{Exp}\right)\right] = \alpha + \left[\ln\left(L_{NP,kt}^{New}\right) - \ln\left(L_{NP,kt}^{Exp}\right)\right] + \varepsilon_{kt} \tag{6}$$

The above relation holds in the absence of quotas, when relative labor demand and free mobility across sectors combine to determine relative employment. Equation (6) establishes that the demand for new relative to experienced workers in the for-profit sector follows the same variation over time as relative demand in the non-profit sector up to a constant (α) and a zero-mean random error (ε_{kt}). One way of interpreting equation (6) is that the relative employment of new and experienced H-1B workers in the non-profit sector correlates with that of the for-profit sector when supply responds to demand.

Now consider when the fiscal year 2004 binding quota for new H-1B workers, $\overline{L^{New}}$, was introduced in the for-profit sector only. This rationing causes the difference $\ln\left(L_{PR,kt}^{New}\right) - \ln\left(L_{PR,kt}^{Exp}\right)$ to depart from what is predicted in Equation (6) and a negative gap will arise. The absolute value of this gap is large when the quota is small and/or when the underlying relative demand for new relative to experienced workers is large. This latter condition is captured by relative non-profit sector demand, $\ln\left(L_{NP,kt}^{New}\right) - \ln\left(L_{NP,kt}^{Exp}\right)$.

The quota for new H-1B workers in the for-profit sector has been binding since 2004 when it was significantly reduced by 66% (from 195,000 to 65,000). In FYs 2008 and 2009 an exceptionally high level of demand led the number of H-1B applications to exceed the

cap in the first week of the filing period. Hence, we can augment expression (6) with the possibility of a rationing gap opening after 2004 and becoming larger in 2008 and 2009 as follows:

$$\begin{aligned}\left[\ln\left(L_{PR,kt}^{New}\right)-\ln\left(L_{PR,kt}^{Exp}\right)\right] &= \alpha+\left[\ln\left(L_{NP,kt}^{New}\right)-\ln\left(L_{NP,kt}^{Exp}\right)\right]+ \\ &+\beta_1 * I(Year \geq 2004)+\beta_2 * I(Year=2008,2009)+\varepsilon_{kt}\end{aligned} \tag{7}$$

The indicator $I(Year \geq 2004)$ equals one starting in 2004 so that the coefficient β_1 captures the departure of new H-1B employment among for-profit relative to non-profit firms due to the binding cap. The size of this coefficient represents the estimated percentage deviation of capped H-1B workers relative to unconstrained demand. Similarly, $I(Year = 2008, 2009)$ is an indicator equal to one in FYs 2008 and 2009 so that $\beta_1 + \beta_2$ captures the further distance between the cap and demand when demand increased. Equation (7) will be the basis of our empirical analysis.

4 Data

Our data comprises individual-level information from I-129 forms of processed H-1B applications between fiscal years 2002 and 2009, obtained through a Freedom of Information Act (FOIA) request. This is an ideal period to analyze the effects of a binding cap. First, it corresponds to an expansionary cycle ending just prior to the full onset of the Great Recession. Second, the fall in the H-1B cap occurs towards the middle of this time period. Third, hiring in the for-profit sector in the years prior to 2004 was essentially unconstrained as the quota did not bind. Only after the cap fell did the quota bind, growing progressively more imposing as the economy expanded before the Great Recession.

This dataset contains information on the employer, employee demographics, wages, occupation, and other characteristics that allow us to determine whether the permit would count toward the H-1B cap. We impose several sample selection criteria. We remove applications that were denied, allowing us to identify H-1B recipients rather than simply the count of processed applications. We retain H-1B recipients age 21-65 (inclusive), born outside of US territories, who have obtained at least a bachelor's degree, and who are working in identifiable occupations. To remove outliers and reduce measurement error, we trim workers in the top and bottom 0.5% of the H-1B wage distribution.

We separate individuals into whether they were employed at for-profit or non-profit firms. The latter group consists of colleges, universities, and non-profit research institutions that

were always exempt from H-1B quotas during the period of analysis. We also separate individuals into applicants for new H-1B employment versus established H-1B workers. This latter group consists of H-1B employees who receive an extension of their visa with their current firm as well as those who changed employers.[8]

We then aggregate workers into skill cells representing distinct labor markets. We take two approaches. The first identifies a skill cell according to a worker's occupation, education, and experience. The second uses occupation and education only. While potential experience is often used to differentiate skill groups (e.g. Card and Lemieux 2001 or Borjas 2003), education and occupation more strongly characterize the specific skills used in jobs. Cells based only on those two features are likely to be strongly differentiated and represent well-defined labor markets.

We use 16 broad occupational groupings.[9] The largest, Computer-Related Occupations, accounts for 40% of new H-1B issuances. Not surprisingly, occupational composition varies substantially across the for-profit and non-profit sectors. Computer occupations represent 50% of new issuances among for-profit firms but only 2.5% of new non-profit employment (though they rank among the top five occupations among new hires in each sector). Occupations in education account for over half of new non-profit H-1B employment but just 1% of new for-profit employment. Other important for-profit occupations for new hires include Managers and Administrative Officials[10] (17%), Engineers (14%), Medical and Health Professionals (4.6%), and Social Scientists (2.9%). Important non-profit occupations include Medical and Health Professionals (18%), Life Scientists (12%), and Mathematicians and Physical Scientists (4.2%).

Individuals are grouped into four education levels: Bachelor's (45% of new H-1B recipients), Master's (35%), Professional (6%), and Doctorate (14%). Again, representation varies across sector. Doctorates comprise 48% of new non-profit employment, whereas Bachelor's and Master's degree holders comprise 53% and 40% of new for-profit H-1Bs, respectively.

Consistent with the past literature, we deduce total potential experience through an intersection of age and educational attainment. However, our dataset presents unique challenges. First, as a temporary work permit program for foreign-born labor, one can correctly infer that most H-1B recipients have limited work experience within the US labor market. About half of new H-1Bs are awarded to people under age 30, and 90% are awarded to people under

[8] As a technical point, an established H-1B worker at non-profit firm who then seeks for-profit employment would count toward the cap.

[9] Aggregation is based upon the USCIS Department of Homeland Security Form M-746, I-129 Dictionary of Occupational Titles (DOT) Codes.

[10] This is a broadly-defined grouping that includes not just managers but accountants, auditors, and related occupations as well (Dictionary of Occupational Title codes 160-189).

age 40. Hence there is not a lot of experience variation within the program. Second, whereas the national-approach usually defines cells according to educational attainment ranging from high school drop outs to college graduates, our data is from a much narrower range of educational attainment that is limited to college graduates. This may reduce the differentiation across skill groups.

Nonetheless, we proceed as follows: We first define years of experience as the difference between a person's age and their expected age upon completing their highest degree. Expected ages at graduation are 23 for bachelor's, 25 for master's, 26 for professional, and 28 for doctorate. Next we place workers into (approximately) five-year experience groups: those with 5 or fewer years of expected experience (including observations with negative values), 6-10 years, 11-15 years, and so on. The eighth and most experienced group has more than 35 years of expected experience. Not surprisingly, less-experienced workers are highly represented. Workers in experience groups one (57%), two (24%), and three (10%) account for more than 90% of new H-1B issuances. These values do not vary much across for-profit and non-profit sectors.

The year (8), occupation (16), education (4), experience (8), and firm-type (2) groupings imply 8,192 potential jkt (sector-skill-year) observations. We are interested in how a policy change proportionally affected employment of H-1B recipients in each skill group, so we measure employment quantities in natural logs. This leaves the dataset with 4,556 observable first-differences between new and established employment, $\ln\left(L_{jkt}^{New}\right) - \ln\left(L_{jkt}^{Exp}\right)$, and 3,512 observations in which first differences are defined for both $j = PR$ and $j = NP$ (hence, 1,756 of the potential 4,096 skill-k period-t cells have defined values for the double-difference between the for-profit and non-profit sectors). The average value of log H-1B issuances to new employees is 2.34 with a standard deviation of 2.02. The distribution is heavily skewed to the right. Log wages paid to these workers have an average value of 11, a standard deviation of 0.41, and are normally distributed. Since many experience groupings result in few observations, we also perform regressions that eliminate the eight experience distinctions. This results in 1,024 potential jkt observations, 938 observable first-differences, and 894 first-differences defined for both sectors. Log new H-1B issuances have an average of 4.09 and standard deviation of 2.32. Log wages average 10.93 with a standard deviation of 0.33.

Given the variation in importance of occupations and education levels across sectors, there could be some concern that the unique labor markets identified in our skill cells exclusively exist in only one sector or the other so that comparisons of skill cells between for-profit and non-profit firms cannot be done. Figure 2 helps to alleviate this concern. When new H-1B issuances for the entire period are aggregated to the cell level, there is a high degree of positive correlation between the number of for-profit and non-profit issuances. Cells that

contain large numbers of new for-profit workers tend to contain large numbers of non-profit workers as well.

The empirical design compares changes in new relative to experienced H-1B employment between the for-profit and non-profit sector. Figure 3 provides a sense of trends in H-1B issuances from FYs 2002-2009 in the for-profit and non-profit sector. The figure shows the average cell differences in log-issuances between new and established H-1Bs (described further in the next section) for the non-profit (solid line) and for-profit (dashed line) sectors. New issuances were fairly constant relative to established ones prior to the 2004 cap restriction. Additionally, there is no evidence of differential pretrends across sectors. The difference subsequently declined – a regularity that holds for both the for-profit and non-profit sectors. This fall, however, was more severe in the for-profit sector than it was for cap-exempt employers. Our empirical methodology described in the next section will take a more systematic approach to assessing whether differences in these two trends appear after the cap was reduced for fiscal year 2004 and beyond, and whether differences further increased during lottery years.

5 Empirical Methodology: Estimating the Effect of a Binding Cap

We formalize our triple difference strategy around the estimating equation in (8), which represents a simple transformation of the model derived in (7).

$$\begin{aligned} \ln\left(H1B_{jkt}^{New}\right) - \ln\left(H1B_{jkt}^{Exp}\right) \;=\; & \\ & \alpha + \beta_1 \cdot t_{\geq 2004} \cdot d_{FP} + \beta_2 \cdot t_{\geq 2008} \cdot d_{FP} \\ & + d_{FP} + \sigma_k + \sigma_t + b\varepsilon_{kt} \end{aligned} \tag{8}$$

The dependent variable in (8) represents the difference in the natural log of H-1B permits awarded to new workers relative to those awarded to experienced workers within a particular sector (j), skill group (k), and year (t). The indicator $t_{\geq 2004}$ takes a value of one in fiscal year 2004 and after, while $t_{\geq 2008}$ is equal to one for years 2008 and 2009. The dummy d_{FP} is equal to one for observations in the treatment for-profit sector; it equals zero for observations in the control non-profit sector. The model also includes skill-group fixed effects, σ_k, and year dummies, σ_t to absorb variation in productivity across skill groups and time. The coefficient β_1 represents the proportional reduction of new H-1Bs issued to workers in the for-profit sector the decrease in the quota in FY 2004. β_2 represents the additional rationing when

firms faced particularly large H-1B demand in FYs 2008 and 2009.

Causal inference in the triple-difference framework requires several assumptions. First, the policy must not have been a response to differentially changing conditions in the labor market for new foreign workers at for-profit firms. In this sense, studying the fall in the H-1B cap in 2004 is arguably advantageous as it was not a new policy, but rather a reversion to a pre-existing policy. The high H-1B quotas in the early 2000s were contingent on Congressional renewal. Congress had once previously renewed the high quota, and even went on the raise the cap further in FY 2001 (Shih 2016). This ex-ante uncertainty of Congressional action circa FY 2004 likely made the fall in the quota unpredictable.

Second, the triple difference should not exhibit a trend pre-2004. Though the period with a non-binding cap is short, Figure 3 suggests no visual pretrend. Additionally, our analysis will employ a variety of controls to assess robustness. The baseline empirical specification controls for skill cell and year fixed effects. This should account for any productivity difference specific to particular skill cells and for yearly changes between the for-profit and the non-profit sector. Other specifications using year dummies and skill-group by sector fixed effects deliver robust results.

Third, the estimated impacts must not be attributed to any other confounding shocks that differentially affected hiring of new relative to experienced H-1B workers at for-profit versus non-profit firms. To this end, we perform a test by examining native-born workers, who are not subject to the quota. Assuming a similar evolution for the relative demand of native and foreign workers in the same skill cell, evidence of a systematic employment difference arising after 2004 for natives might signal that other factors rather than H-1B policy could be at work. Our results do not indicate any differential hiring response among new native workers relative to experienced ones at for-profit firms after 2004. This suggests that our estimates are credibly driven by H-1B policy and not by other confounding economic shocks.

6 Empirical Results

6.1 Effect on the Number of H-1B Workers and on Native Workers

We estimate specification (8) to assess the effect (β_1) of reducing the cap on new H-1B employment relative to what would have occurred under a non-binding constraint. As we use newly issued H1B relative to established in for-profit firms as treated group and the same relative value in non-profit firms as control, our identified effect is really a relative effect and could derive from the decline in the for profit H1B or from the increase in non-profit H1B,

which could be both a consequence of the cap. Results are reported in Table 1. Columns 1-3 (left panel) use skill groups defined by occupation, education, and potential experience. Columns 4-6 (right panel) use skill groups defined by occupation and education only. The columns within each panel represent specifications in which we progressively add controls. The first includes skill cell fixed effects and indicators for the collective groups of cap-years and lottery-years. The second replaces the cap-year and the lottery-year dummies with fixed effects for each individual year of the dataset. The third column balances the panel so that both sectors $j = PR, NP$ are observed in a kt cell. It also replaces sector and skill indicators with sector-by-skill $(j * k)$ fixed effects.[11] Standard errors are clustered by skill cell in the first two columns and by skill*sector dyad in the third column.

Our interest is in the coefficient estimates of β_1, from the interaction Cap Year*Treated (i.e. $t_{\geq 2004} \cdot d_{FP}$), and β_2, from the interaction Lottery Year*Treated (i.e. $t_{\geq 2008} \cdot d_{FP}$). The estimates of β_1 indicate that H-1B restrictions introduced in 2004 reduced new H-1B hiring at for-profit firms between 18 and 40 log points (between 20 and 50%). All estimates are statistically significant at the 5% level and most are significant at the 1% level. As restrictions became more intense in FYs 2008 and 2009, because firm demand for new H-1B workers was so large that all cap-bound permits were allocated by lottery, H-1B hiring declined by an additional 3 to 8 log points, though estimates are imprecise. Certainly these results reveal that the H-1B cap tightening made the quota binding and reduced H-1B employment at for-profit firms.

Next we analyze whether similar changes were observed in the relative employment of native-born workers after 2004. These results serve as a check on the assumption that there was no deviation in relative demand before or after 2004. They also serve as test of substitutability between H-1B and native workers. Using data from the American Community Surveys, we define new native skilled (college-educated) workers in each skill cell as those having three or fewer years of work experience. This is done to mirror the initial three years duration of the initial visa period for new H-1B workers. We then use two separate criteria to define experienced workers. First, we use natives who have 4-6 years of experience, which aligns with H-1B workers who have renewed their visa for a second three-year period. Second, we use all native workers with four or more years of experience. Because we cannot differentiate between general work experience and work experience in the United States for natives, we are only able to use skill cells defined by occupation and education.

Table 2 presents results from regressions of (8) using differences in log native employment

[11] This third specification delivers coefficient estimates equal to those of a simple transformation of (7) that would regress $\left[\ln\left(L^{New}_{PR,kt}\right) - \ln\left(L^{Exp}_{PR,kt}\right)\right] - \left[\ln\left(L^{New}_{NP,kt}\right) - \ln\left(L^{Exp}_{NP,kt}\right)\right]$ on a constant, $t_{\geq 2004}$ and $t_{\geq 2008}$ indicators, and skill cell (k) fixed effects.

as the dependent variable. The results are somewhat noisily estimated, but they do not suggest any change in relative demand for native workers after 2004. The gap between new and established native employment in for-profit relative to non-profit sectors did not change significantly after 2004. The point estimate on the Cap-Year*Treated interaction equals about plus or minus ten log points with an equivalent standard error. This evidence supports the idea that the decrease in H-1B employment was due to the fall in the quota and was not attributable to contemporaneous shocks and/or omitted variables. These results also indicate that the fall in H-1B employment did not produce a spillover benefit, whereby for-profit firms facing restrictions on foreign workers began hiring natives instead.

In summary, the reduction in the H-1B cap from 195,000 to 65,000 per year in 2004 had its intended impact. The hiring of new foreign-born H-1B workers at for-profit firms fell by roughly 20-50% relative to new foreign-born H-1B workers at non-profit. While not surprising, we are the first to empirically assess the efficacy of the cap reduction. Further, we find such effects were not accompanied by changes in native employment at for-profit firms. The fact that large declines in H-1B employment were not offset by gains in native employment suggests low substitutability between native-born and H-1B workers in the same skill groups. The reduction in new H-1B workers after the fall in the quota sets the stage for analyzing the effect of policy on H-1B composition, which we turn to next.

6.2 Effect on the Composition of H-1B Workers

Our empirical model assumed workers within a skill group and firms were homogeneous. In reality, immigrants and the firms that hire them are heterogeneous. Changes in the characteristics of selected H-1B workers, and the types of firms participating in the program could all be important and unintended consequences of immigration policy.

Much of the literature on selection models migration as an individual choice made under constraints, thereby revealing that those who benefit most are the ones more likely to migrate.[12] In practice, however, selection in the H-1B program occurs within a narrow range of college-educated workers and individual choice is not the sole factor – firms play a strong role in selecting workers. Moreover, differential costs in hiring H-1B workers across firms and sectors implies differential levels of efficiency in dealing with the constraints imposed by the quota.

These factors make it difficult to theoretically predict the type of selection generated by

[12]Borjas (1987) provided the earliest the formalization of the Roy (1951) model to study migration. More recent work by Chiswick (2000), Grogger and Hanson (2011), Belot and Hatton (2012), and Brücker, Capuano, and Marfouk. (2013) argue that migrants are, in general, positively selected. See Ortega and Peri (2013) or Bansak, Simpson, and Zavodny (2015) for a review.

the policy change. Analyses of how policy alters immigrant selectivity are, in general, rare.[13] We add to this literature by exploring the potential for the H-1B cap reduction to have altered the selection of H-1B workers that ultimately arrive in the US. We do this without a clear prior of what the direction of selection should be.

6.2.1 Effect on Worker Quality

Given that critics have argued that the H-1B program does not attract the highest ability workers into the country[14], we first examine how the quota reduction impacted worker quality, by examining wage offers on the H-1B application. If tighter caps lead to a selection of higher quality workers, then efforts to further reduce the quota might be justifiable on efficiency grounds. Alternatively, if tighter caps disproportionately reduce the number of high ability workers, then further contractions will exacerbate concerns that H-1B limits inhibit US productivity.

On the one hand, the quota reduction in might increase wages due to the greater scarcity of foreign labor. Wages could also rise due if firms choose to only to seek out foreign workers with very high marginal productivity and ability. Alternatively, the average quality and wages might fall following the quota reduction. High quality workers likely have an abundance of employment opportunities outside the US. Coveted workers might elect to work elsewhere when faced with employment uncertainty due to rationing. In turn, firms may pursue a safer strategy of hiring lower quality workers, helping them to save on costs, rather than spending resources pursuing high achievers.

Table 3 performs regressions of (8) using differences in log average wages as the dependent variable. New H-1B workers at for-profit firms continue to constitute the treatment. The format of Table 3 follows that of Table 1. The reduced H-1B cap beginning in 2004 has no statistically significant relationship with wages. Point estimates of the Cap-Year*Treated interaction are small, ranging from a 0.3% wage drop to a 1.1% wage increase. When using cells defined by occupation, education, and experience, however, we do see evidence for a 6.2 to 7.8% wage decline in lottery years for the treated group of new H-1Bs in for-profit firms.

Altogether, the average wage results are rather imprecise and non-robust. A potentially more troubling limitation, however, is that average effects could mask heterogeneous migration effects along the wage distribution. That is, we know from Table 1 that restrictive H-1B caps reduced total new H-1B employment at for-profit firms, but neither the quantity results in Table 1 nor the average wage results in Table 3 are informative about whether the quota had differential effects for the inflows of low, medium, and high wage workers.

[13] See Kato and Sparber (2013) and Chen (2005) for examples.
[14] See Matloff (2008) or Hira (2007), for example.

To examine this question, we first divide H-1B workers into quintiles of the H-1B wage distribution in which they would have fallen in 2002. The lower-end wage cutoffs for each quintile in real 2010 dollars are {\$0; \$41,088; \$51,660; \$66,550; and \$86,100}. We then return to the triple difference model (8), simply replacing the aggregate sums of H-1B workers in the dependent variable ($H1B_{jkt}^{New}$ and $H1B_{jkt}^{Exp}$) with the sums of H-1B workers from a given quintile ($H1B_{jkt}^{q,New}$ and $H1B_{jkt}^{q,Exp}$, for $q = 1...5$). We then estimate five separate regressions, one for each quintile of the wage distribution.

Figure 4 displays the pertinent estimates from regressions analogous to Columns 3 and 6 from Table 1 that incorporate year and sector-by-skill cell fixed effects. The vertical axis of Figure 4 measures the combined effect of the cap and lottery ($\beta_1 + \beta_2$) on the gap in log job offers between new and established workers at for-profit firms relative to non-profit employers. Markers represent the point estimates, and two-standard-error confidence intervals are provided for reference. The horizontal axis indicates the quintile of the wage distribution. The top panel uses skill cells defined by occupation, education, and experience. The bottom uses the occupation and education cell definition.

This exercise reveals heterogeneity that is masked when looking at aggregate employment or average wages. New, for-profit H-1B employment from the middle of the wage distribution exhibits no statistically significant change arising from the restrictive H-1B quota. In contrast, employment losses are concentrated at the tails of the distribution, indicating that H-1B restrictions most strongly reduced the number of workers coming from the top and bottom 20% of the H-1B wage distribution. In terms of average wage effects, these employment losses offset each other, resulting in the insignificant average wage estimates of Table 3.

In terms of policy ramifications, Figure 4 is perhaps most troubling in that it reveals a particularly sharp decline in employment from the top-end of the wage distribution even after conditioning on occupation, experience, and education. The binding H-1B cap reduced the number of workers who were likely to have been among the most talented and productive foreign individuals seeking US employment. Since employment among the lowest wage workers also fell, it implies that policy has caused the composition of H-1B workers to become more concentrated among workers with middle-levels of skill or ability.

6.2.2 Effect on Other Worker Characteristics

A restricted quota could generate changes in the characteristics of hired H-1Bs beyond their productive skill level. For example, it could have altered the cost of hiring some types of workers due to network effects, connections to particular firms, or firm productivity and expertise. Two groups that have garnered significant attention are Indian-born (45% of all

H-1B issuances in this period) and computer-related (44%) workers, who jointly comprise one third of H-1Bs. Insight into whether cap restrictions alter the proportion of these workers entering the US is important for responding to H-1B critics who argue that the program does not provide any meaningful contribution to innovation or productivity, but instead provide a vehicle for firms to import large numbers of low-wage Indian IT workers that displace American computer workers.[15] This section explores how the Indian-born and computer-related occupational composition of H-1B recipients has evolved in response to the cap.

Our regression strategy uses a simple modification of the triple-difference specification in (8). We replace the gap in log employment ($\ln\left(H1B_{jkt}^{New}\right) - \ln\left(H1B_{jkt}^{Exp}\right)$) in the dependent variable with the gap in the share of H-1B employment meeting characteristic c ($\frac{H1B_{jkt}^{c,New}}{H1B_{jkt}^{New}} - \frac{H1B_{jkt}^{c,Exp}}{H1B_{jkt}^{Exp}}$). Specifications include sector-by-skill cell ($j * k$) fixed effects and year indicators, analogous to Columns (3) and (6) of the baseline Table 1 specifications.

Table 4 displays the results. Specifications in columns (1) and (2) define c as employees born in India, a group that comprises 44% of the entire sample. The regressions identify whether the reduced H-1B cap affected the proportion of Indian-born workers hired by for-profit firms. Column (1) defines skill cells by occupation, education, and experience. Column (2) defines skill cells only by occupation and education.

In both cases, the effect is small. The first point estimate finds a 2.3 percentage-point increase in the Indian-born share of new H-1B employment at for-profit firms. However, the estimate does not differ from zero at conventional significance levels. Some of this imprecision might be due to a lack of data variation: about $\frac{2}{3}$ of the observations have Indian-share values that equal zero. The higher level of aggregation defined by occupation and education cells in Column (2) helps decrease the preponderance of zero values. The estimate rises to a 3.9 percentage-point increase in the Indian-born share of new H-1B employment at for-profit firms. The coefficient is significant at the 10% level. These results indicate that quota restrictions may have also had the unintended effect of shifting the composition of new H-1B workers towards having Indian-origin and away from other source countries.

Column (3) examines changes in occupational composition and defines c as computer-related workers. This forces us to leave our usual skill cell definitions in favor of one that defines k according to education and experience only, thereby greatly reducing the number of available observations. Nonetheless, regressions uncover important significant effects. The proportion of new job offers extended to computer-related workers at for-profit firms grew by 5.5 percentage-points as a result of the H-1B cap, and it grew another 4.6 percentage points during the period of heightened H-1B demand in fiscal years 2008 and 2009. Again,

[15] See Hira (2007, 2016).

this suggests an unintended consequence in that policy did not affect all sectors equally.

These results are fascinating, in part, due to their irony: many opponents of the H-1B program who advocate stricter limits lament the number of issuances to Indian-born computer-related workers. But those same limits have led to a compositional shift favoring those workers. These findings are also interesting in their implications for underlying economic behavior. Namely, job search costs and uncertainty in the H-1B application process could favor firms with past H-1B employment experience and new workers with existing labor market networks. The next section examines heterogeneous effects across firms, and regressions identify results consistent with this possibility.

6.3 Effect on Firm Participation

The reduction in the number of H-1B visas available altered the composition of H-1B workers, but the effects might not be limited to recipients. The policy change could alter the types of firms participating in the H-1B program as well. Firms' costs of participating in the H-1B program can be quite significant even in the absence of a quota. In addition to application fees that can range in the thousands, firms often need legal assistance to deal with the adjudication process. This can incur additional costs for firms that need to outsource such legal tasks. Moreover, firms cannot escape search costs in the hiring process, or costs associated with the uncertainty regarding the true productivity of a worker.

Costs rise in the presence of a restrictive quota. USCIS's allocation procedure requires firms to act quickly to extend offers to desired candidates before permits are exhausted. Uncertainty also rises – even after identifying its desired workers, the lotteries meant that there was no guarantee that firms would be legally allowed to hire them. These costs could vary across firms for a variety of reasons. Large firms with in-house legal teams might have an easier time navigating the bureaucratic hiring process. They might also be better equipped at absorbing labor shocks that arise when their actual number of job offers winning the H-1B lottery is greater or less than what the firm had expected. Thus, it is conceivable that the increased uncertainty induced by strict H-1B quotas has had a differential effect across employers.

Our dataset includes the firm name of each individual's employer but with an important caveat: Data on this variable is subject to a large degree of measurement error created by alternative firm name spellings and typos. For example, while "Microsoft Corp" accounts for 99% of all firm names beginning with "Microsoft" in Redmond, Washington for fiscal year 2007, there are also observations for "Microsoft Coporation (sic)," "Microsoft Coprporation (sic)," and "Microsoft Inc," among several other related entries. Though performing manual

or automated routines to group names of likely-identical firms would be possible, this too could generate measurement error. For the exercise in this section, we take only minimal steps to harmonize firm names and rely primarily on the information provided by USCIS, although we do drop individuals whose employer names are missing or unknown. The heaviest for-profit users of the H-1B program during this period were Infosys Technology Limited, Microsoft Corporation, Cognizant Technology Solutions US Corporation, Wipro Limited, and Intel Corporation. The heaviest non-profit users were Yale University, University of Michigan, Stanford University, and Columbia University. Hospitals and medical clinics are among the most significant non-educational cap-exempt H-1B employers.

As a first step in empirically assessing whether the H-1B quota led a shift in the types of firms hiring new H-1B workers, we consider the unequal distribution of H-1Bs across firms over time. The four panels of Figure 5 plot Lorenz curves for four separate H-1B groups: (1) new hires at for-profit (cap-bound) firms, (2) new hires at non-profit (cap-exempt) firms, (3) experienced hires at for-profit firms, and (4) experienced hires at non-profit firms. Each panel plots curves for the pre-binding-cap period (2002-2003), the binding-cap pre-lottery period (2004-2007), and the lottery years (2008-2009). The vertical axes measure the cumulative percentage of H-1B issuances. The horizontal axes measure the cumulative percentage of firms. A higher concentration of H-1Bs among a smaller number of employers would be indicated by a shift of the Lorenz curve to the lower-right; a Lorenz curve of complete equality would fall along a 45-degree line.

As can be seen in the graphs, the curves for pre- and post-cap periods are similar in all cases except for that of new hires at for-profit firms. Prior to the cap reduction, 80% of for-profit firms accounted for 40% of new H-1B hires. This concentration grows after the fall in the cap, whereby 80% of firms account for only 20% of new hires. This growth in the concentration of H-1B visas among firms does not appear in any of the other groups.

Figure 6 provides another visual representation of the rising concentration of H-1B employment among for-profit firms. First we compute two separate indices of inequality for each of the four groups of interest. The first is a Gini coefficient arising from annual Lorenz curves analogous to those in Figure 5. The second is a Herfindahl Index of concentration, which measures the sum of squared H-1B employment shares across firms in each of the four groups. We then calculate the double-difference of each index, measuring the gap in inequality between new and established workers at cap-bound versus cap-exempt employers. Consistent with Figure 5, both indices rise after 2004, suggesting new H-1B hires are increasingly concentrated among fewer for-profit firms.

To formalize these concepts in a regression framework, we define firm characteristic c

as "large" H-1B employers that hired 50 or more total H-1Bs in a given year.[16] As stated earlier, large firms possess economies of scale that likely allow them to maintain lower costs of hiring H-1B workers. Firms with fewer H-1B workers, and therefore less experience with the program, often need to outsource the cost of hiring H-1B workers to legal firms. A fall in the ex-ante payoff to hiring a foreign skilled worker due to declines in H-1B limits might induce small firms to reduce participation.

Analogous to our exploration of heterogeneous implications across worker characteristics, our regression strategy in this section measures the difference in the proportion of new versus established H-1B workers hired by large H-1B firms. The regression in Column (4) of Table 4 uses occupation*education*experience skill cells; Column (5) uses occupation*education cells. We again see that the level of aggregation plays a role in determining the significance of coefficients. In Column (4), the point estimate suggests large H-1B firms see a small and insignificant 1.5 percentage-point rise in their proportion of new, for-profit, H-1B workers. However, two-thirds of the share values equal zero. With the higher level of aggregation in the cell construction used in Column (5), the point estimate rises substantially and is significant at the 5% level. The binding cap causes large firms to account for a 5.9 percentage point increase in the share of new H-1B employment at for-profit firms. Thus, despite the decrease in total new, for-profit, H-1B employment, large firms have an advantage in hiring the workers they seek.

In terms of composition, declines in new H-1B hiring are concentrated among firms that use the program sparingly. The change in H-1B policy appears to have shifted foreign labor resources away from firms that employ H-1B workers less-intensively toward larger ones that might be better able to provide legal services for hiring and/or are more capable of absorbing employment shocks generated by the lottery. The change in the types of firms participating might also be related to changes in the types of workers that were hired. The evidence for compositional changes of firms and workers is suggestive of important network effects. Policy changes restricting inflows of H-1B workers are more punitive to nativities, occupations, and employers with less experience with the H-1B program.

7 Conclusion

The United States imposed an annual cap of 195,000 new H-1B hires in the early 2000s. When Congress declined to renew legislation maintaining this limit, the cap reduced to 65,000 beginning in fiscal year 2004. With the addition of 20,000 visas available to foreign-

[16]We do not use a static definition based on a pre-period base-year to avoid measurement error. We do not want the regressions to be confounded by firm names that might change over time.

workers who have obtained advanced degrees from US universities, the cap increased to 85,000 in 2005 where it has remained ever since. Rising H-1B interest among foreign workers and US firms that wish to hire them has led all new visas for employees of for-profit firms to be allocated by lottery in recent years.

We presume that by letting the 195,000 quota lapse, policy-makers intended to reduce new H-1B employment at most firms. In this goal, the policy was effective. Assuming that non-cap bound firms continued to hire on their labor demand curve, we estimate that new H-1B employment at cap-bound firms declined roughly 20 to 50% compared to what it otherwise would have been.

However, the cap restriction also generated other consequences that were presumably less-intended. Perhaps most troubling, H-1B declines are concentrated at the lowest and highest ends of the wage distribution. In the latter case, this suggests that it is the highest ability workers with the highest earnings potential who are most likely to be turned away from entering the US labor market as a result of H-1B restrictions. Given the potential for productivity-enhancing technological gains generated by H-1B workers – as identified in other research – this loss could reverberate throughout the economy.

Other important effects are distributional. H-1B restrictions have led to a compositional shift in new H-1B employment favoring Indian-born workers, computer-related occupations, and firms that use the H-1B program heavily. One interpretation of these results is that acute visa restrictions increase the importance of labor networks, economies of scale in hiring foreign-labor, and skill in navigating the H-1B program.

Expanded work on the consequences of immigration policy on the selection of workers and firms remains crucial. As current efforts turn towards reforming immigration policy, legislators have placed a renewed emphasis on the H-1B program. Vehemence against the current state of the H-1B program – the large amount of Indian computer scientist, the domination by huge IT firms, and the potential displacement of native workers – has generated increased pressure for further quota restrictions. Our work indicates that further reducing the H-1B cap is likely to skew the characteristics of the H-1B program further in this direction.

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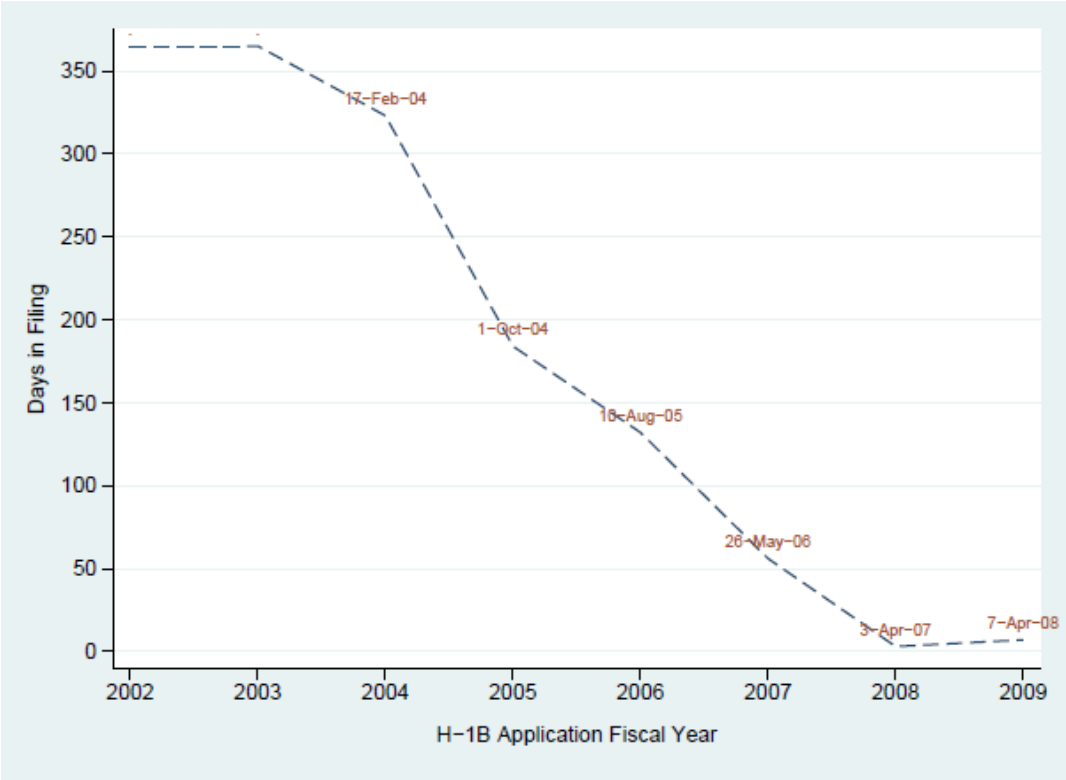
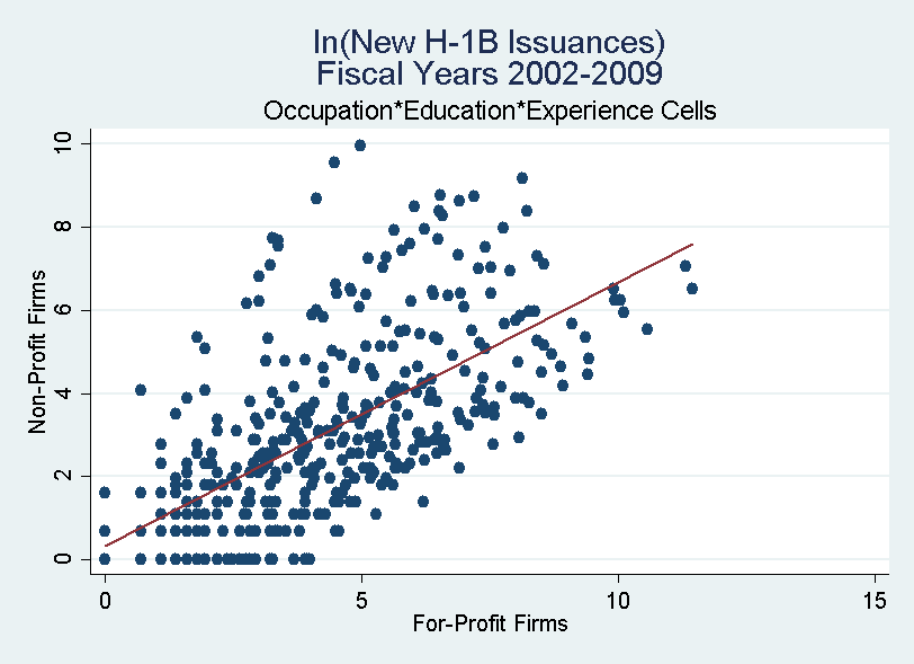
Figure 1: Application Period for H-1B filings in each fiscal year 2002-2009



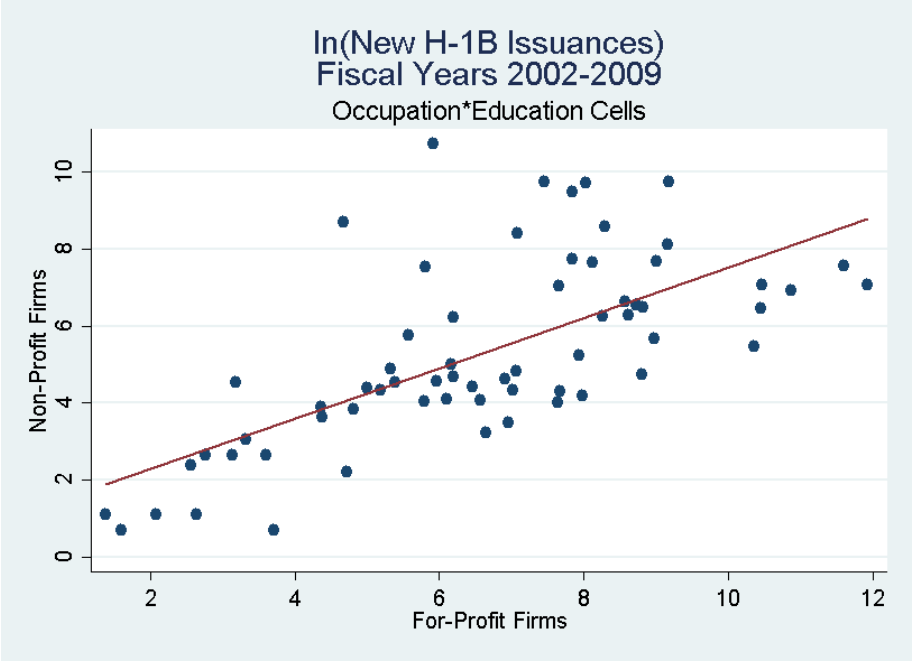
Note: The vertical axis indicates the Application Period in days for H-1B applications in each fiscal year. Before 2004, the period equaled 365 days, as H-1B visas were not exhausted and an application could be processed each day of the year. A decline in the application period implies an increase in applications relative to total available visas. Starting in 2008 all H-1B visas were requested in the first week of the fiscal year and allocated via a lottery.

Figure 2: Aggregate H-1B issuances for each skill-cell: For profit versus non-profit sector

Panel (a)

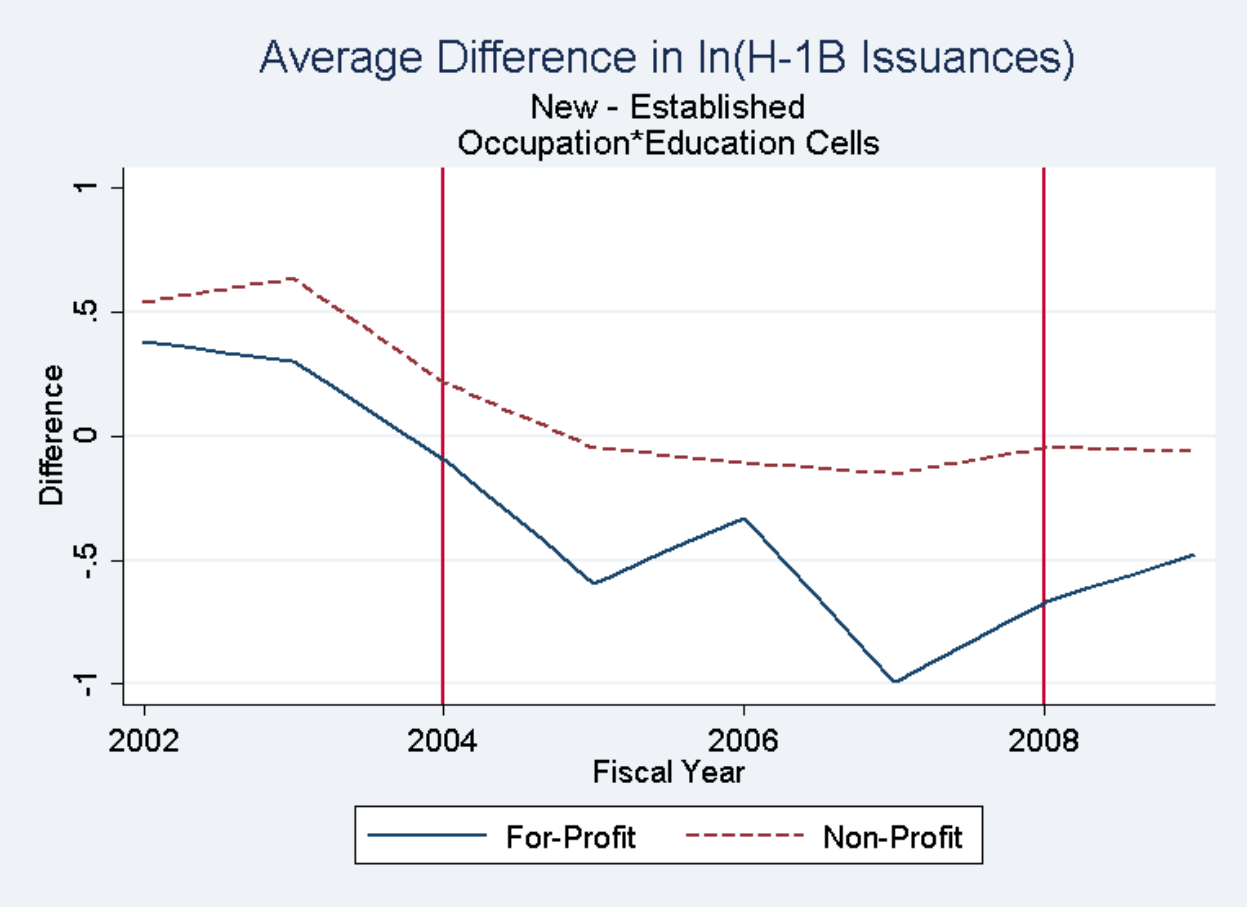


Panel (b)



Note: Each point represents the H-1B visas issued for a skill-cell in the whole 2002-2009 period. Panel (a) defines skill-cells as occupation-education-experience, while Panel (b) uses education-occupation as cells. The line shows the linear correlation between non-profit and for-profit H-1B employment across cells.

Figure 3: Average difference in new versus established log-H-1B issuances.

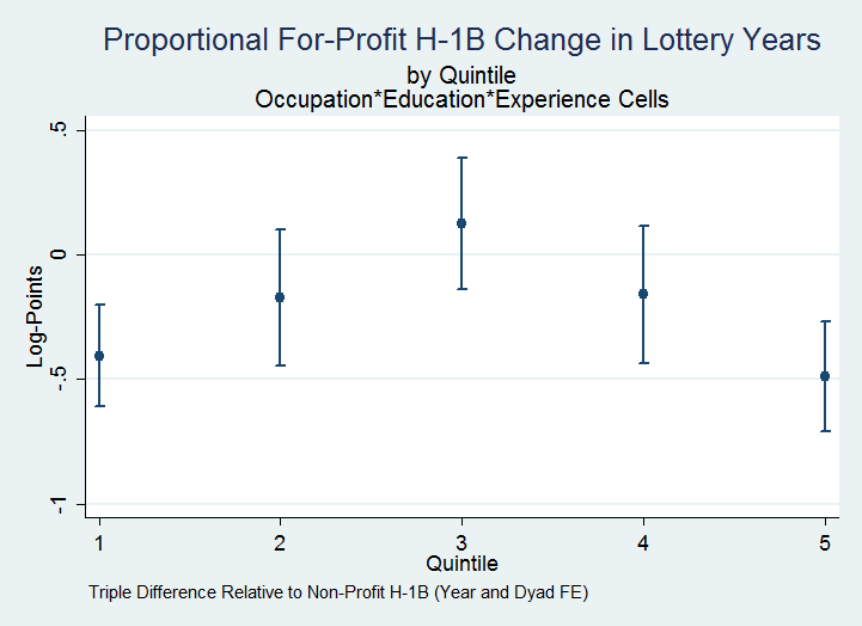


Note: The solid line represents the average difference in log issuances of new versus established H-1Bs for the non-profit sector across skill cells. The dashed line represents the same difference for the for-profit sector. Cells are defined by occupation and education.

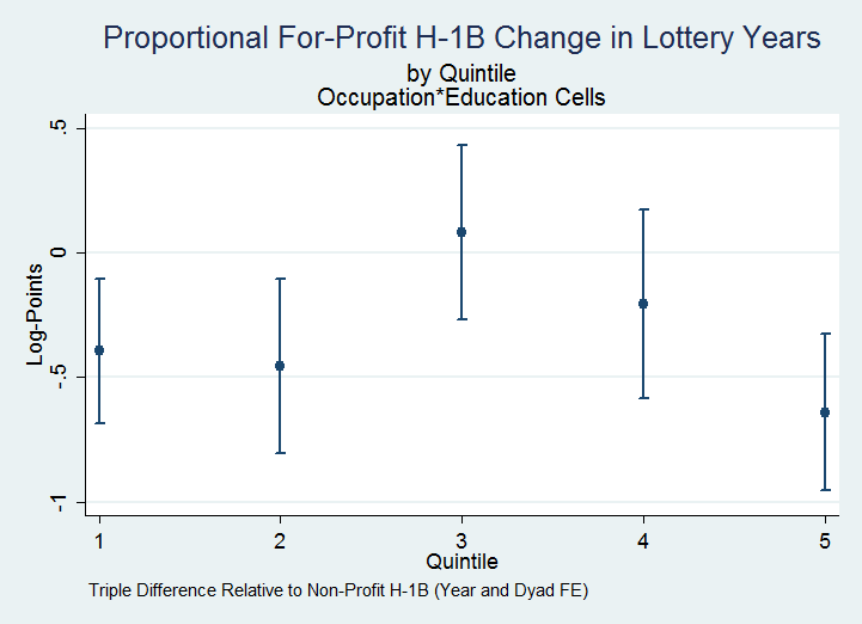
Figure 4: Change in for-profit H1B employment at different quintile of wage distribution

*Sum of coefficients on the Cap-Year*Treated plus Lottery*Treated Interactions*

Panel (a)

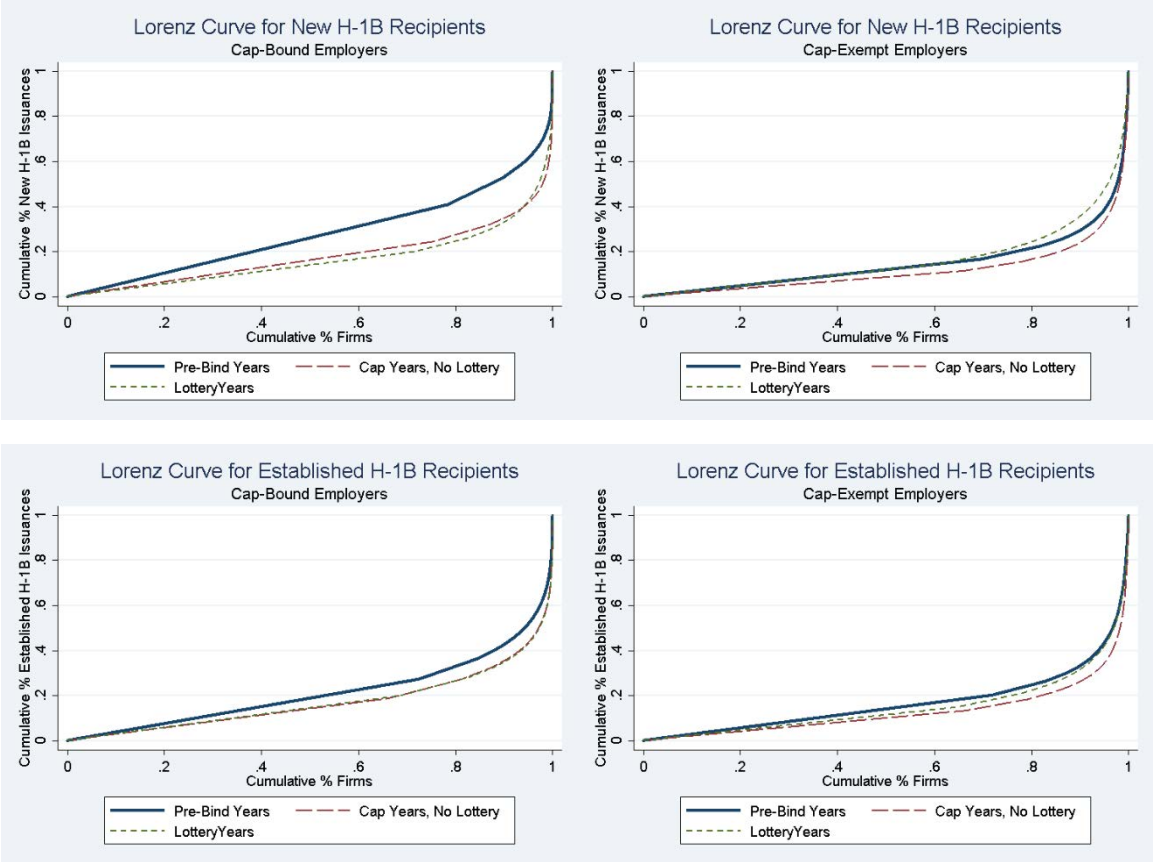


Panel (b)



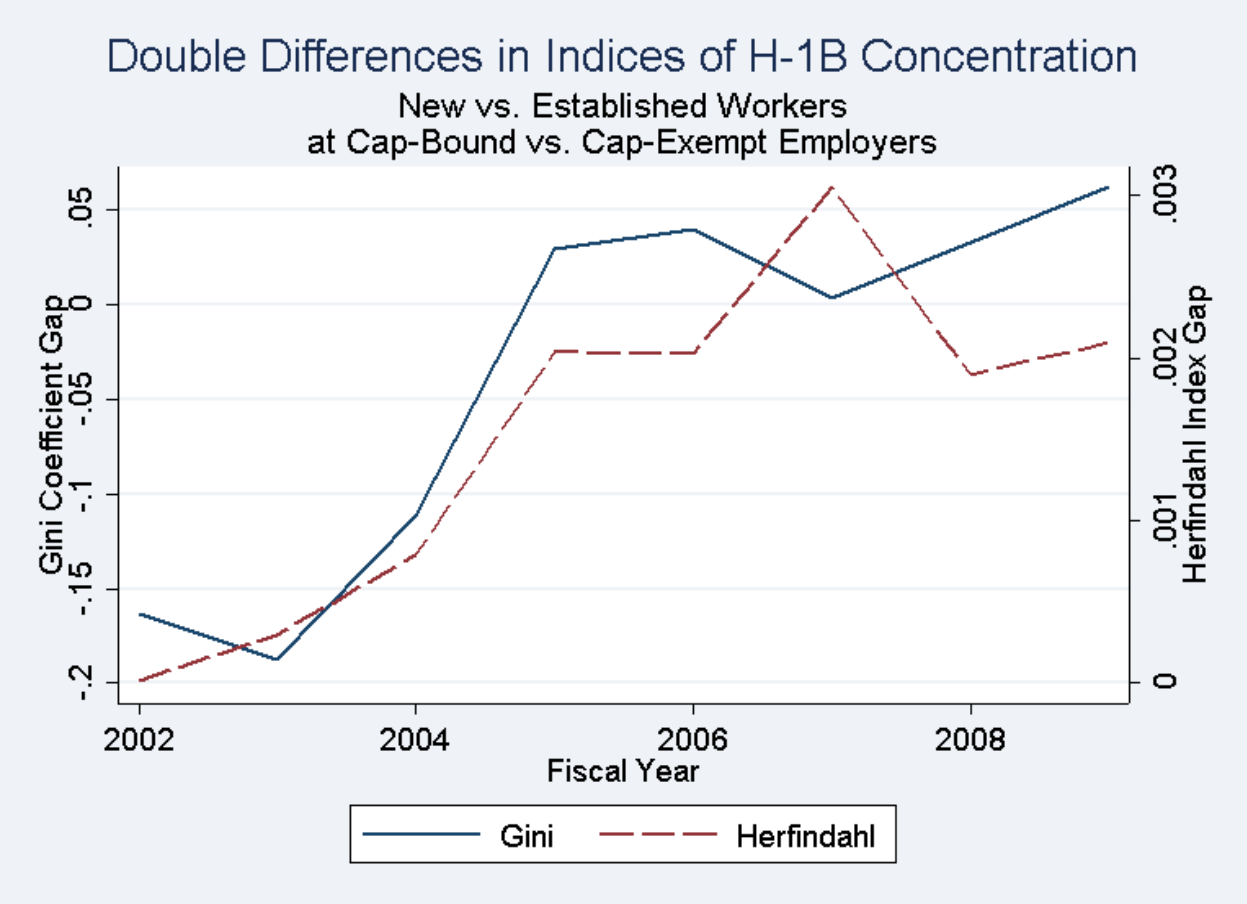
Note: The graphs show the sum of estimated coefficients on the Cap-Year and Lottery-Year interactions with Treated when the dependent variable is the difference in log-issuances in for-profit relative to non-profit firms at the relative quintile of the wage distribution. The vertical bar shows the 95% confidence interval. Panel (a) uses estimates from skill-cells constructed using occupation, education, and experience groups. Panel (b) uses estimates from skill-cells defined only by education and occupation.

Figure 5: H-1B Concentration in Firms
Lorenz Curves for the inequality in H-1B issuances across firms



Note: Each panel show the Lorenz curve of H-1B concentration for a group (new and established) and a sector (for profit and non-profit). The three line correspond to the curve pre-2004 when the cap was high (blue, solid, thick), fiscal years 2004-2007 with lower cap (red, long-dash), and 2008-09 with lower cap and Lottery (green, short-dash).

Figure 6: H-1B Concentration in Firms, Gini Coefficient and Herfindahl Index



Note: We calculate indices of H-1B concentration within firms for four groups: New workers at for-profit firms, established workers at for-profit firms, new workers at non-profit firms, and established workers at non-profit firms. We then calculate the double-difference in these indices. The figure indicates a proportional increase in H-1B concentration within firms for new H-1B workers at for-profit firms relative to other groups. This is true using both the Gini Coefficient of inequality (blue, sold, left axis) and the Herfindahl (red, dashed, right axis) index of concentration.

Table 1: Baseline Triple-Difference Results for H-1B Issuances

	(1)	(2)	(3)	(4)	(5)	(6)
Cell Definition:	OCC*ED*EXP			OCC*ED		
Panel Fixed Effects:	Skill-Cell + Sector	Skill-Cell + Sector	Skill-Cell * Sector	Skill-Cell + Sector	Skill-Cell + Sector	Skill-Cell * Sector
Time Fixed Effects:	Cap Year + Lottery Year	Year	Year	Cap Year + Lottery Year	Year	Year
Balanced Panel:	No	No	Yes	No	No	Yes
Cap Year * Treated	-0.389***	-0.403***	-0.331***	-0.181***	-0.187***	-0.202**
	(0.047)	(0.047)	(0.060)	(0.066)	(0.065)	(0.078)
Lottery Year * Treated	-0.052	-0.036	-0.061	-0.078	-0.069	-0.034
	(0.044)	(0.045)	(0.048)	(0.072)	(0.071)	(0.074)
Treated	-0.141***	-0.141***		-0.280***	-0.279***	
	(0.041)	(0.041)		(0.069)	(0.069)	
Observations	4,556	4,556	3,512	938	938	894
R-squared	0.574	0.621	0.707	0.476	0.542	0.632

Note: Dependent variable is the logarithm of New H1B employment minus the logarithm of the established H1B employment in the skill-cell and sector (for-profit and nonprofit) in each year 2002-2009. Each column represents an estimated specification. Columns 1-3 define skill groups by occupation, education, and experience, while columns 4-6 use occupation and experience. The variable "Cap Year" is equal to one in fiscal years 2004-2009 and zero otherwise. The variable "Lottery Year" is equal to one in fiscal years 2008 and 2009 and zero otherwise. The "treated" variable is a dummy equal to one for cells in the for-profit sector. In columns 1 and 4 skill-cell and sector fixed effects are included plus cap year and lottery year dummies. In columns 2 and 5 skill-cell and sector fixed effects plus year effects are included. In columns 3 and 6 we include skill-cell by sector effects and year effects. The method of estimation is least squares with standard errors clustered at the skill cell level. *** p<0.01, ** p<0.05, * p<0.1

Table 2: Triple-Difference Results for Native-Born Employment

	(1)	(2)	(3)	(4)	(5)	(6)
Experience Definition	4 - 6 Years			More than 3 Years		
Panel Fixed Effects:	Skill-Cell + Sector	Skill-Cell * Sector	Skill-Cell * Sector	Skill-Cell + Sector	Skill-Cell * Sector	Skill-Cell * Sector
Time Fixed Effects:	Cap Year + Lottery Year	Year	Year	Cap Year + Lottery Year	Year	Year
Balanced Panel:	No	No	Yes	No	No	Yes
Cap Year * Treated	-0.011	-0.009	0.106	-0.116	-0.115	-0.109
	(0.102)	(0.102)	(0.103)	(0.093)	(0.093)	(0.087)
Lottery Year * Treated	-0.050	-0.053	-0.110	-0.023	-0.022	-0.077
	(0.092)	(0.093)	(0.085)	(0.071)	(0.071)	(0.063)
Cap-Bound Employer	0.134	0.134		0.518***	0.516***	
	(0.081)	(0.082)		(0.095)	(0.095)	
Observations	759	759	686	798	798	718
R-squared	0.326	0.331	0.425	0.656	0.660	0.755
All Regressions Define Skill Cell by Occupation*Education						

Note: Dependent variable is the logarithm of new native employment minus the logarithm of the experienced native employment in the skill-cell and sector (for-profit and nonprofit) in each year 2002-2009. Each column represents an estimated specification. The variable "Cap Year" is equal to one in fiscal years 2004-2009 and zero otherwise. The variable "Lottery Year" is equal to one in fiscal years 2008 and 2009 and zero otherwise. The "treated" variable is a dummy equal to one for cells in the for-profit sector. In columns 1 and 4 skill-cell and sector fixed effects are included plus cap year and lottery year dummies. In columns 2 and 5 skill-cell and sector fixed effects plus year effects are included. In columns 3 and 6 we include skill-cell by sector effects and year effects. The method of estimation is least squares with standard errors clustered at the skill cell level. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Triple-Difference Results for H-1B Wages

	(1)	(2)	(3)	(4)	(5)	(6)
Cell Definition:	OCC*ED*EXP			OCC*ED		
Panel Fixed Effects:	Skill-Cell + Sector	Skill-Cell * Sector	Skill-Cell * Sector	Skill-Cell + Sector	Skill-Cell * Sector	Skill-Cell * Sector
Time Fixed Effects:	CapYear + LotteryYear	Year	Year	CapYear + LotteryYear	Year	Year
Balanced Panel:	No	No	Yes	No	No	Yes
Cap Year * Treated	0.009	0.009	0.005	0.011	0.011	-0.003
	(0.022)	(0.022)	(0.023)	(0.040)	(0.040)	(0.036)
Lottery Year * Treated	-0.071***	-0.071***	-0.082***	-0.009	-0.009	-0.035
	(0.026)	(0.026)	(0.025)	(0.044)	(0.045)	(0.038)
Cap-Bound Employer	-0.047**	-0.047**		-0.059*	-0.059*	
	(0.019)	(0.019)		(0.032)	(0.032)	
Observations	4,556	4,556	3,512	938	938	894
R-squared	0.181	0.181	0.294	0.137	0.139	0.288

Note: Dependent variable is the average logarithm of New H-1B wage minus the logarithm of the established H-1B wage in the skill-cell and sector (for-profit and nonprofit) in each year 2002-2009. Each column represents an estimated specification. Columns 1-3 define skill groups by occupation, education, and experience, while columns 4-6 use occupation and experience. The variable "Cap Year" is equal to one in fiscal years 2004-2009 and zero otherwise. The variable "Lottery Year" is equal to one in fiscal years 2008 and 2009 and zero otherwise. The "treated" variable is a dummy equal to one for cells in the for-profit sector. In columns 1 and 4 skill-cell and sector fixed effects are included plus cap year and lottery year dummies. In columns 2 and 5 skill-cell and sector fixed effects plus year effects are included. In columns 3 and 6 we include skill-cell by sector effects and year effects. The method of estimation is least squares with standard errors clustered at the skill cell level. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Triple-Difference Results for H-1B Compositional Changes

	(1)	(2)	(3)	(4)	(5)
Share of Group:	Indian-Born Workers		Computer-Related Workers	Large H-1B Firms	
Cell Definition:	OCC*ED*EXP	OCC*ED	ED*EXP	OCC*ED*EXP	OCC*ED
CapYear * Treated	0.023	0.039*	0.055**	0.015	0.059**
	(0.014)	(0.021)	(0.025)	(0.018)	(0.023)
LotteryYear * Treated	-0.005	0.002	0.046*	-0.000	-0.036*
	(0.015)	(0.025)	(0.025)	(0.018)	(0.021)
Observations	3,512	894	506	3,506	894
R-squared	0.309	0.259	0.431	0.231	0.308

Note: Dependent variable is the share of workers with a characteristic (identified in the top row) among new H-1B workers minus the same share among established H-1B workers in the skill-cell and sector (for-profit and nonprofit) in each year 2002-2009. Columns 1 and 4 use the combination of occupation-education–experience-sector as cells. Columns 2 and 5 use education-occupation-sector cells. Column 3 uses education-experience cells. The variable "Cap Year" is equal to one in fiscal years 2004-2009 and zero otherwise. The variable "Lottery Year" is equal to one in fiscal years 2008 and 2009 and zero otherwise. The "treated" variable is a dummy equal to one for the cells in the "for-profit" sector. All regressions use skill-cell by sector effects and year effects. The method of estimation is least squares with standard errors clustered at the skill-cell level. *** p<0.01, ** p<0.05, * p<0.1