UPSKILLING: DO EMPLOYERS DEMAND GREATER SKILL WHEN WORKERS ARE PLENTIFUL?

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Abstract

The relationship between the unemployment rate and the job vacancy rate, commonly known as the Beveridge Curve, changed significantly following the Great Recession. Changes in recruiting intensity, such as tougher hiring standards and employee screening methods, may explain a significant portion of this shift. In this paper, we provide new, direct evidence on changes in employer hiring standards using a database that covers the *near universe* of online job postings. We show that employer education and experience requirements rose during the Great Recession, and that these increases were larger in states, occupations, and years that experienced greater increases in the supply of available workers. We argue that a significant portion of this relationship is causal with employers raising skill requirements in response to labor market slack and show that it is robust to controlling for local demand conditions as well as firm-job title fixed effects. Using a natural experiment arising from U.S. troop withdrawals from Iraq and Afghanistan as an *exogenous* shock to local, occupation-specific labor supply, we further identify the causal impact of increased labor supply on employer requirements. Our results imply that increases in the number of people looking for work can account for at least 30 percent of the total increase in employer skill requirements observed between 2007 and 2010.

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I. Motivation: Shifting Employer Skill Requirements and Recruitment Intensity

The persistent weakness of the U.S. labor market following the Great Recession remains poorly understood. One feature of this weakness is that the relationship between the unemployment rate and the job vacancy rate, known as the Beveridge curve, has shifted. Following the recession, the unemployment rate was significantly higher relative to the vacancy rate than one would have projected from the stable pre-recession relationship (Hobjin and Sahin 2013, Diamond and Sahin 2014).

A number of explanations for this shift have been proposed, each with potentially different policy implications. Some have interpreted the shift in the Beveridge curve as a deterioration in the matching/hiring process in the economy. For example, Sahin et. al. (2014) measure the degree of mismatch between vacancies and workers across occupations and geographies and find that mismatch can potentially account for one-third of the increase in the unemployment rate during the Great Recession. Others have pointed to the lack of real wage growth observed even within industries and occupations with relatively strong demand during the recovery period, suggesting an even smaller role for labor market mismatch. This has prompted research exploring the importance of the composition of workers (Veracierto, 2011; Barnichon and Figura, 2010; Shimer, 2012; Fujita and Moscarini, 2013; Hall and Schulhofer-Wohl, 2013) and the motivation of job seekers (Mukoyama, Patterson, Sahin 2014; Hagedorn et al. 2014) in explaining Beveridge curve movements.

More recently, the literature has focused on a third potential factor contributing to this observed shift in the Beveridge Curve—namely a decrease in "recruitment intensity" per vacancy during the recession (Davis et al. 2012). In this context, recruitment intensity is described as a set of actions that employers can take to influence the rate of new hires, such as

changes in "advertising expenditures, screening methods, hiring standards, and the attractiveness of compensation packages." For a given vacancy-to-unemployment ratio, a lower recruiting intensity per vacancy lowers the fill rate, resulting in an upward shift in the Beveridge Curve. This finding has sparked several theoretical models that endogenize this channel (Kaas and Kircher 2014, Gavazza, Mongey, and Violante 2015). Yet to date this approach has been limited by the absence of direct measures of recruiting intensity across employers (Diamond 2013, Rothstein 2012).

In this paper, we directly measure an important channel along which recruitment intensity may have shifted during the Great Recession—in the skill requirements employers use to screen candidates when filling a new vacancy. Indeed, media reports and employer surveys indicate that employer requirements increased sharply during the Great Recession such that a college degree is now required for a number of occupations that previously required only a high school degree—a trend that has colloquially become known as "upskilling".[1] Using a proprietary dataset of 68 million online job postings, we document that employers raised both education and experience requirements within occupations during the Great Recession. Figure 1 shows that the percentage of vacancies requiring a bachelor's degree or higher rose by more than 10 percentage points from 2007 to 2010 and then fell as labor markets recovered. A similar relationship is observed for the percentage of postings requiring four or more years of experience. Clearly, there is a strong time-series correlation between employer skill requirements and aggregate labor market slack as measured by the national unemployment rate. Yet it is still unclear whether

[1] For example, according to a survey by CareerBuilder in 2013, almost one-third of employers said that: their educational requirements for employment have increased over the last five years and specifically that they are hiring more college-educated workers for positions that were previously held by high school graduates. See Rampell, Catherine. 2012. "Degree Inflation? Jobs That Newly Require B.A.'s" The New York Times, December 4.

these aggregate trends reflect a shift in recruitment in intensity or a structural and persistent mismatch between workers' skills and firms' needs.

To determine whether employer upskilling was, in part, an endogenous response to labor market slack, we further exploit the variation in the unemployment rate across states during the Great Recession. We show that employer skill requirements increased more within six-digit detailed occupations in states experiencing greater increases in their unemployment rate. The baseline OLS relationship is economically important: a 1 percentage point increase in the state unemployment rate is associated with the fraction of jobs requiring a Bachelor's degree rising by 0.6 percentage points and the fraction of jobs requiring 4 or more years of experience rising by 0.8 percentage points. These estimates are robust to using alternative measures of labor market slack and to including controls for occupation, location, and time. Our results imply that the increase in the number of people looking for work during the Great Recession can account for at least 30 percent of the total increase in employer skill requirements observed between 2007 and 2010. To our knowledge, these findings provide some of the first empirical evidence of a shift in recruitment intensity whereby employer skill requirements are driven—in part—by the available supply of labor.[2]

Although this OLS relationship between rising employer requirements and the supply of jobless people seeking work is intriguing, the observed variation in the unemployment rate is obviously correlated with other factors. These include short-term factors such as changes in the demand for certain goods or services and credit availability as well as longer term trends such as changes in technology or other production processes that may alter the composition of employers

[2] A more recent unpublished paper by Hershbein and Kahn (2015) uses the same dataset of online job vacancies and a similar approach but focuses on the long-term structural shifts in employer skill requirements driven by changes in technology and other factors during this period. In contrast, this paper focuses on the *causal* identification of the portion of the increase in employer skill requirements that is related to the increased availability of workers during the business cycle

posting vacancies and/or the types of vacancies that are posted, potentially shifting employer skill requirements.

To establish a causal relationship between changing employer skill requirements and the number of job seekers in a location and occupation, we employ several identification strategies to explicitly measure shifts *along* the demand curve in response to changes in labor supply. First, to account for changes in local demand conditions, we show that the upskilling relationship is robust to the inclusion of occupation, state, and year fixed effects. Second, to account for changes in the composition of employers and/or vacancies over time, we show that upskilling occurs even **within firm-job title** pairs—not just within occupations.[3] We further show these results for online vacancies as well as those collected via a state survey of employers. Thus, we observe greater increases in employer skill requirements in states experiencing larger increases in the unemployment rate, both within and across firm-job title pairs.

Yet it may still be the case that relying on variation in the unemployment rate across states during the Great Recession as the primary source of identification could lead to biased results given that the unemployment rate is correlated with other factors at the firm level that we cannot control for. Thus, we make use of a natural experiment that represents a clear shock to labor supply: the drawdown of troops from Iraq and Afghanistan that lead to an additional 200,000 to 300,000 veterans entering the U.S. domestic labor force each year between 2009 and 2012. We show that state-occupation cells receiving larger numbers of returning veterans correspondingly experienced a greater increase in their skill requirements. These relationships imply effects that are as large as or larger than the non-IV results, and indicate that exogenously increasing the supply of potential applicants leads firms to change their job posting requirements.

[3] It has been shown that firm-job titles account for the vast majority of the variance in wages within occupations, making confounding composition changes unlikely (Marinescu and Wolthoff 2015).

Finally, we show that the degree of unemployment-related upskilling across occupations and states is consistent with a causal effect on employer searching—it is larger when employee turnover rates are lower, when employers on-the-job training time is higher, and when skill premiums are larger.[4] We also provide evidence demonstrating the forces underlying employer decisions to upskill, showing that the college wage premium for new hires falls as the unemployment rate rises, incentivizing employers to switch from low- to high-skill labor. Similarly, occupations with greater wage rigidity—as measured by collective bargaining concentration within occupations—have a greater propensity to upskill during recessions, to compensate for their inability to lower entry level wages. Taken together, these facts provide evidence that the empirical relationship we measure is consistent with standard models of employer search and provides a theoretical basis to explain the pattern of upskilling that we observe the data.

The finding that employer skill requirements are driven—in part—by the available supply of labor has important implications for understanding the dynamics of the labor market that is relevant for both the economics literature as well as for policy. We document a novel feedback mechanism between labor supply and the selectivity of vacancies that operates within occupations and is consistent with macroeconomic models of employer search decisions (Davis et al. 2012) and heterogeneous workers (Shimer 2005, Albrecht and Vrooman 2002). Importantly, we find that this occurs even within firm-job title pairs, a notion which runs counter to some of the existing approaches to modeling changes in recruitment intensity as solely a composition effect. Moreover, a related literature has explored worker entry and mobility during recessions, particularly for college graduates. These studies typically find that workers match at

[4] Time-to-start is a recruiting metric defined as the actual time (in days) between when recruiting is initiated and when the new hire begins employment.

lower entry wages during recessions and have less steep wage trajectories over time (e.g. Kahn 2010, Oreopoulous et al. 2012, Moscarini, 2001). We find that changes in employer requirements over the business cycle is consistent with—and even serves to reinforce—this effect.

Finally, our results indicate that much of the observed increase in skill requirements within detailed occupations is correlated with the business cycle and may be subject to reversion as the labor market tightens, potentially informing the ongoing mismatch debate. Numerous media reports and employer surveys have suggested that the lack of skilled workers has made it difficult to fill jobs that are in high demand during the economic recovery, leading to slower than expected improvement in the labor market. Yet the economics literature has largely concluded that the weak labor market after the Great Recession was not due to a skills mismatch or other structural factors, but instead was a function of weak aggregate demand that increased unemployment across worker types, industry sectors, and occupation groups. Our results confirm that a significant portion of what is sometimes labeled as structural mismatch employment is actually cyclical, reflecting in part the change in recruitment intensity over the business cycle.

The paper proceeds as follows. Section II lays out a theoretical framework and model to provide a rationale for how changes in employer skill requirements would be expected to respond to the business cycle. Sections III and IV describe our empirical methodology as well as the unique features of the online job vacancy data used in our estimation. Section V reports the basic OLS estimates of the relationship between employer skill requirements and the business cycle as well as our robustness tests for alternate interpretations while section VI provides evidence from our natural experiment related to the drawdown of troops from Iraq and Afghanistan. Section VII exploits various characteristics of occupations associated with

employer upskilling to examine the mechanisms behind this phenomena and section VIII concludes.

II. Theoretical Framework

In this section we describe a partial equilibrium model illustrating the dynamics by which employers choose the skill requirements for their vacancies in the short run, based on the availability of workers. As such, our model will focus on measuring movements along the labor demand curve, building off three stylized facts about the recruitment process and the business cycle.

1. *The Number of Available High Skilled Job Seekers per Vacancy Correlates Strongly with the Overall Unemployment Rate.* Figure 2 shows the relationship between the ratio of unemployed college graduates to total job openings as measured by the JOLTS and the aggregate unemployment rate over time. As is evident in the figure, the two are strongly correlated. Intuitively, and in our model, this relationship increases the probability of hiring (and thus reduces the cost of waiting for) such an individual. Thus, in times of higher unemployment, there are more available college workers for a given vacancy, thereby incentivizing employers on the margin to switch from low- to high-skill labor.
2. *The College Wage Premium for <u>New Hires</u> is Cyclical.* Figure 3 shows that during the business cycle, the college wage premium for new hires falls as the unemployment rate rises. This relative fall in price can also incentivize employers to switch from low- to high-skill labor.[5] The negative relationship between the college wage premium for new

[5] As far as we can tell, prior work has only looked at the aggregate premium, not the premium for new hires, which is relevant here. To calculate the college wage premium for new hires, we use the multi-month matched CPS sample based on a matching algorithm similar to that proposed by Madrian and Lefgren (1999). The matching algorithm is based on a series of household identifiers and demographic characteristics including sex, age, and race. This multi-month matched sample enables us to observe labor market transitions over the eight periods that an individual is

hires and the unemployment rate is quite strong, with a correlation coefficient of 0.9. This correlation could stem from high skilled workers indeed moving down the wage distribution as well as from the more binding constraints on the degree to which low-skill wages can fall due to union contracts or minimum wage laws. In either case, a falling wage premium suggests that employers may be increasing skill requirements because high-skill workers have become relatively less expensive.

3. *Recruitment Costs are Large.* Finally, we build our framework based on the observation that recruitment costs are large. Industry estimates indicate that these costs typically range from $1,000 to $5,500 per hire, with interviews and other screening time as a major component.[6] Search and matching models of the labor market typically calibrate vacancy posting costs in this range as well (Finkelstein Shapiro and Gonzales 2015).

Motivated by these three facts, we construct a simple partial equilibrium model of a firm's decision whether or not to post minimum skill requirements. The model is designed to capture short run effects, and thus takes firm entry or the number of potential openings as well as the skill distribution of workers as fixed. Moreover, it assumes some short-run downward wage rigidity, so that adjustment does not take place solely along that margin. Though many possible models could be written that do not make these assumption, this succinct framework conveys our intuition and allows us to derive estimating equations that ultimately closely match the data.

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potentially sampled, and link these transitions to wages which are only reported in months 4 and 8. Once we identify individuals who experienced a labor market transition (i.e. are newly hired) and match them to a subsequent wage report, we calculate the average hourly wage for these individuals by educational attainment and year. If the respondent identifies themselves as an hourly worker, we use reported hourly wage. Otherwise, we estimate hourly wage by dividing weekly earnings by usual hours worked per week. We measure the college wage premium as the log difference in these hourly wages.

[6] Society of Human Resources Executive Brief: What Factors Influence Cost-per-Hire?

We begin by assuming there are a fixed number of firms each posting a vacancy V. Employers in labor market i choose between posting a vacancy with a minimum skill requirement and accepting low-skill worker. These firms face an applicant pool L divided between a small fraction of high-skilled applicants γ and a large fraction of low-skilled applicants $(1-\gamma)$. We normalize the value of having a vacancy filled with a low-skill worker to be equal to 1 and set the value of having a vacancy filled with a high-skill worker equal to $\theta>1$, which is assumed to be constant across labor markets. Each employer has a stochastic cost c of leaving the vacancy unfilled which is drawn from a uniform density distribution. These costs may vary across firms by the premium they attach to high skilled workers over low skilled worker θ, the exogenous turnover rate $1-\delta$ of their employment relationships, and the urgency for new hires to begin working modeled via their discount rate $1-\rho$. [7]

To motivate the problem, we assume that high skilled applications are uncoordinated or allocated across vacancies randomly, making the number of applications a Poisson random variable. Each period, the odds that a vacancy receives at least one high skilled applicant is given by $\left(1-e^{\frac{-\gamma L}{V}}\right)$, which is increasing in the number of total applicants L. For simplicity, we'll assume that for the range of L considered, there are sufficiently many low skilled workers that firms can match low skilled workers with certainty. Note that this matching probability depends on the *number* of high skilled workers per vacancy $\gamma L/V$, not the ratio of high to low skilled job seekers.

In this environment, firms face a single decision; whether to accept a low skilled worker in the event of not matching a high skilled worker or whether to keep searching. In our empirical

[7] We normalize the firm's profit when employing a low skilled worker to 1.

context, firms that elect to keep searching are analogous to firms requiring a Bachelor's degree or greater work experience. The firm value function for firm *i* can be written as:

$$V_i(\theta_i, \rho_i, \delta_i, c_i, L, V) = -c_i + \left(1 - e^{\frac{-\gamma L}{V}}\right)\frac{\theta}{1-\delta\rho} + e^{\frac{-\gamma L}{V}} max\left\{\rho V_i, \frac{1}{1-\delta\rho}\right\}.$$

It is straightforward to show that, in this environment, firms' decisions follow a cutoff rule in their costs of maintaining a vacancy c_i^*. Employers with costs below the cutoff post minimum skill requirements and employers with costs above the cutoff do not. Since costs are drawn from a uniform distribution, c_i^* (when scaled) is also the fraction of employers posting vacancies with skill requirements. The fraction of firms that wait for a high skilled worker $F(c^*)$ is increasing the size of the labor market L and skill premium θ, and is decreasing in the turnover rate $1-\delta$ and urgency of hiring $1-\rho$.

The decision rule depends on the number of high skilled applicants per posting $\frac{-\gamma L}{V} = U_i$. The derivative, or the change in this fraction for a given change in the number of applicants L, corresponds to our empirical notion of upskilling. We can then decompose the change in the fraction of employers posting vacancies with skill requirements as it relates to structural versus cyclical factors:

$$\Delta c_i^* = \alpha \times \Delta\theta + \beta \times \Delta U_i + \varepsilon_i$$

where α measures the structural change in the relative value of hiring a high- versus low-skill worker (as measured at the national level) and β measures the cyclical component, wherein more slack labor markets raise the probability of hiring a high-skill worker.

In our empirical work, we proxy for changes in U_i using two different measures. First, given the strong correlation between the number of skilled workers per posting and the overall

unemployment rate (as shown in Figure 3), we use the state unemployment rate for all workers as well as the state unemployment rate for individuals with a Bachelor's degree. Second, we also construct a supply/demand ratio of the number of unemployed individuals to the number of postings by state and broad occupation group which provides variation across occupations as well as within a state. Thus, the movements in L we are able to construct empirically are meaningful measures of the supply of skilled workers over time.

With such a motivating model in mind, it becomes clear that changes in employer skill requirements and the unemployment rate are jointly endogenously determined. For example, local demand shocks or credit market constraints could differentially affect the demand for low-skilled workers, independent of supply, thereby affecting the composition of vacancies within occupations.[8] Alternatively, upskilling may be driven by ongoing secular increases in employer demand for skilled workers such as changes in technology or production.[9]

Thus, the goal in our empirical strategy below will be to carefully measure movements along the labor demand curve rather than shifts in the demand curve. For these reasons, we employ a number of identification strategies to determine the degree to which the observed decrease in employer skill requirements is related to the degree of labor market slack. This may arise either in terms of the number or quality of the applicants that perhaps leads firms to be strategic or

[8] Specifically, local demand shocks could affect the composition of vacancies that are posted. For example, suppose there are two kinds of baristas positions: (1) Starbucks, which requires a Bachelor's degree, and (2) Dunkin Donuts, which has no education requirement. A local recession might differentially reduce coffee purchases by Dunkin Donuts customers. If that were the case then skill requirements for baristas would be correlated with unemployment, but the channel would be demand, not labor supply. Similarly, credit market constraints could alter the mix of jobs requiring a Bachelor's degree within an occupation. For example, suppose there are two kinds of homebuilders: (1) luxury homebuilders, which require skilled craftsmen with more than 4 years of experience, and (2) subprime builders, which have no experience requirement. If credit market constraints are such that the financing for subprime borrowers has dried up but credit for individuals buying luxury homes persists, then skill requirements for craftsmen would be correlated with unemployment, but the channel would be credit market constraints, not labor supply.

[9] For example, the manufacturing sector has shifted over time from low-skill "dirty jobs" in traditional factories to higher-skilled "clean-tech jobs" working with state of the art computerized machinery.

opportunistic in their hiring strategies.[10] As such, in our empirical analysis it will be crucial to identify that portion of the variation in labor supply that is *not* correlated with shifts in labor demand. We turn to this discussion in the next section.

III. Empirical Approach

We seek to explore the upskilling dynamic by measuring the degree to which the observed increase in employer skill requirements is related to the degree of labor market slack during the Great Recession. Between 2007 and 2010, state unemployment rates increased by 4.4 percentage points on average, ranging from a low of 0.7 percentage points in North Dakota to a high of 9 percentage points in Nevada.[11] Using this variation in state labor markets over time, we initially estimate the basic OLS relationship between changes in employer skill requirements and changes in the degree of labor market slack using the following specification:

$$\Delta \textit{ Share of Vacancies Requiring Skill } S_{ijt} = \alpha + \beta \Delta UR_{jt} + \gamma X_{i,j,t} + \tau_t + e_{ijt}\,, \qquad (1)$$

Where for occupation *i*, in state *j* over time period *t*:

ΔS_{ijt} = percentage point change in skill requirements (either education or experience)

ΔUR_{jt} = percentage point change in the state unemployment rate

X_{it} = vector of control variables related to occupation or state characteristics

τ_t = time period dummy to capture changes in the general composition of vacancies

The coefficient of interest in equation (1) is β which measures the increase in skill requirements related to changes in the business cycle. A larger β suggests more opportunistic upskilling in requirements on the part of employers. A small β suggests that upskilling is not

[10] We use the term opportunistic as a descriptor of employers behaving strategically in response to labor market conditions. It is not meant to convey any value judgement.
[11] Local Area Unemployment Statistics, Bureau of Labor Statistics, http://www.bls.gov/lau/

related to employer attempts to adjust to labor market slack by changing education or experience requirements.

In the above regression, we examine changes in employer requirements across occupations and locations over time. The key identifying assumption is that different parts of the U.S. recovered at different rates from the Great Recession, allowing us to exploit the variation in local labor markets across states and time periods. Although the specification above may indicate a positive correlation between changes in employer requirements for skill and the availability of skilled labor, we still need to address several identification concerns to reliably establish a causal relationship. For example, changes in the availability of skilled workers across states and occupations are likely to be endogenous, and reliable estimates require tests to address the possibility of omitted variable bias and the changing composition of firms.

We test for these possibilities in several ways. First, we use the variation within states across broad occupation groups to include state fixed effects to control for local demand conditions. Second, we address concerns over changes in employer composition and data quality over time by focusing on within firm-job title changes. Over the course of the Great Recession, the composition of employers as well as the types of jobs posted may have changed as industries suffered differential declines in employment. In addition, our primary data source begins in 2007 and the data collection mechanism may have changed over time.[12] To test whether the relationship between labor market slack and rising skill requirements is driven by changes in composition and/or data collection, we compare changes in employer requirements ***within*** firms-job title pairs over the business cycle, demonstrating that employers increase requirements for the same job title in response to the availability of skilled workers. In addition, we also make use

[12] Although Burning Glass Technologies consistently applies the same filtering and de-duplication algorithm across years, even retroactively as improvement are made, the number of sources scraped may have evolved over time.

of a state job vacancy survey that consistently measures the number of job vacancies since 2001 for a representative sample of employers drawn from the QCEW sampling frame using a set of questions that are similar to those found in the JOLTS.

Third, it may still be the case that relying on the variation during the recovery period of the business cycle as the primary source of identification could lead to biased results given that the unemployment rate is correlated with other factors at the firm level such as product demand and access to credit. Thus, we further makes use of a natural experiment that represents a clear shock to labor supply: the drawdown of troops from Iraq and Afghanistan that caused an additional 200,000 to 300,000 veterans to enter the U.S. labor force each year between 2009 and 2012 (Blimes 2013). The timing of troop drawdowns was driven by strategic and political considerations and was orthogonal to local economic conditions. Nevertheless, certain locations and occupations received significantly larger labor supply shocks than others. We use the variation in the number of returning veterans across these state-occupation cells to test whether there was a corresponding increase in employer skill requirements. In addition, we also instrument for veteran state of residence using their state of birth, to account for selection in location choices which may be correlated with local labor market conditions.

Finally, we make use of various occupational characteristics to shed light on the mechanisms behind employer upskilling. Specifically, we test whether the degree of unemployment-related upskilling across occupations and states is consistent with a causal effect on employer searching—i.e. is it larger when employee turnover rates are lower, when employers spend greater time on training, and when skill premiums are larger. These tests are used to determine if the empirical upskilling relationship is consistent with standard models of

employer search and to provide a theoretical basis to explain the pattern of upskilling that we observe the data.

IV. Data: Using Job Postings to Measure Changes in Employer Skill Requirements

In this paper, we are able to study changes in employer hiring dynamics by using a large, detailed dataset of online job postings. Until recently, little has been written about employer job posting requirements due to a lack of detailed data. However, with the advent of online job posting and searching in the early 1990s, the collection and availability of this data has increasingly made such information available to researchers.[13] Over the past decades, online vacancy data have been used by a number of researchers to study labor market dynamics (e.g., Sahin et al. 2014, Marinescu and Wolthoff 2013, Lazear and Spletzer 2012, Faberman and Mazumder 2012, Rothwell 2012, Bagues and Labini 2009, Kuhn and Skuterud 2004, Gautier, van der Berg, van Ours, and Ridder 2002).

Online vacancy data allow analysis at a greater frequency and at more refined geographies than traditional employer surveys, such as the Job Opening and Labor Turnover Survey (JOLTS).[14] This is because the data are constructed from measures that are collected by software that parses the text contained in millions of job ads posted online on a daily basis. Although online vacancy postings do not capture all job openings, a recent report from

[13] The first online job listings were posted on Usenet, CareerMosaic, and Monster during 1990-1994. Between 1995 and 1997, additional job boards were launched (e.g. Craigslist) and newspaper job listings began to appear online. Two companies, jungle and careercast, begin scraping and aggregating online job postings. Major changes took place in the years 1998 and 1999 as the job boards industry consolidated and a few key players emerged (e.g. Monster, Career Builder, and Jobsonline). After the dot-com bust, niche job boards proliferated between 2000 and 2002 for marketing, medical, sales, and accounting jobs. Between 2003-2007, the industry matured and experienced significant growth with the launch of LinkedIn and aggregators such as Top USA Jobs, indeed, and simply hired. See Garcia, Stephanie. 2013. "History & Statistics of Job Boards." Joshua Waldman's Career Enlightenment Blog, March 6th , http://careerenlightenment.com/history-statistics-of-job-boards-infographic .

[14] JOLTS is a monthly survey of employers that was developed to provide information on job openings, hires, and separations. Each month the JOLTS sample is comprised of approximately 16,000 businesses drawn from 8 million establishments represented in the Quarterly Census of Employment and Wages. The publically available data provides a measure of labor demand across broad industry classifications at the national level or overall aggregate labor demand for four quadrants of the nation.

Georgetown University estimates that between 60 and 70 percent of job postings are now posted online (Carnevale, Jayasundera, and Repnikov 2014). Moreover, Figure 4 shows that online job ads exhibit similar trends and are closely correlated with employer surveys over time as well as across industries and occupations (Templin and Hirsch 2013, Ganong 2014).

A. Constructing Employer Skill Requirements from Job Vacancy Data

The data used in this paper is collected by Burning Glass Technologies (BGT), one of the leading vendors of online job posting data. BGT collects detailed information on the more than seven million current online job openings daily from over 40,000 sources including job boards, newspapers, government agencies, and employer sites.[15] The data are collected via a web crawling technique that uses computer programs called "spiders" to browse online job boards and other web sites and systematically text parse each job ad into usable data elements.[16] BGT mines over seventy job characteristics from free-text job postings including employer name, location, job title, occupation, years of experience requested and level of education required or preferred by the employer.[17]

BGT provides snapshots of the data in which vacancies are reported on a monthly basis and are pooled over the year without duplication. As such, this data is unique in allowing geographical analysis of occupation-level labor demand by education level and experience level

[15] See http://www.burning-glass.com/realtime/ for more details.

[16] The collection process employed by BGT provides a robust representation of hiring, including job activity posted by small employers. The process follows a fixed schedule, "spidering" a pre-determined basket of websites that is carefully monitored and updated to include the most current and complete set of online postings. BGT has developed algorithms to eliminate duplicate ads for the same job posted on both an employer website as well as a large job board by identifying a series of identically parsed variables across job ads such as location, employer, and job title. In addition, to avoid large fluctuations over time, BGT places more weight on large job boards than individual employer sites which are updated less frequently. In addition, their Labor/Insight analytical tool enables us to access the underlying job postings to validate many of the important components of this data source including timeframes, de-duplication, and aggregation.

[17] Note that the BGT data do not contain any information on the duration of the vacancy, how many applications a vacancy received, nor whether a vacancy was filled.

over time. Using the entire universe of job vacancies collected by BGT, we construct several measures of employer skill requirements based on the education and experience fields parsed from the online advertisement. The data are available for detailed occupation by Standard Occupation Code (SOC) down to the six-digit level, by state for 2007 and 2010 and 2012.[18] In total, our data represent roughly 66.8 million vacancies during this period.

Table 1 provides descriptive statistics for the dependent variables constructed from the BGT data by state/occupation/year cells. On average, there are roughly 500 to 600 postings for a given state x occupation cell in each year (2007, 2010, and 2012). It should be noted that these data exhibit a considerable amount of variation given the different employment levels of these occupations, even at the state x occupation x year level. The number of underlying observations available to construct some cells varies from as few as one posting to as many as 60,000 postings at this level of dis-aggregation. To ensure that our dependent variables are capturing meaningful differences over time and accurately represent the state of the labor market, we drop observations with fewer than 15 total postings in a given cell which corresponds to eliminating the bottom 5 percent of the sample.[19] In addition, since we are analyzing changes in the fraction of postings requiring a particular skill, we weight the observations by the occupation's share of total openings in the state in a given time period in all regressions. This ensures that our results are not driven by outlier occupations with few underlying postings.

We have constructed a range of dependent variables by state, occupation and year that measure the percentage point change in the share of online job postings along two dimensions of skill: educational attainment and years of experience. Our education categories of interest range

[18] No data are available for 2008 and 2009.

[19] These basic results are robust to the various weighting schemes we have used such as weighting observations by the minimum total openings in both periods and dropping observations for which there are fewer than 75 openings for a given occupation/state cell in either period from our sample.

from the share of postings with no education requirement to the share requesting a Graduate or Professional degree and everything in-between.[20] Experience is defined in the BGT data using the following categories: no experience requested, >0 but <2 years, ≥2 years but <4 years, ≥4 years but <7 years, and ≥7 years.[21] Prior to the Great Recession, roughly 13 percent of postings requested a Bachelor's degree or higher in 2007 whereas 8 percent of postings requested 4 or more years of experience. Employer requirements along both dimensions of skill changed over time, with the majority of the increase occurring between 2007 and 2010 during the height of the Great Recession.

As a robustness check, we also construct similar measures of employer skill requirements using an actual survey of employers conducted by the Minnesota Department of Labor.[22] The Minnesota Job Vacancy Survey is one of twelve state job vacancy surveys conducted in the United States, collected biannually since 2001. Using the QCEW sampling frame, it is designed to estimate hiring demand and job vacancy characteristics by industry and occupation.[23] The survey uses a set of questions similar to those employed by the JOLTS to ask employers about their vacancies and plans to fill them, including minimum requirements for education and experience. These requirements display a similar pattern as those measured using the BGT data with employer skill requirements increasing over time, particularly during the Great Recession

[20] For education, some job postings in our sample express both a minimum ("required") and maximum ("preferred") requested educational qualification. For example, approximately 12 percent of job postings specify both a bachelor's and graduate degree in the original job posting. In response, we have created two measures of requested educational qualifications: one identifying the minimum educational qualification requested and the other using the maximum. The results in all of our baseline specifications are qualitatively similar for both measures. We use the maximum requested education qualification for the specifications presented which biases against our finding a significant increase in qualifications over time.
[21] Using the midpoint of these categories we also created a variable measuring the average years of experience.
[22] See Table A2 for descriptive statistics reported from the Minnesota Job Vacancy Survey for 2001 through 2012.
[23] Information is gathered through the survey of a stratified sample of about 10,000 firms in 13 regions of Minnesota. Firms excluded from the sampling process include private households, personnel service industry establishments and businesses with no employees. For the purpose of this study, a job vacancy is a position that is currently open-for-hire at the time of the survey. This survey excludes job vacancies reserved for contract consultants, employees of contractors and others not considered employees of surveyed firms.

period from 2007 to 2010. In addition, a unique identifier is assigned to each employer that allows one to track postings by job title for the same employer. As such, we will use the Minnesota survey data to measure upskilling and test whether our BGT results reflect changes in online job posting prevalence or data collection.

B. Constructing Labor Market Measures

Our basic empirical strategy is to explore the relationship between changes in employer skill requirements and changes in local labor market conditions during the Great Recession. Table 1 reports descriptive statistics for several alternative measures we have assembled to capture the variation in the availability of labor across states. Our initial measure of labor market slack is the change in the state unemployment rate as reported by the Bureau of Labor Statistics. We also construct analogous variables from the American Community Survey, measuring the state unemployment rate for (1) individuals with a bachelor's degree or higher and (2) for those age 35 or more years, to better capture changes in available labor supply of individuals with higher levels of education and experience.

We also construct two measures of labor supply that vary within both state and occupation to be able to control for local demand shocks. These measures are modeled on the Conference Board's Labor Supply/Demand Ratio for their Help Wanted OnLine (HWOL) dataset and represents the number of unemployed individuals relative to the number of vacancies posted by state for six broad occupation groups.[24] The numerator for our constructed supply/demand ratios is estimated using data on unemployed individuals from the American

[24] These broad groups consist of Management and business/financial (SOC 11–13), Professional & related (SOC 15–29), Services (SOC 31–39), Sales and office (SOC 41–43), Construction and maintenance (SOC 45–49), Production and transportation (SOC 51–53). This occupational division is used by Help Wanted Online when reporting sub-state vacancy measures and is very similar to the major occupational level of detail in Current Population Survey.

Community Survey. The denominator is calculated from two different data sources: the first measure uses the number of postings from the BGT data discussed above while the second measure uses HWOL as published by The Conference Board.[25] Although the two indices differ in terms of the level of slack they indicate for a given occupation x state x year cell, they similarly capture movements over time.[26]

We also employ additional covariates that we use to control for omitted factors.[27] To control for heterogeneity in the pre-existing pool of skilled labor available to employers, our baseline controls include the share of the state population with a bachelor's degree in 2000 and the average age of the state population in 2000. We also include two additional controls to account for heterogeneity across occupations. The first is the initial share of openings requiring a particular skill in 2007 (i.e. the 2007 share requesting a bachelor's degree or 4 or more years of experience) which is used to account for the variation in the initial level of skill required across occupations within a state. The second is the percent change in total openings over the period 2007–2012, as a share of employment in 2007 to control for the degree of turnover across occupations during this period.

V. OLS Results from Business Cycle Variation

As discussed above, we explore whether there is an increase in the education or experience requirements for job postings with a narrowly defined occupation and whether this increase is linked to the availability of skilled workers. Specifically, we begin by running

[25] HWOL provides state-level measures of labor demand at the 6-digit SOC level. HWOL is slightly different from BGT in that the program collects job postings from a smaller subset of sources, using vacancies posted directly on internet job boards and online newspaper ads, but not those posted on corporate websites.
[26] Despite collection from a smaller subset of sources, the number of postings in HWOL exceeds the number reported by Burning Glass for all three years in our study, thus producing a labor supply/demand ratio that indicates less labor market slack compared to the BGT labor supply/demand ratio. See Appendix Table A.1 for a matrix showing the correlation across the various labor supply variables for both the level and the change over time.
[27] See the data appendix for more detailed information on these covariates.

regressions of the form described above in Equation (1). Recall that the relationship of interest is β, the increase in skill requirements related to changes in labor supply. A larger β indicates that skill requirements rose more within occupations in state's experiencing rising unemployment. Of course, it would be naïve to infer causality from these relationships, given the potential for serious omitted variable bias. Still, investigating the baseline correlations is useful for comparison purposes.

A. Basic OLS Relationships

Table 2 reports the results of these initial regressions for each BGT measure of employer requirements of education and experience levels. Note that the share of employers *not* specifying an education or experience requirement decreased significantly in states where there was a greater increase in the unemployment rate, resulting in a negative coefficient that is consistent with upskilling. In all other specifications for our categorical skill measures, β is positive and statistically significant, indicating that there was an increase in the share of jobs requiring skilled workers across education and experience measures. Among the education measures, the effect is strongest for the share of postings requesting a bachelor's degree. Similarly, the strongest effect among the experience measures is for postings requesting up to 4 years of experience.

Our primary dependent variables sum across these skill categories yielding two cumulative measures: the share of employers requesting a bachelor's degree or higher and the share of employers requesting four or more years of experience. Using these cumulative measures, we continue to find a strong positive effect between employer skill requirements and

the degree of labor market slack.[28] Note that these basic correlations are robust to the inclusion of occupation x year fixed effects as well as the baseline state and occupation controls that we described earlier. As such, it is unlikely that our results are driven by changes over time in the composition of postings or the BGT data collection method.[29]

To give one a sense of the magnitude of this relationship, Figure 5 plots the change in employer requirements versus the change in the unemployment rate by state for all state/occupation cells. Our baseline estimates indicate that a 1 percentage point increase in the state unemployment rate raises the share of jobs requiring a bachelor's degree by 0.613 percentage points and increases the fraction of openings requiring 4 or more years of experience by 0.830 percentage points.

How large is this effect in terms of economic importance? In the context of the most recent downturn, our results imply that the nationwide increase in unemployment rates between 2007 and 2010 raised education requirements within occupations by 2.9 percentage points and raised experience requirements by 3.9 percentage points respectively. Relative to the observed increases in skill requirements reported in Table 1 during this period, our estimates suggest that changes in employer skill requirements due to the business cycle can account for roughly 30 percent of the total increase for education and nearly 60 percent of the increase for experience.

B. Accounting for Local Demand Shocks

[28] Our education measure captures the share of employers requiring a bachelor's degree or higher as the maximum education level for a given job posting. However, the results are very similar in magnitude and significance if instead we base our measure on the share of employers requiring a bachelor's degree or higher as the minimum education level for a given job posting.

[29] These baseline controls include the initial share of employers requiring each skill in 2007, the change in total postings between 2007 and 2012, the share of the state population with either a Bachelor's degree (for education specifications), and the average age of the state population (for experience specifications).

Although our baseline correlations demonstrate a significant and positive relationship between employer skill requirements and the state unemployment rate, this coarse labor supply measure does not allow us to control for local demand shocks, since it does not vary within a state. To better capture the availability of labor across states as well as occupations we construct supply/demand ratios at the state level for six broad occupation groups measured as the ratio of the number of unemployed individuals to the number of vacancies using data from both BGT and HWOL.[30]

Table 3 demonstrates that we continue to find a positive and significant relationship between employer requirements and labor market slack using these alternative measures. In addition, the construction of the supply/demand ratios provides us with the opportunity to control for local demand shocks and credit market constraints by making use of the variation within states across broad occupation groups by including state fixed effects in our regressions. Despite the addition of state fixed effects we still see a positive and significant relationship between changes in employer requirements and looser labor market conditions of virtually the same magnitude. Thus even controlling for differences in the state of the local economy, local labor supply increases remain correlated with rising employer skill requirements. Moreover, this relationship continues to hold even when we control for different trends for each state-occupation pair with the addition of state × occupation fixed effects, further verifying that the results are not simply driven by changes in the composition of vacancies that reflect pre-existing trends.

[30] HWOL publishes monthly a state-level supply and demand rate, expressed as the number of unemployed workers (as reported by the BLS) per advertised vacancy. We replicate this measure using their data on new advertised vacancies by state and broad occupation group (six broad occupation groups in total). We estimate the number of unemployed worker at the state/broad occupation group level using the American Community Survey divided by an average of the monthly number of vacancies reported for each state/broad occupation group. This measure is replicated, using total number of vacancies in Burning/Glass for each state/broad occupation groups divided by 12, to create the BGT index.

C. Controlling for Changes in Employer Composition and Data Quality Over Time

As discussed earlier, we also need to worry about changes in employer composition and data quality over time. Over the course of the Great Recession, the composition of employers as well as the types of jobs posted may have changed as industries suffered differential declines in employment. In addition, our primary data source begins in 2007 and the data collection mechanism may have changed over time.

To test this, we look at changes in employer requirements within an individual firm and job title over time using data from both BGT as well as the Minnesota Job Vacancy Survey. The top panel of Table 4 demonstrates that the share of online job postings in the BGT data that require a bachelor's degree or higher or 4 or more years of experience increased significantly with the state unemployment rate—even when controlling for **the same job title at the same employer.** A one percentage point increase in the state unemployment rate increases the probability that a particular firm/job title pair will increase skill requirements by 0.17 percentage points for education and by 0.12 percentage points for experience. Moreover, this effect is robust to controlling for trends for firm/job titles within a particular state.

Similarly, the bottom panel of Table 4 shows that share of openings measured by the Minnesota job vacancy survey requiring a college degree or "related" experience increases significantly with the local unemployment rate—again when controlling for **the same job title at the same employer.** This means that we can observe upskilling for the same job over time and that it is more prevalent during recessions when the supply of available workers is greater. This effect is also robust to the inclusion of controls for job characteristics such as part-time versus full-time positions as well as whether the job provides health care retirements benefits. Finally, the magnitude of the effect is similar to what we find using the BGT data, confirming

that the trends we find using the online job vacancy data do in fact reflect those of "real" vacancies as measured by employer surveys.

VI. Identification from a Natural Experiment: Troop Withdrawals from Iraq and Afghanistan

As a source of exogenous variation, we make use of a natural experiment resulting from the large increase in the post 9/11 veteran labor force following troop withdrawals from Iraq and Afghanistan from 2009-2012. Approximately 2.5 million service men and women served in Operation Enduring Freedom (2001), Operation Iraqi Freedom (2003), and Operation New Dawn (2010). In 2009, the U.S. began withdrawing these troops and by September 2012 approximately 1.6 million veterans had returned home and left active duty (Bilmes 2013). These returning veterans were concentrated in certain locations and occupations, providing a sizeable exogenous shock to the number of applicants per postings in select markets.

To capture the change in veteran labor supply over this period, we use the American Community Survey to estimate the change in the number of post-9/11 veterans in the labor force at the state level each year from 2007 through 2012.[31] An additional 200,000 to 300,000 post 9/11 veterans joined the labor force each year between 2007 and 2012 providing an exogenous increase in the supply of skilled labor.[32] Figure 6 demonstrates that the changes in the post-9/11 veteran population relative to the number of job postings varied considerable across the U.S. with some states receiving a disproportionate share of the veteran withdrawal.

[31] Appendix Table A.3 reports summary statistics for our veteran supply shock measures.
[32] Interestingly, the educational attainment of post-911 veterans is higher than that of the non-veteran population with a significantly lower share of high school dropouts and high school graduates with no college, a significantly higher share of individuals with some college or an associate's degree, and similar shares of individuals with a bachelor's degree or higher. http://www.jec.senate.gov/public/?a=Files.Serve&File_id=dbd50af7-f2c8-4a61-8f81-02b80637a369

We also used the ACS to estimate veteran concentration within an occupation as the occupation's share of veteran employment.[33] Figure 7 shows that veteran employment is concentrated among a select group of occupations that typically make use of the specialized skill set that comes from serving in the military. These military-specific occupations include protective services such as police officers and sheriffs, security guards, and fire fighters as well as operations specialists such as aircraft mechanics, logisticians, and computer support specialists. This variation across states, occupations, and years creates a natural experiment from which we can measure the response of skill requirements to labor supply. For example, Figure 8 shows that logisticians—an occupation with a high concentration of veteran employment—experienced significant "up-skilling," whereas dental hygienists—an occupation with few veterans—did not.

To more formally capture this targeted impact of the increase in the supply of post 9/11 veterans on the labor market, we construct several measures of changes in the supply of labor across state-occupation-year cells. We then replicate our earlier model by regressing changes in skill requirements on this supply measure, with a variety of controls:

$$\Delta\ Share\ of\ Vacancies\ Requiring\ Skill\ S_{ijt} = \alpha_i + \alpha_j + \beta \Delta Veteran\ Supply_{ijt} + \alpha X_{itj} + \tau_t + e_{ijt}$$

where the α_i are state fixed effects, α_j are occupation fixed effects, τ_t are year fixed effects, and X_{itj} are the baseline controls discussed in Table 2. As before the coefficient of interest is β

[33] These occupation shares are calculated using ACS 3yr 2007 PUMS to reflect pre-recession trends.

which measures the degree of supply-induced upskilling across state-occupation cells over time.[34]

The results of these regressions are reported in Table 5 using four different measures of the veteran supply shock. The first three of these measures are broadly similar and are presented in Panel A. The measure presented in the first row is simply the log difference in the number of Post-9/11 veterans in the state labor force, as measured in the ACS, multiplied by the occupation's share of veterans. The results in the first row of Panel A in this table show that this simple measure is correlated with increasing skill requirements, for both education and experience, with and without state fixed effects.

One drawback to this measure is that the 1-year ACS was not designed to measure high frequency changes in the number of post-9/11 veterans at the state level. As a result, the changes we measure are noisy and thus our estimates are subject to attenuation bias. An alternative approach is to take the log difference in the number of Post-9/11 veterans at the national level and create state level variation by multiplying this change by a state's average share of the post-9/11 veteran labor force measured over time. This approach is similar in spirit to the "initial immigrant share" method used by Card (2009) and others to study the impact of migrants.

Of course, the residence of veterans following the drawdown in Iraq and Afghanistan is potentially endogenous, as veterans can choose to migrate to better employment opportunities. This is particularly relevant during the period we are studying at the height of the Great Recession. To address this issue, we once again construct an allocation-based measure using based on the national change in post-9/11 veterans. This time, however, instead of allocating

[34] As before, we will weight our observations by each occupation's share of the state total, restrict the sample to occupations with greater than 15 postings, and cluster the standard errors by state.

veterans to states based on that state's current residents, we allocate them based on the veterans' share by **state of birth.** This measure of location is truly exogenous, as veteran state of birth from several decades ago is not correlated with changes in the current state of the labor market today. Yet, places where many veterans were born do receive a larger labor supply shock as many veterans return home.

Panel A of Table 5 demonstrated that there is a strong, significant and positive relationship between these measures of the veteran supply shock and the change in employer requirements. Moreover, controlling for state fixed effects, which we alternately do in the columns, does not have a large impact on these results. This suggests that we are not picking up some hidden, underlying state-level trend. As expected and explained above, we tend to get more precise estimates when we use the allocation technique. The implied magnitudes suggest that a 1 standard deviation larger veteran shock causes a 0.6 to 1.4 percentage point increase in the share of postings requiring a bachelor's degree and a 0.7 to 1.5 percentage point increase in the share requiring 4+ years of experience.

How do these results compare to the OLS results described in previous sections? To create a more directly analogous measure, we take the change in number veterans (again measuring by state of birth) and multiply this by the occupation's veteran share. We then divide this absolute supply measure by the total number of postings in each broad occupation group within the state, creating a BGT Supply /Demand Ratio for Post-9/11 Vets.[35] As seen in the first row in Panel B, changes in this measure again strongly correlates with upskilling. The implied magnitude is quite similar to the results in Panel A; a 1 standard deviation increase in supply is

[35] To eliminate outliers due to noise in the denominator in small occupations and states we drop the bottom and top 5% of values.

associated with a 0.76 percentage point increase in the share requiring a BA and a 1 percentage point increase in the share requiring 4+ years of experience.

This veteran supply and demand measure can also be used as an instrument for the aggregate supply-and-demand measure described in Table 3. This instrument captures both information about the number of searchers and total demand in a labor market and occupation. As such, it has sufficient power to surpass traditional weak instrument benchmarks as shows by the first stage F-Statistic is reported at the bottom of Panel B (Stock and Yogo 2005). These IV estimates—again using veteran intensity by *state of birth* – are if anything larger than those reported in Table 3.

Of course, the veteran intensity shocks matter most for certain occupations and locations, which may not be representative along certain dimensions. Still, the fact that our natural experiment provides similar results to the baseline OLS regressions using the business cycle variation as well as the within firm-job title estimates strongly suggests that a causal upskilling relationship exists between employer requirements and the supply of available workers.

VII. Mechanisms: Predictions from Employer Search Theory Applied to Upskilling

In this section we show that the strength of the upskilling relationship varies along dimensions predicted by a standard stopping problem model of employer job search. Specifically, we test whether the degree of employer upskilling in slack labor markets is consistent with a causal effect on employer searching. Recall that from our employer wait-and-see stopping model that the firm value function for firm *i* can be written as:

$$V_i(\theta_i, \rho_i, \delta_i, c_i, L, V) = -c_i + \left(1 - e^{\frac{-\gamma L}{V}}\right)\frac{\theta}{1-\delta\rho} + e^{\frac{-\gamma L}{V}} max\left\{\rho V_i, \frac{1}{1-\delta\rho}\right\}.$$

In this environment, firms' decisions follow a cutoff rule in their costs of maintaining a vacancy c_i^*. Employers with costs below the cutoff post minimum skill requirements and employers with costs above the cutoff do not. Since costs are drawn from a uniform distribution, c_i^* (when scaled) is also the fraction of employers posting vacancies with skill requirements. The fraction of firms that wait for a high skilled worker $F(c^*)$ is increasing the size of the labor market L and skill premium θ, and is decreasing in the turnover rate $1-\delta$ and urgency for new hires to begin working $1-\rho$. Thus, the magnitude of the upskilling effect depends on the parameters θ, δ, and ρ. The model's cross-partials demonstrate[36] that extent of upskilling that increases with the college premium θ, decreases with the turnover rate $1-\delta$, and decreases with the urgency of work commencing $1-\rho$.

Armed with these predictions, we now test whether the degree of employer upskilling across labor markets matches the model. To do this, we must create empirical analogs for the parameters θ, δ, and ρ. We measure θ and δ at the six digit occupation level, using data from the BLS. We set the skilled wage premium θ equal to the log difference in wages between the 75th percentile and the 25th percentile from the 2007 Occupational Employment Statistics Report. We measure δ using replacement rates in the Employment Projections Survey. Finally we measure ρ, the urgency of work beginning, at the six digit occupation level using data from O*Net. We take as a proxy for the lack of time sensitivity the average reported time, in months, spent training after being hired. We explore how these proxies moderate upskilling in Table 6. The results in columns (1)–(3) and (5)–(7) indicate that upskilling is more prevalent when average turnover rates are lower, when on the job training time is greater, and when average skill premiums are

[36] The model yields $\frac{dc^*}{dL} = \frac{\gamma}{V} e^{-\frac{\gamma L}{V}} \left(\frac{\theta - 1}{1-\beta\delta}\right)$, and all of the necessary cross-partials follow trivially.

higher. In fact, upskilling of education requirements appears to be largely driven by occupations with higher wage premiums.

A richer model of employer search would allow for a wage setting margin as well. For example, suppose the probability of drawing a high skilled worker $p(L, w)$ depends positively on the number of workers *L* and the wage *w*. Further suppose that while $\frac{\partial p}{\partial w} > 0, \frac{\partial^2 p}{\partial w^2} < 0$, so that higher wages increase the probability of matching at a decreasing rate. In this case, a profit maximizing firm would decrease wages in response to an increase in *L*, moderating the increase in matching probability and the motivation to up-skill.[37] By this logic, firms that cannot adjust wages are more likely to raise skill requirements than firms that can adjust along multiple margins.

We again test this intuition in Table 6 using data from the CPS on union coverage across occupations.[38] One would expect to find greater upskilling within occupations that are exposed to a greater degree of downward nominal wage rigidity, such as that associated with collective bargaining. This is because when workers are plentiful, it is less costly for employers to raise skill requirements to boost productivity relative to other adjustments in wages or production. In Columns (4) and (8), we show that, indeed, the upskilling margin is larger in occupations with greater wage rigidity.

The upshot of these tests is that upskilling appears strongest among occupations in a manner consistent with standard economic models.[39] This result is strong evidence that the

[37] Suppose a firm maximizes profits $\mathrm{p(L,w)}(\ \theta\ -\mathrm{w})$ under the condition in the text. The equilibrium wage w^* satisfies $\frac{\mathrm{dw}^*}{\mathrm{dp}} = \frac{1}{\frac{\partial^2 \mathrm{p}}{\partial \mathrm{w}^2}} < 0$.

[38] Compiled by unionstats.com using CPS Outgoing Rotation Group data.

[39] One concern is that this simple discussion took the number of firms posting vacancies as given, rather than allow free entry. This would not be essential to the result, though, in a more complex model. For example, Kaas and

causal impact of labor availability on skill requirements is not spurious. Further, these cross-sectional findings suggest important mechanisms for macroeconomic models and narrower targets for policy intervention.

As an additional check, one can also examine the relationship between changes in employer requirements and changes in wages. If changes in employer requirements were driven by changes in the demand for skilled workers, rather than by an increase in their supply, then we would observe an increase in the skilled wage premium. The first four columns of Table 7 report the coefficients from regressing the log change in the skilled wage premium from before as well as the log change in mean wages on the change in employer requirements. The results demonstrate that there is no statistically or economically significant relationship between changing employer requirements and changes in wages during this period, confirming that the upskilling we observe is not driven by changes in demand for skilled workers.

VIII. Conclusion

The persistent weakness of the U.S. labor market following the Great Recession continues to be of concern to both researchers and policymakers alike. On the one hand, employers report having difficulty finding skilled workers to fill open positions, suggesting the potential for some degree of labor market mismatch across industry, occupation, or geography. Yet on the other, economists point to the lack of real wage growth observed even within industries and occupations with relatively strong demand suggesting little role for labor market mismatch. More recently, the economics literature has explored the possibility that a decrease in

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Kircher (2014) get time-varying and pro-cyclical recruitment intensity in one model with free-entry by setting recruitment costs as a convex function of the vacancy rate (V/Employees). In this situation, entry by small firms does not displace hiring by incumbents, and incumbents will look to adjust both the number of vacancies and their recruiting intensity in response to labor supply shocks.

"recruitment intensity" per vacancy during the recession has resulted in an upward shift in the Beveridge Curve such that a higher vacancy rate now prevails for a given unemployment rate (Davis et al 2012). Yet to date the application of this theory has been limited by the absence of direct measures of recruiting intensity across employers.

In this paper, we directly measure one channel along which recruitment intensity may have shifted during the Great Recession—in the skill requirements employers use to screen candidates when filling a new vacancy—and find evidence of *opportunistic* upskilling. Using data from online job vacancy postings, we examine changes in employer requirements across occupations and locations during the course of the Great Recession. We find that, in loose labor markets, employer requirements rise for both education and experience—even when controlling for time, occupation, and state fixed effects among other covariates. This pattern is found using multiple measures of labor availability. Using both online vacancy data as well as that from a state-level employer survey, we find that unemployment-related upskilling occurs even within firm-job title pairs during downturns. We also find a similar pattern of employer upskilling associated using a natural experiment based on troop withdrawals from Iraq and Afghanistan as a source of exogenous variation. Again, this indicates that the upskilling we observe during this period is caused by increases in the availability of workers rather than shifts in demand.

Finally, we show that the degree of unemployment-related-upskilling across industries and states is consistent with a causal effect on employer searching: it is larger when average turnover rates are lower, when on-the-job training time is greater, and when other margins like wages are less flexible. We also provide new evidence demonstrating that the college wage premium for new hires falls as unemployment rises, which may motivate firms to increase their skill requirements when they can hire new talent "on the cheap."

The finding that weaker labor markets lead to rising job posting requirements has important implications for models in labor and macroeconomics that are aimed at explaining the dynamics of labor market during recessions. In particular, we are able to document a novel feedback mechanism between labor supply and the selectivity of vacancies that may be relevant for macroeconomic models with heterogeneous workers and welfare analysis. For example, our results indicate that between one-quarter and two-third of the observed increase in skill requirements *within* detailed occupations is correlated with the business cycle. This is yet another piece of evidence in the literature that substantiates the notion that what is sometimes labeled as structural mismatch employment is at least partially cyclical as not all vacancies represent the same urgency to hire.

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Table 1. Summary Statistics

Mean:	2007	2010	2012	Δ2007–10	Δ2010–12
Employer Education and Experience Requirements					
Total Number of Job Posting Ads					
Mean	634.40	516.73	625.19	-97.46	95.49
Standard Deviation	1,977.38	1,701.25	2,052.94	579.56	497.86
Mean Share of Job Postings Requesting:					
No Educational Requirement	76.98	57.84	52.63	-19.45	-5.09
High School Degree	8.40	16.72	19.02	8.25	2.37
Associate's Degree	1.69	3.01	3.40	1.37	0.38
A Bachelor's Degree	9.73	16.6	18.44	7.23	1.72
A Graduate Degree	3.20	5.83	6.51	2.60	0.63
A Bachelor's or Greater	12.93	22.43	24.95	9.83	2.34
Share of Job Postings Requesting:					
No Experience	76.95	58.86	54.95	-18.49	-3.76
Less Than Two Years of Experience	5.92	10.66	12.43	4.75	1.75
Two to Less than Four Years of Experience	8.54	15.92	17.26	7.50	1.29
Four to Less Than Seven Years of Experience	5.93	10.13	10.83	4.38	0.66
Seven or More Years of Experience	2.47	4.04	4.14	1.65	0.06
Four or More Years of Experience	8.40	14.17	14.97	6.04	0.72
Measures of Labor Market Slack					
State Unemployment Rate					
Mean	4.43	9.07	7.59	4.64	-1.5
Standard Deviation	0.87	1.95	1.61	1.51	0.76
State UR for Workers with a Bachelor's Degree of Greater	2.62	4.69	3.97	2.09	-0.73
State UR for Workers Aged 35 Plus	3.11	7.13	5.80	4.02	-1.33
HWOL Broad Occ. Group Labor Supply/Demand Ratio	5.51	9.38	5.37	3.67	-3.96
BGT Broad Occ. Group Labor Supply/Demand Ratio	10.99	17.08	11.73	5.75	-5.28
Observations	18694	19470	18970	18694	18970

Notes: Observations are State × 6-digit Standard Occupation Code (SOC) cells containing at least 15 total postings. The last two columns are summary statistics for the change in these measures by time period and combined represent the estimation sample for the baseline relationships with controls presented in Table (2). Help Wanted Online (HWOL) and Burning Glass Technologies (BGT) Broad Occupation Group Labor Supply/Demand Ratios are annual, state-level measures for the average number of unemployed persons per job postings within six, broad occupation groups. Both measures are constructed by dividing the number of unemployed persons by the average monthly count of job postings reported by the two firms within a broad occupation group for a given year.

Source: Employer requirements calculated using data from Burning Glass Technologies (2007, 2010, 2012); state unemployment rates collected from the Bureau of Labor Statistics; state unemployment rates by education and age constructed using ACS 1yr. PUMS, IPUMS-USA; HWOL and BGT broad occupation group labor supply/demand rates are constructed using data from the Conference Board, Burning Glass Technologies and ACS 1yr. PUMS.

Table 2. Changes in Employer Requirements and Labor Market Slack, 2007–2012.

Panel A: Education Qualifications

	Percentage Point Change in the Share of Postings Requesting:					
	No Educ. Requested	High School	Associate's Degree	Bachelor's Degree	Graduate Degree	Bachelor's Degree or Greater
	(1)	(2)	(3)	(4)	(5)	(6)
Δ State UR	-1.768***	0.541***	0.173***	0.925***	0.129***	0.613***
	(0.155)	(0.0920)	(0.0181)	(0.0714)	(0.0214)	(0.203)
Δ State UR:	-3.815***	1.220***	0.354***	1.962***	0.280***	0.965***
Bachelor's or Greater	(0.342)	(0.203)	(0.0419)	(0.165)	(0.0532)	(0.277)
Occ × Year Fixed Effects	No	No	No	No	No	Yes
Baseline Controls	No	No	No	No	No	Yes
Observations	40366	40366	40366	40366	40366	37664

Panel B: Experience Qualifications

	Percentage Point Change in the Share of Postings Requesting:					
	No Exper. Requested	>0 to <2 Yrs.	⩾ 2 to <4 Yrs.	⩾4 to <7 Yrs.	⩾ 7 Yrs.	⩾ 4 Yrs.
	(1)	(2)	(3)	(4)	(5)	(6)
Δ State UR	-2.421***	0.545***	0.828***	0.657***	0.359***	0.830***
	(0.157)	(0.0651)	(0.0564)	(0.0493)	(0.0298)	(0.135)
Δ State UR:	-2.711***	0.605***	0.928***	0.742***	0.402***	0.823***
Workers 35 Plus	(0.179)	(0.0681)	(0.0617)	(0.0580)	(0.0388)	(0.138)
Occ × Year Fixed Effects	No	No	No	No	No	Yes
Baseline Controls	No	No	No	No	No	Yes
Observations	40366	40366	40366	40366	40366	37664

Notes: The dependent variables for Panel A columns (1)–(5) are percentage point changes in the share of posting listing no educational requirement, a High School degree, an Associate's degree, a Bachelor's degree, and a Graduate/Professional degree respectively. The dependent variable for column (6) is the percentage point change in the share of posting requesting a Bachelor's degree or greater. The dependent variables for Panel B columns (1)–(5) are percentage point changes in the share of posting listing no experience requirement, less than 2 years, 2 to less than 4 years, 4 years to less than 7 years, and 7 or more years respectively. The dependent variable for column (6) is the percentage point change in the share of postings requesting 4 or more years experience. Baseline controls include the initial (2007) share of postings requiring the skill measured; change in the number of total postings, 2007–2012, as a share of total employment in 2000; and the share of the state population with a Bachelor's Degree or greater in 2000 (Panel A)/average age of the population in 2000 (Panel B). Observations are State × Occupation cells containing at least 15 job posting (for both years over which the change is measured) and are weighted by the occupation's share of each state's total postings. Standard errors (in parentheses) clustered by state. * p<0.10, ** p<0.05, *** p<0.01

Table 3. Changes in Employer Requirements and Labor Market Slack, Using *within* State Variation.

Panel A: Education Qualifications

	Percentage Point Change in the Share of Postings Requesting a Bachelor's Degree or Higher:		
	(1)	(2)	(3)
Δ in HWOL	0.198***	0.265***	0.408***
Sup/Dem Rate	(0.0626)	(0.0693)	(0.107)
Observations	34668	34668	32684
Δ in BGT	0.0974***	0.106***	0.173***
Sup/Dem Rate	(0.0318)	(0.0369)	(0.0482)
Observations	34816	34816	32270
Baseline Controls	Yes	Yes	Yes
Occ × Year Fixed Effects	Yes	Yes	Yes
State Fixed Effects	No	Yes	No
State∗Occ FE	No	No	Yes

Panel B: Experience Qualifications

	Percentage Point Change in the Share of Postings Requesting 4 or More Years Experience		
	(1)	(2)	(3)
Δ in HWOL	0.294***	0.278***	0.467***
Sup/Dem Rate	(0.0497)	(0.0587)	(0.0918)
Observations	34668	34668	32684
Δ in BGT	0.178***	0.157***	0.255***
Sup/Dem Rate	(0.0268)	(0.0418)	(0.0526)
Observations	34816	34816	32270
Baseline Controls	Yes	Yes	Yes
Occ × Year Fixed Effects	Yes	Yes	Yes
State Fixed Effects	No	Yes	No
State∗Occ FE	No	No	Yes

Notes: Help Wanted Online (HWOL) and Burning Glass Technologies (BGT) Broad Occupation Group Labor Supply/Demand Ratios are annual, state-level measures for the average number of unemployed persons per job postings within six broad occupation groups. Both measures are constructed by dividing the number of unemployed persons by the average monthly count of job postings reported by the two firms within a broad occupation group for a given year. Observations are State × Occupation cells containing at least 15 job posting (for both years over which the change is measured) and are weighted by the occupation's share of each state's total postings. Standard errors (in parentheses) clustered by state. * p<0.10, ** p<0.05, *** p<0.01

Table 4. Changes in Employer Requirements and Labor Market Slack, Using *within* Firm × Job-Title Variation.

Panel A: Burning Glass Online Vacancy Data

	Share of Postings Requesting a Bachelor's Degree or Greater		Share of Postings Requesting 4 or More Years Experience	
	(1)	(2)	(3)	(4)
State Unemployment Rate	0.172**	0.279*	0.125**	0.237*
	(0.0692)	(0.154)	(0.0477)	(0.121)
Firm × Job-Title Fixed Effects	Yes	No	Yes	No
Firm × Job-Title × State FE	No	Yes	No	Yes
Observations	12536279	10958041	12536279	10958041

Panel B: Minnesota Job Vacancy Survey

	Share of Postings Requesting a Bachelor's Degree or Greater		Share of Postings Requesting Related Experience	
	(1)	(2)	(3)	(4)
Regional Unemployment Rate	0.487***	0.684***	0.206	0.389**
	(0.104)	(0.102)	(0.194)	(0.196)
Firm × Job Title Effects	Yes	Yes	Yes	Yes
Job Characteristic Controls	No	Yes	No	Yes
Employee Benefit Controls	No	Yes	No	Yes
Observations	205860	184358	202528	182478

Notes: Observations in Panel A are individual job postings from Burning Glass Technologies from 2007, 2010, and 2012. All specifications include a linear time trend. Note that we drop observations with more than 50 duplicate posting for a given firm-job-state-year-month pair. Observations in Panel B are job openings reported by firms from the Minnesota Job Vacancy Survey. Dependent variable for columns (1) and (2) is a binary indicator for whether the job opening requires a college degree; dependent variable for columns (3) and (4) is a binary indicator for whether the job requires *related* experience. The MNDEED survey data reports three distinct categories for experience: no work experience, some work experience, related work experience. The constructed dependent variable for experience identifies whether the job requires *related* experience only. The regional unemployment rate covariate is reported at the Minnesota Economic Development Region level of variation. The level of geographic detail in the MN job survey data changes in 2005 from six geographic regions to thirteen economic development regions. The unemployment rate data used for specifications in Panel B are reported at the lowest level of geographic detail provided for each job opening in a given year. All specifications in Panel B include a linear time trend. Job characteristic controls include indicator variables for full or part time position and if the position requires a certificate/licensure. Employee benefit controls include indicator variables for health insurance, retirement, and paid time off benefits. * p<0.10, ** p<0.05, *** p<0.01

Table 5. Changes in Employer Requirements and Veteran Supply Shock

Panel A: OLS Estimates Using Veteran Supply Shock	Change in Share of Postings Requesting a Bachelor's Degree or Greater		Change in Share of Postings Requesting a 4 or More Years Experience	
	(1)	(2)	(3)	(4)
Δ Log Post 9/11 Vets by State × Occ Vet Share	1.458*	1.662*	1.788**	1.692*
	(0.784)	(0.885)	(0.859)	(0.934)
Δ Log Post 9/11 Vets × State Vet Share × Occ Vet Share	0.413**	0.361***	0.696***	0.483***
(Allocated By State of Residence)	(0.168)	(0.0971)	(0.162)	(0.110)
Δ Log Post 9/11 Vets × State Vet Share × Occ Vet Share	0.464**	0.314***	0.558***	0.404***
(Allocated By State of Birth)	(0.191)	(0.0930)	(0.129)	(0.0976)
Baseline Controls, Occ and Year FEs	Yes	Yes	Yes	Yes
State Fixed Effects	No	Yes	No	Yes

Panel B: IV Estimates Using Veteran Supply Shock	Change in Share of Postings Requesting a Bachelor's Degree or Greater		Change in Share of Postings Requesting a 4 or More Years Experience	
	(1)	(2)	(3)	(4)
Δ BGT Supply /Demand Ratio for Post-9/11 Vets	1.380***	1.317**	1.840***	1.823***
(Allocated by State of Birth)	(0.514)	(0.621)	(0.506)	(0.646)
Δ BGT Supply/Demand Ratio	0.498***	0.544**	0.582***	0.645***
IV with Δ BGT Supply /Demand Ratio for Post-9/11 Vets	(0.153)	(0.204)	(0.142)	(0.208)
(Allocated by State of Birth)				
First Stage F-Statistic (for Δ BGT Supply/Demand Ratio)	16.4	21.7	16.4	21.7
Baseline Controls, Occ and Year FEs	Yes	Yes	Yes	Yes
State Fixed Effects	No	Yes	No	Yes

Notes: Each coefficient represents a separate regression, with the same baseline controls, weights, and sample constructions as in our other tables. All standard errors are clustered by state. Panel A uses three related measures of the veteran supply shock. The first measure uses the log change of post-9/11 veterans residing in the state, as calculated from the annual American Community Survey, multiplied by the occupation's share of employees who are veterans. The second measure measure is the log change in Post-9/11 veterans at the national level multiplied by each state's average share of veterans over the entire period and then multiplied by the occupation's share of employees who are veterans. The third measure re-computes the second measure using state of birth in place of state of residence. Panel B uses two supply and demand measures similar to those found in Table 3 to create comparable IV estimates. The first is the supply/demand ratio for post-9/11 veterans by state of birth which is constructed as the the number of Post-9/11 veterans in the labor force multiplied by an occupation's share of employees who are veterans divided by the broad occupation group's total job postings. This variable is then used to instrument for the previous BGT supply/demand ratio found in Table 3. As before, outliers below the 5th and 95th percentile of the supply and demand ratio distribution are removed. First stage F-statistics demonstrating the absence of weak-instrument bias are reported for these IV regressions in the line below. * p<0.1, ** p<0.05, *** p<0.01

Table 6. Changes in Employer Requirements and Labor Market Slack, by *Occupation Characteristics*

	Change in Share of Postings Requesting a Bachelor's Degree or Greater				Change in Share of Postings Requesting 4 or More Years of Experience			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ State UR	0.954***	0.428***	0.104	0.373	1.314***	0.483***	0.471***	0.606***
	(0.277)	(0.157)	(0.220)	(0.245)	(0.212)	(0.102)	(0.172)	(0.174)
(Δ State UR)*(Occ Replacement Rate)	-0.00996**				-0.0213***			
	(0.00437)				(0.00478)			
(Δ State UR)*(On The Job Training Time)		0.289***				0.330***		
		(0.0762)				(0.0783)		
(Δ State UR)*(Initial Hr. Wage Prem. (07))			0.997***				0.759***	
			(0.322)				(0.266)	
(Δ State UR)*(State Union Membership Share)				0.0286*				0.0272*
				(0.0163)				(0.0140)
Baseline Controls	X	X	X	X	X	X	X	X
Occ × Year Fixed Effects	X	X	X	X	X	X	X	X
Observations	36972	31916	34352	37578	36972	31916	34352	37578

Notes: The dependent variable for columns (1)–(4) is the percentage point change in the share of posting requesting a Bachelor's degree or greater and the percentage point change in the share of postings requesting 4 or more years of experience for columns (5)–(8) in Panels A and B. The Occupation Replacement Rate is a national detailed occupation-level measure for the annual replacement needs over the period 2012-2022 as a share of 2012 employment. On the Job Training Time is a detailed occupation-level measure provided by ONET. The initial hourly wage premium is a state by detailed occupation-level measure, calculated by taking the log difference in the 75th and 25th percentiles of hourly wages as reported by BLS Occupational Employment Statistics in 2007. State union membership concentration is the share of employees in the state covered by a collective bargaining agreement as reported by the Current Population Survey. Observations are State × Occupation cells containing at least 15 job posting in both periods for which the change is measured and are weighted by the occupation's share of each state's total postings. Standard errors (in parentheses) clustered by state. * p<0.10, ** p<0.05, *** p<0.01

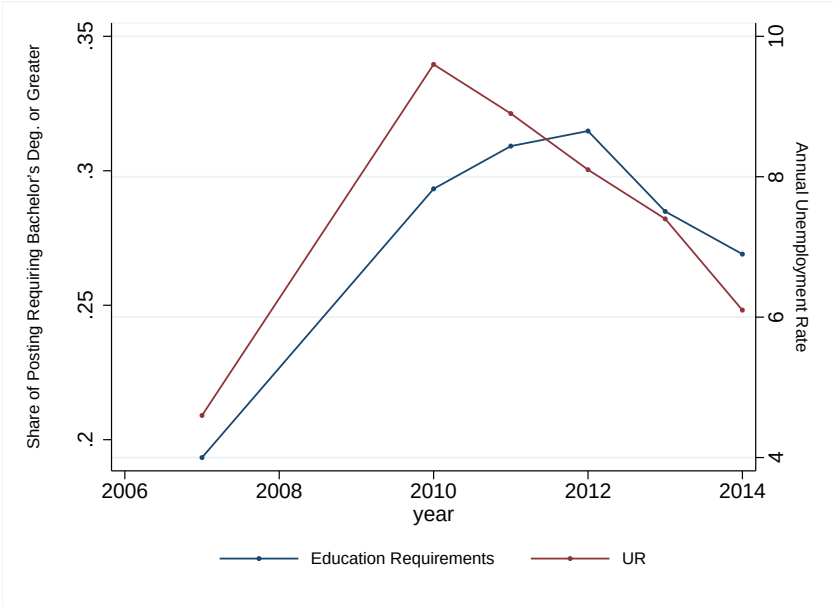
Table 7. Relationship Between Change in Wages and Change in Employer Requirements

	Log Difference in Hourly Wage Premium				Log Difference in Mean Hourly Wage			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Share of Postings Requesting Bachelor's Degree or Greater	-0.0000700	-0.0000585			-0.000106	-0.000118		
	(0.000131)	(0.000130)			(0.000148)	(0.000143)		
Δ Share of Posting Requesting 4+ Years Experience			-0.0000711	-0.0000462			-0.0000383	-0.0000665
			(0.000123)	(0.000121)			(0.000186)	(0.000184)
Δ State UR		-0.000443		-0.000485		0.000476		0.000559
		(0.000780)		(0.000748)		(0.000760)		(0.000802)
Baseline Controls	X	X	X	X	X	X	X	X
Occ × Year Fixed Effects	X	X	X	X	X	X	X	X
Observations	32555	32555	32555	32555	33462	33462	33462	33462

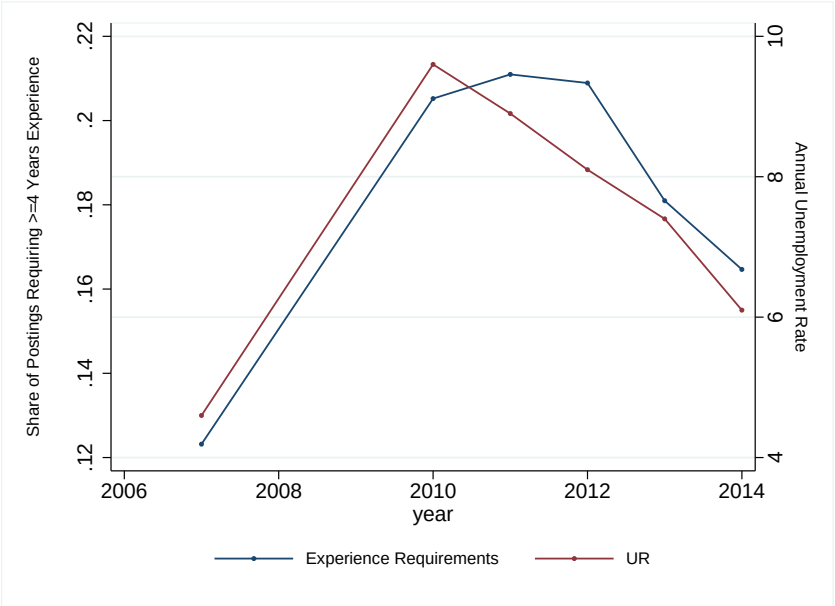
Notes: NO NOTES– this is a new table.

Figure 1. Relationship between Changes in Employer Requirements and Labor Supply

Requested Educational Qualifications



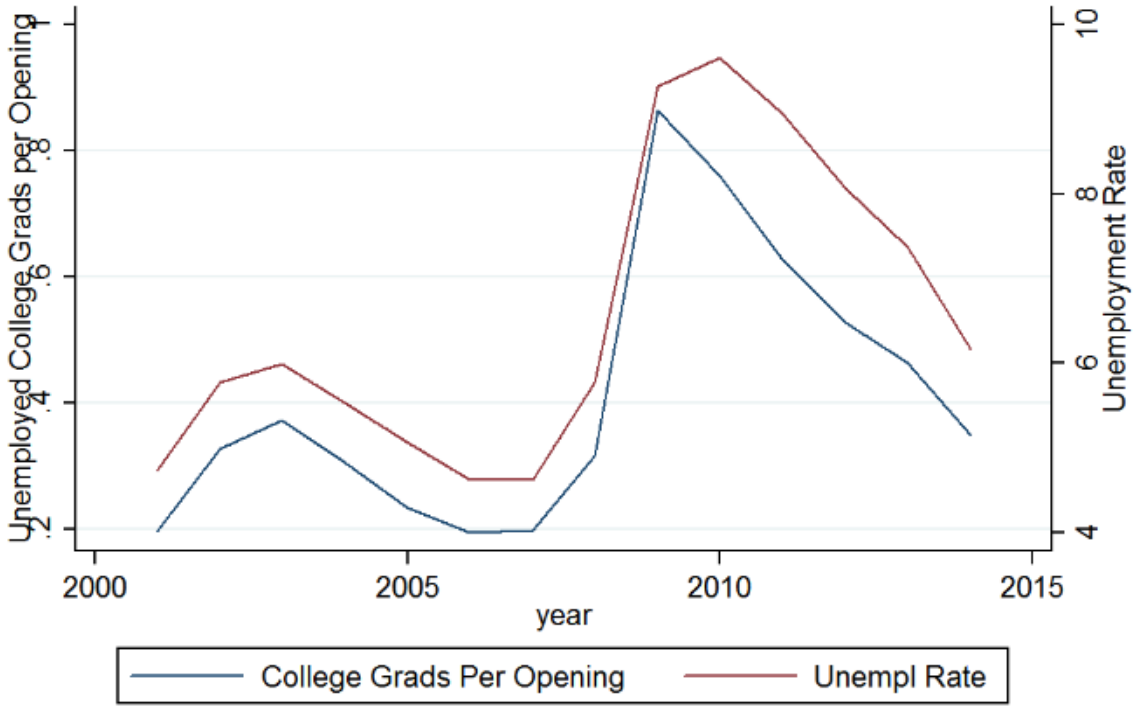
Requested Experience Qualifications



Source: Authors' analysis using data from Burning Glass Technologies, 2007, 2010–2014.

Source: Author's analysis of data from Burning Glass Technologies; state unemployment rates collected from the Bureau of Labor Statistics.

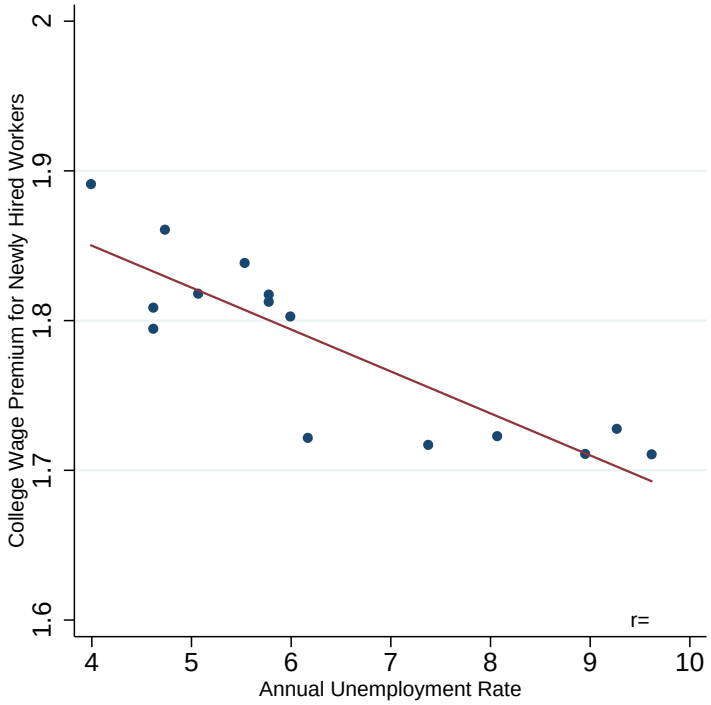
Figure 2. Correlation Between Skilled Workers Per Posting and the Unemployment Rate, 2000–2014



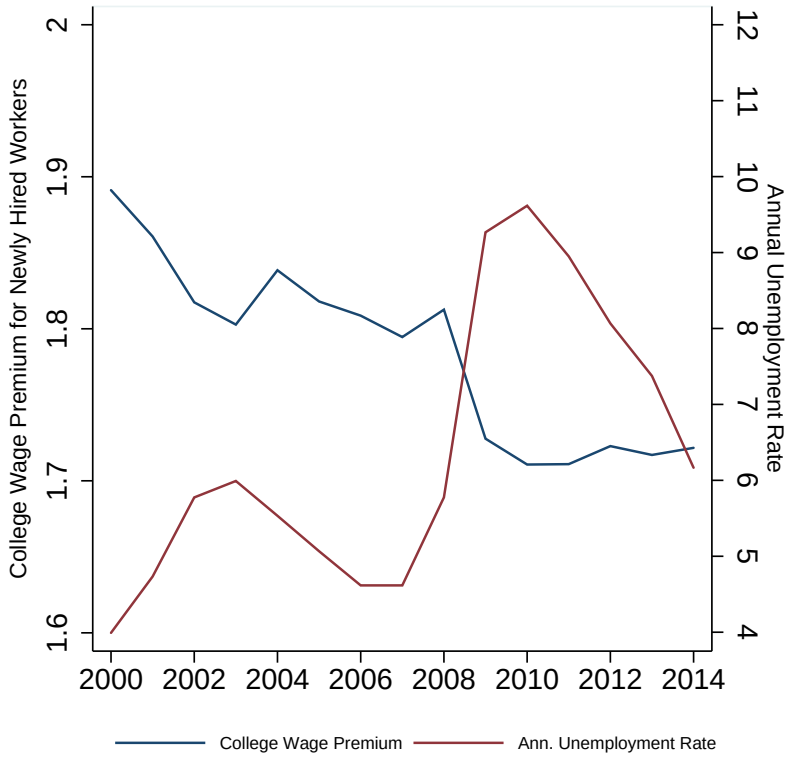
Notes: The unemployment rate is the annual rate for the U.S. as reported by the Bureau of Labor Statistics. The number of unemployed college graduates per opening is calculated by dividing the number of college graduates divided by the number of job openings each year for the U.S. The number of college graduates is calculated from the Current Population Survey. The number of job openings is the average over the twelve months of the year as reported by the Job Openings and Labor Turnover Survey collected by the Bureau of Labor Statistics.

Figure 3. Relationship between Changes in Employer Requirements and Labor Supply

Panel A: College Wage Premium for New Hires **and Unemployment Rate over Time**

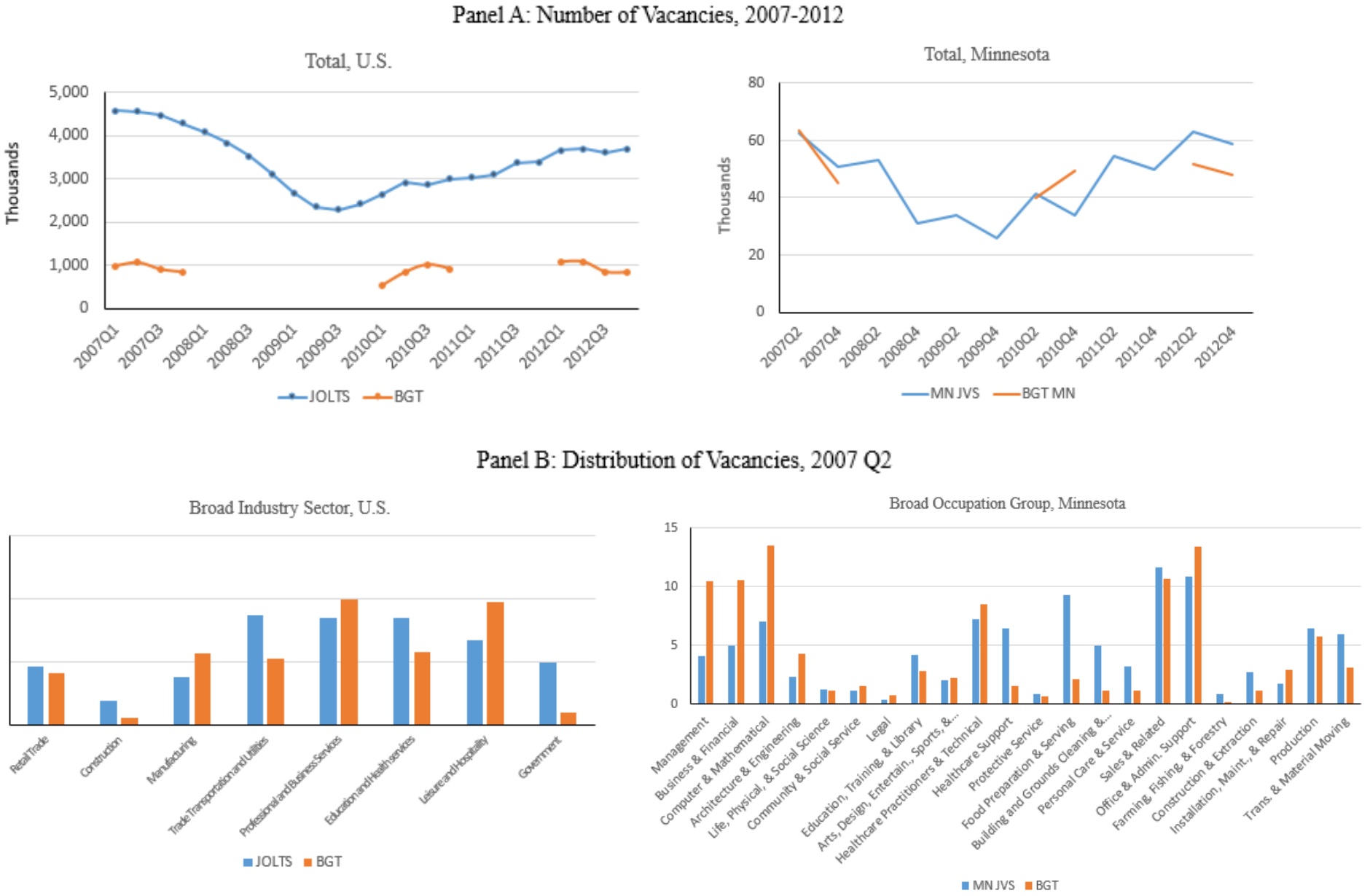


Panel B: Correlation between College Wage Premium for New Hires **and Unemployment Rate**



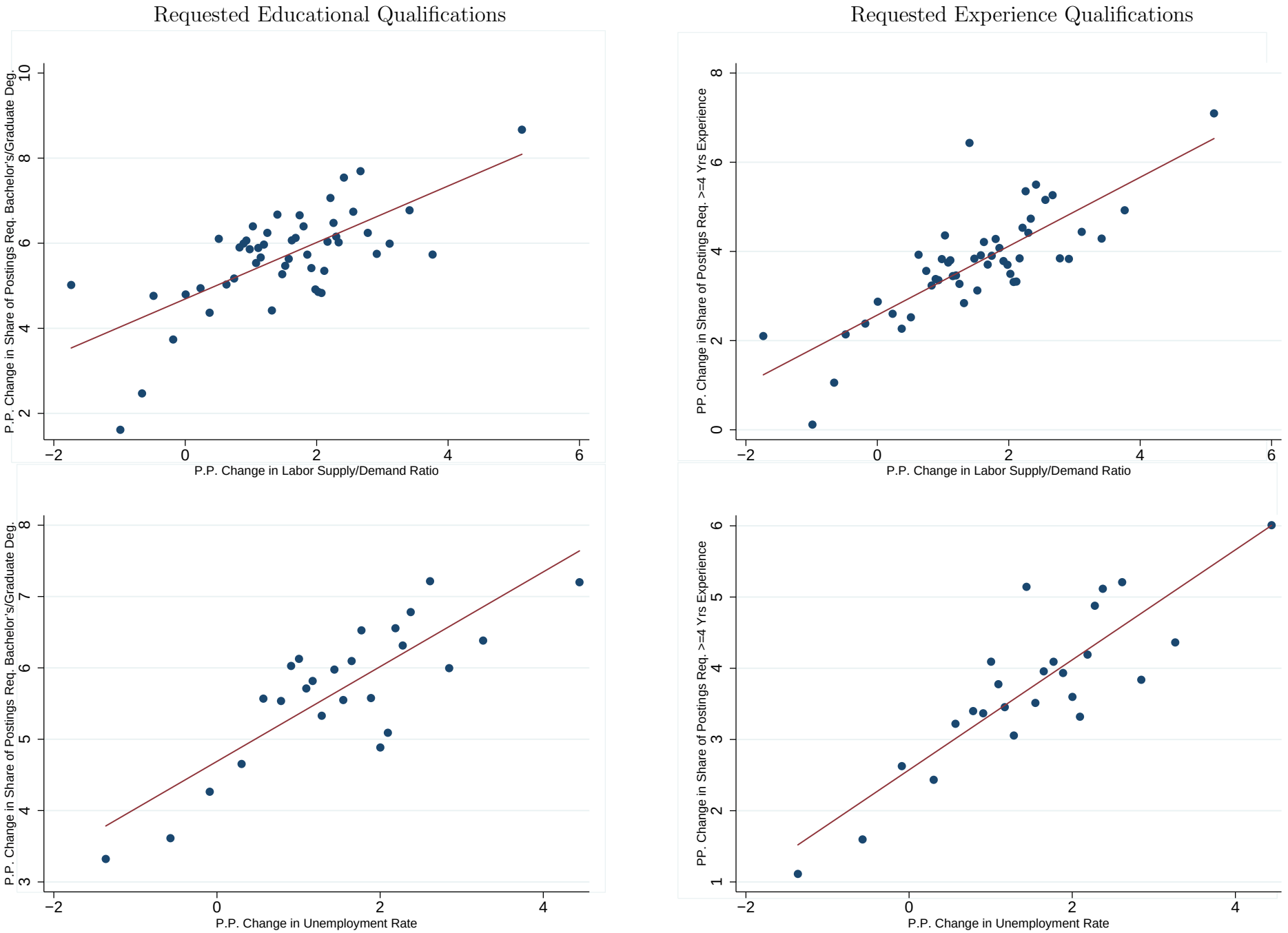
Notes: Panel A plots our calculated college wage premium for newly hired workers and the annual average unemployment rate over the time period 2000–2013. Panel B shows the correlation between these two variables. We calculate the college wage premium for newly hired workers using a multi-month matched CPS sample using a matching algorithm similar to that proposed by Madrian and Lefgren (1999). The matching algorithm is based on a series of household identifiers and demographic characteristics including sex, age, and race. This multi-month matched sample enables us to observe labor market transitions over the eight periods that an individual is potentially sampled. A multi-month matched sample is necessary as wages are only reported in periods 4 and 8. Once all the individuals who experienced a labor market transition are identified and matched to a period we observe wages, we calculate the average hourly wage for these individuals by educational attainment and year. *Source:* CPS Matched Monthly Sample, Federal Reserve Bank of Boston analysis of monthly CPS Data, 2000–2014.

Figure 4. Correlation Between Measures of Labor Demand for Online versus Survey Vacancy Data



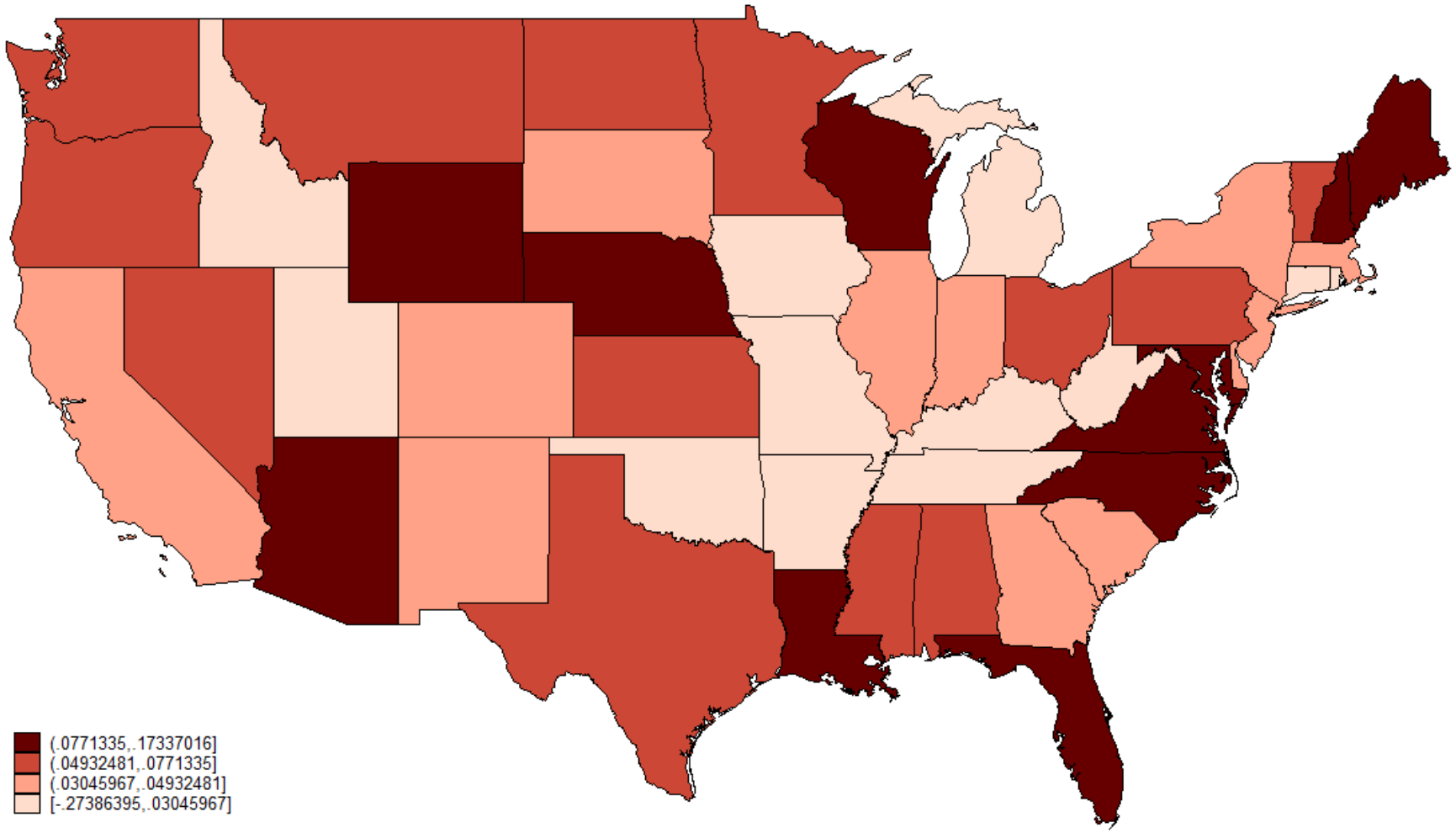
Notes: Data are authors calculations based on the Job Openings and Labor Turnover Survey produced by the Bureau of Labor Statistics, the Minnesota Job Vacancy Survey collected by the Minnesota Department of Employment and Economic Development, and data provided by Burning Glass Technologies.

Figure 5. Relationship Between Changes in Employer Requirements and Labor Market Slack



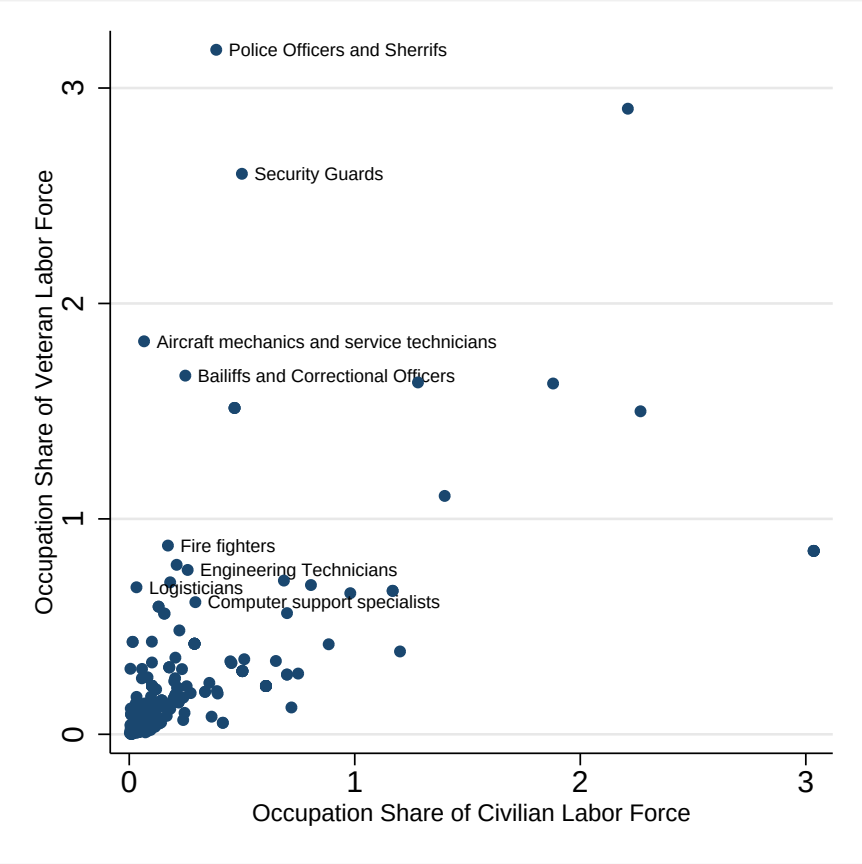
Notes: Figures are binned scatterplots showing the baseline relationship between the percentage point change in employer requirements and change in labor supply (the BGT labor supply/demand ratio or percentage point change in the state unemployment rate).

Figure 6. Change in Post-9/11 Veterans in the Labor Force per Job Posting, 2007-2012.



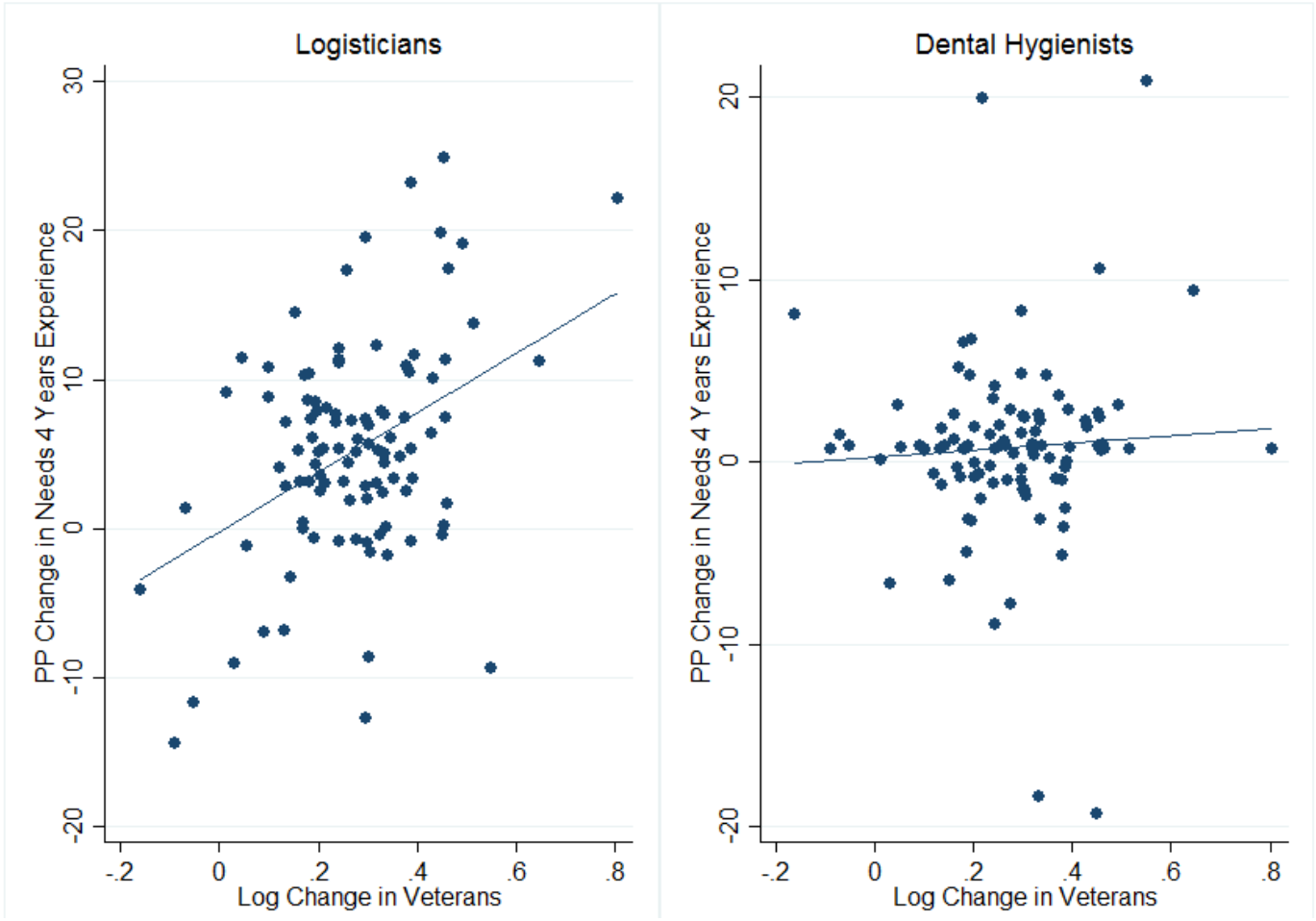
Notes: Authors calculations comparing the ratio of the number of post-9/11 veterans to the number of job postings by state for 2007 versus 2012. The number of post-9/11 veterans in the labor force by state are estimated using the 1 year American Community Survey from the PUMS for 2007 and 2012. The number of job postings by state is estimated from data provided by Burning Glass Technologies for 2007 and 2012.

Figure 7. Relationship between Measures of Veteran and Civilian Concentration *Across* Occupations, 2007



Source: The above figure displays each occupations's share of the total veteran labor force by the occupation's share of the civilian labor force. Share are calculated using the ACS 2007 3yr PUMS.

Figure 8. Relationship Between Employer Skill Requirements and Veteran Supply Shock, 2007-2012.



Notes: Figures are binned scatterplots showing the baseline relationship between the percentage point change in employer requirements requesting four or more years of experience and the change in the veteran labor supply. Veteran labor supply is measured as the log change in the number of post-9/11 veterans in the labor force by state using the 1 year American Community Survey from the PUMS for 2007 and 2012. The share of employers requesting four or more years of experience is estimated from data provided by Burning Glass Technologies for 2007 and 2012.

Table A.1 Correlation between Alternate Measures of Labor Market Slack

Level of:	State UR	State UR for BA+	State UR for Workers Aged 35+	HWOL Broad Occ Group Sup/Dem Ratio	BGT Broad Occ Group Sup/Dem Ratio
State UR	1				
State UR for Workers with a Bachelor's Degree of Greater	0.866	1			
State UR for Workers Aged 35 Plus	0.977	0.891	1		
HWOL Broad Occ. Group Labor Supply/Demand Ratio	0.306	0.248	0.276	1	
BGT Broad Occ. Group Labor Supply/Demand Ratio	0.261	0.252	0.246	0.907	1

Change in:	State UR	State UR for BA+	State UR for Workers Aged 35+	HWOL Broad Occ Group Sup/Dem Ratio	BGT Broad Occ Group Sup/Dem Ratio
State UR	1				
State UR for Workers with a Bachelor's Degree of Greater	0.930	1			
State UR for Workers Aged 35 Plus	0.985	0.930	1		
HWOL Broad Occ. Group Labor Supply/Demand Ratio	0.659	0.627	0.657	1	
BGT Broad Occ. Group Labor Supply/Demand Ratio	0.575	0.560	0.572	0.839	1

Source: Authors' analysis using data from Burning Glass Technologies, 2007, 2010, and 2012.

Table A2. Minnesota Job Survey Summary Statistics

Mean:	2007	2010
Employer Education and Experience Requirements		
Share of Job Postings Requesting:		
No Educational Requirement	0.24	0.17
High School Degree	0.39	0.29
Associate's Degree	0.19	0.2
A Bachelor's Degree	0.15	0.28
A Graduate Degree	0.04	0.06
A Bachelor's or Greater	0.18	0.34
Share of Job Postings Requesting:		
No Experience	0.36	0.25
Some Work Experience	0.26	0.33
Related Work Experience	0.38	0.41
Measures of Labor Market Slack		
Regional Unemployment Rate		
Mean	4.25	5.92
Standard Deviation	0.94	1.09
Observations	14359	24231

Source: Author's analysis of data from the Minnesota Job Vacancy Survey.

Table A3. Summary Statistics for Veteran Supply Shock Measures

Panel A: Annual Change in Post-9/11 Veteran Population, 2006-2012

Year	Number of Post 9/11 Veterans in the Labor Force	YOY Change
2006	1,504,807	
2007	1,537,363	32,556
2008	1,559,495	22,132
2009	1,619,193	59,698
2010	1,927,541	308,348
2011	2,126,179	198,638
2012	2,330,987	204,808

Panel B: Constructed Veteran Supply Shocks

	Δ2007–10				Δ2007–10			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Δ Log Raw Post 9/11 Vets × Occ Vet Share	0.3022	0.1379	-0.0682	0.6469	0.2440	0.1420	-0.1608	0.8052
Δ Log Post 9/11 Vets × State Vet Share × Occ Vet Share (Allocated By Residence)	0.7567	1.8045	0.0000	66.16	0.6359	1.5128	0.0000	55.59
Δ Log Post 9/11 Vets × State Vet Share × Occ Vet Share (Allocated By State of Birth)	0.7683	1.7782	0.0000	68.26	0.6451	1.4889	0.0000	57.35
Δ BGT Supply /Demand Ratio for Post 9/11 Vets (By State of Birth)	0.1863	0.5284	-1.5770	1.6864	0.0405	0.5608	-1.5638	1.7363

Source: Author's analysis using data ACS 1yr PUMS, 2006-2012, IPUMS-USA.