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

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In the wake of the Great Recession, policymakers and academics have expressed concerns about rising employer skill requirements. Using a large database of online job postings for middle-skill occupations, we demonstrate that employers opportunistically raise education and experience requirements, within occupations, in response to increases in the supply of relevant job seekers. This relationship is robust to numerous tests for potentially confounding factors, is present even within firm-job title pairs, and is consistent with the predictions of a standard employer search model. We further identify this effect by exploiting the natural experiment arising from troop-withdrawals in Iraq and Afghanistan as an exogenous shock to local, occupation-specific labor supply. Our results imply that increases in the number of people looking for work can account for roughly 30 percent of the total increase in employer skill requirements observed between 2007 and 2010. *JEL* Codes: J23, J21, J63.

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I. Motivation: Shifting Requirements for Skill

Like most downturns, the Great Recession and subsequent recovery have been particularly painful for low-skilled workers. From 2007 to 2012, the unemployment rate rose by 6.4 percentage points for non-college workers, relative to an increase of only 2.3 percentage points for the college educated. Perhaps less well-known, this differential was also evident *within* occupations. According to the American Community Survey, college educated workers were 2 percentage points less likely to be unemployed from 2007 through 2012 within six-digit occupational codes. Indeed, Figure 1 shows that during this period, the share of workers with a college degree increased rapidly within middle- skill occupations.[1] This growth in skill levels *within occupations* has colloquially become known as "upskilling."

There are, of course, many potential explanations for why we might observe a larger share of higher-skilled individuals employed within these occupations in equilibrium. The recession may have reduced demand for the services or products of lower skilled workers within occupations, changing the skill composition of available jobs. Similarly, tightening credit constraints may be more severe for firms or regions with more low skilled workers. Recessions may also be correlated with policy changes, changes in technology, or changes in search behavior by skill groups, all of which might result in employment differentials.

In this paper, we focus on identifying and measuring the size of one mechanism explaining this phenomenon, namely the possibility that employers respond to labor market slack

[1] While the observed increase in the share of workers with a college degree within occupations may be partially explained by an increase in the share of all workers with a college degree, data on changes in educational attainment suggest this is unlikely. From 2007 through 2012 the fraction of the prime age (25-65) population with a college degree rose by approximately 1.3 percentage points. However, within middle-skill occupations-defined as those where 40% to 60% of workers held a college degree in 2007-this share rose by 3.3 percentage points, a rate roughly 2.5 times as fast. Carnevale (2012) similarly documents that traditionally low-, middle-, and high-skill occupations all hired a greater share of college-educated workers during the current economic recovery than before the recession.

by opportunistically raising their skill requirements. There are numerous anecdotal reports to support this claim—as one recruiter put it, "the recession is a wonderful opportunity to acquire top talent."[2] We seek to test empirically whether—holding demand, credit, policy, and other factors constant—firms respond to more unemployed job seekers by increasing their selectivity on traditional measures of worker skills. By estimating this causal effect we provide, to our knowledge, some of the first empirical evidence that employer skill requirements are driven—in part—by the available supply of labor.

We explore this mechanism using a novel data set of online job vacancy postings from Burning Glass Technologies, a leading developer in the collection, aggregation, and de-duplication of real-time online job vacancy data. Containing information on seven million current online job openings updated daily from over 40,000 sources, the great advantage of these data is that they allow us to measure changes in employer behavior directly, rather than inferring them through equilibrium outcomes. Using these data, we find that there is a strong correlation between the number of people without jobs searching for work and employer requirements for education and experience. The baseline relationship is economically important: a 1 percentage point increase in the local unemployment rate is associated with the fraction of jobs requiring a BA rising by 0.5 percentage points and the fraction of jobs requiring 2 or more years of experience rising by 0.8 percentage points.

Although this relationship between rising employer requirements and the supply of workers is intriguing, it too may instead be explained by other changes in demand for certain goods or services, technology, policy or credit availability that are correlated with the state of the

[2] Barry Deutsch, chief executive of Impact Hiring Solutions. Accessible at http://www.impacthiringsolutions.com/blog/featured-in-forbescom-article-on-hiring-during-the-recession/. See also CareerBuilder (2014), Galston (2014), Rampell (2012), and Green (2009).

labor market. We address this possibility in a number of ways. First, using the richness of our data, we show that changing requirements correlate with the number of unemployed searchers in a location and occupation—even holding constant aggregate conditions. This pattern is established using multiple measures of labor availability, is robust to inclusion of numerous controls, and even occurs **within firm-job title** pairs. Unemployment-related-upskilling is also comparable across traded and non-traded industries, and is therefore unlikely to be driven by local demand or credit shocks.

Next, we exploit a natural experiment associated with troop withdrawals from Iraq and Afghanistan over this period. Roughly 200,000–300,000 veterans entered the domestic labor force per year from 2009–2012. The timing of troop drawdowns was driven by strategic and political considerations and was orthogonal to local economic conditions. Nevertheless, certain regions and occupations received significantly larger labor supply shocks than others. We show that these state-occupation cells correspondingly experienced a significant increase in their skill requirements. For example, logisticians—an occupation with a high concentration of veteran employment—experienced significant "up-skilling," whereas occupational therapy assistants—an occupation with few veterans—did not. This holds true when using the current residence of veterans and when instrumenting for veteran location choices using their birthplace. These relationships imply effects on the same order of magnitude as the non-IV results, and indicate that exogenously increasing the supply of potential applicants leads firms to change their job posting requirements.

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 time-to-start horizons are more delayed, and when skill premiums

are larger.[3] We also provide evidence demonstrating the forces underlying employer decisions to upskill, showing that the college wage premium for new hires falls as unemployment 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 higher labor costs. 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 weaker labor markets lead to rising job posting requirements is important for both labor and macroeconomics. A mature literature has looked at polarization of outcomes by skill, routine, and non-routine occupations in recent-U.S. (Katz and Murphy 1992; Autor, Katz, and Kearney 2006; Autor and Dorn 2012) and European history (Goos and Manning 2007). A more recent literature has explored the extent of mismatch (Sahin et al. 2014) and rising polarization across industries and occupations during recessions (Autor 2010, Foote and Ryan 2014, Jaimovich and Siu 2014, Tuzeman and Willis 2013). We focus on a feedback mechanism between labor supply and the selectivity of vacancies that may be related to these broader trends, but also operates within detailed occupations.

This mechanism also sheds light on macroeconomic models with heterogeneous workers (Shi 2002, Albrecht and Vrooman 2002) and employer search decisions (Davis, Faberman, and Haltiwanger 2012). The sensitivity of skill requirements to applicants and its correlation with average turnover, hiring delays, and flexibility is consistent with a model with costly applicant screening and heterogeneous employer surplus. It also builds on a small, but growing literature

[3] 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.

on online vacancies (Gautier, van der Berg, van Ours, and Ridder 2002, Marinescu and Wolthoff 2013).[4]

The relationship between rising job requirements and the state of the labor market is relevant for policymakers as well. Our results indicate that the demand for skilled workers is perhaps more dynamic and responsive to labor market conditions than previously thought, suggesting the need for worker training and education programs to be increasingly targeted and nimble. Indeed, since 2007, several states— including Maryland, Washington, and Michigan— have re-designed their worker training and education to make them more responsive to the perceived demand for skilled labor.[5] Greater use of tools like real-time labor market information contained in online job postings may help unemployed workers search more efficiently, guide individual choices when selecting a program of study, and design training and education programs at community colleges and other institutions that are responsive to employer demands.

The paper proceeds as follows. Section II describes the data set used in our estimation. Section III contains the basic relationships between skill requirements and unemployment rates, and Section IV contains robustness tests for alternate interpretations. Section V reports the results of our analysis exploiting various characteristics of occupations associated with employer upskilling to examine the mechanisms behind this phenomena. Section VI concludes.

II. Data: Measuring Trends in Employer Skill Requirements

Anecdotal reports have suggested rising demand for skills within occupations since 2007 due to the larger number of available applicants per opening. For example, in a survey of 2,200 employers conducted by CareerBuilder at the end of 2013, 58 percent of respondents said they

[4] Through a series of conversations regarding overlapping research interests we are also aware of similar and impressive work being conducted by Lisa Kahn (Yale School of Management) and Brad Hershbein (visiting fellow at The Hamilton Project and an economist at the W.E. Upjohn Institute for Employment Research).
[5] http://www.mass.edu/vpconference/documents/Skills2Compete_ForgottenJobs_MA_EMBARGOED.pdf

were able to hire college degree holders for traditionally high-school level work "because of the (state of the)… labor market."[6]

Despite these reports, few researchers have been able to quantify rising employer requirements due to the difficulty in isolating labor demand from labor supply. In this paper, we are able to study changes in hiring dynamics by using a large, detailed data set of online job postings. Online vacancy data are increasingly being used by researchers to study labor market dynamics (e.g., Sahin et al. 2014, Lazear and Spletzer 2012, Faberman and Mazumder 2012, Rothwell 2012, Bagues and Labini 2009, Kuhn and Skuterud 2004). Aggregate measures are collected from software that parses the text contained in millions of job ads posted online. These 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).[7] Although online vacancy postings do not capture all job openings, a recent report from Georgetown University estimates that between 60 and 70 percent of job postings are now posted online (Carnevale, Jayasundera, and Repnikov 2014). Moreover, online job ads exhibit similar trends and are closely correlated with employer surveys over time (Templin and Hirsch 2013, Ganong 2014).

A. Burning Glass Technologies Labor/Insight Data

Burning Glass Technologies (BGT) is one of the leading vendors of online job ads data. Their Labor/Insight analytical tool contains detailed information on the more than seven million

[6] See CareerBuilder. 2014. "Education Requirements for Employment on the Rise, According to CareerBuilder Survey."http://www.careerbuilder.com/share/aboutus/pressreleasesdetail.aspx?sd=3%2F20%2F2014&id=pr813&ed=12%2F31%2F2014

[7] 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.

current online job openings updated daily from over 40,000 sources including job boards, newspapers, government agencies, and employer sites.[8] 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. 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. As such, this data allows geographical analysis of occupation-level labor demand by education level and experience level.

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. The 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.

B. Skill and Labor Market Measures

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

Using BGT's Labor/Insight analytical tool, we collected data on a sample of occupations from the middle of the skill distribution where it appears employer requirements may be rising as indicated earlier by Figure 1. Specifically, we collected data for a sample of 73 "middle-skill" occupations at the detailed, six-digit Standard Occupation Code (SOC) level by state for three points in time: 2007, 2010, and 2012.[9] Data collection costs limited this sample such that these occupations identified as employing a relatively large share of individuals with some college or an associate's degree based on data from the American Community Survey (ACS).[10] Additionally, these occupations were chosen to yield a sufficient density of postings within the BGT dataset. In total, our sample represents 13.5 million vacancies or approximately 32 percent of the total number of postings for these three years. Examples of middle-skill occupations found in our dataset include Sales Representatives, Customer Service Representatives, Administrative Assistants, Security Guards, Medical Assistants, Aircraft Mechanics and Construction Managers.

Table 1 provides descriptive statistics for the variables constructed from the BGT data for our sample of 73 middle-skill occupations.[11] Observations are occupation/state/year cells unless otherwise noted. On average, this sample of middle-skill occupations contains approximately 1,200 postings for a given occupation/state cell in each of the three years we have collected data,

[9] BGT does not provide data prior to 2007 and no data are available for the intervening years of 2008 and 2009. Data for three occupations (SOC codes: 173020, 333010, 333050) were collected at the 5-digit SOC level, as state × detailed (6-digit) occupation cells were not dense enough in total posting for inclusion in the estimation sample. Postings for all detailed occupations that comprise these 5-digit OCCS were included in our sample. Note that this level of detail is the same as that observed in American Community Survey (ACS) data for these occupations.

[10] Unfortunately, the ACS does not have direct data on relevant work experience.

[11] Following Modestino (2010), we identify 272 "middle-skill" occupations using data on the educational attainment of workers in those occupations from approximately 485 occupations available in the ACS 3yr 2007 PUMS. Specifically, middle-skill occupations are identified as those occupations in which more than one-third of the workers have a high school degree, some college, or an associate's degree. The remaining share of workers within the occupation are identified as low skill (having less than a high school degree) or high-skill (having a Bachelor's or advanced degree). For a complete list of 73 occupations in our sample, see Table A.1.

with fewer total postings observed during the height of the Great Recession in 2010. It should be noted that these data exhibit a considerable amount of variation given the different employment levels of these occupations, even at the 6-digit occupation/state level. The number of underlying observations available to construct some state/occupation/year 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 occupation/state/year cell, which corresponds to dropping approximately 5 percent of the sample.[12] In addition, since we are analyzing changes in the fraction of postings requiring a particular skill, we weight the state-occupation observations by the occupation's share of total openings in the state in a given time period. 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. Employer requirements along both dimensions of skill are rising over time, with the majority of the increase occurring between 2007 and 2010 during the Great Recession. Our education categories of interest are defined as follows: share of postings with no education requirement, share requesting a Bachelor's degree, and share requesting a Graduate or Professional degree.[13] Experience is defined in the BGT data

[12] 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.

[13] 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

using the following categories: no experience requested, >0 but <2 years, ≥2 years but <5 years, ≥5 years but <8 years, and ≥8 years. Using the midpoint of these categories we also created a variable measuring the average years of experience.

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 and subsequent recovery. 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.

It is clearly beneficial to also have measures of labor supply that varies within state as well as occupation. To do this, we construct two supply/demand ratios by state for six broad occupation groups measuring the number of unemployed individuals relative to the number of job postings.[14] For each ratio, the numerator is estimated using the American Community Survey while 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 another source of online job posting data, Help Wanted Online, published by The Conference

maximum requested education qualification for the specifications presented which biases against our finding a significant increase in qualifications over time.

[14] 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.

Board.[15] Although the two indices differ in terms of the level of slack they indicate for a given occupation/state/year cell, they capture movements over time that are very similar.[16]

We also employ additional covariates that we use to control for omitted factors.[17] 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 2 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.

III. Empirical Methodology

As discussed above, we explore whether (1) there is an increase in the education or experience requirements for job postings with a narrowly defined occupation and (2) whether this increase is linked to the availability of skilled workers. Specifically, we begin by running regressions of the form:

[15] 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.

[16] Despite collection from a smaller subset of sources, the number of posting 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.2 for a matrix showing the correlation across the various labor supply variables for both the level and the change over time. Appendix Table A.3 reports standardized coefficients measuring the relationship between employer requirements and labor availability using these alternative measures of labor market slack.

[17] See the data appendix for more detailed information on these covariates.

$$\Delta \text{ Share of Vacancies Requiring Skill } S_{ijt} = \alpha + \beta \Delta Unemployment_{jt} + \tau_t + e_{ijt},$$

where ΔS_{ijt} denotes the percentage point change in skill requirements for occupation *i*, in state *j*, over time period *t*. Here we pool two periods of changes: changes during the Great Recession (2007–2010) and changes during the subsequent recovery (2010–2012) where τ is a dummy for the Great Recession period. 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.

A. 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 almost 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. The only exception is the specification measuring the share of employers requiring a graduate degree, which yields no significant result. This is not surprising given that our estimation sample is restricted to middle-skilled occupations that experienced little variation in this measure over our sample period.

The magnitude of the effect varies across our education and experience measures. Among the education measures, the effect is strongest for the share of postings now stating a BA is required/preferred. Similarly, the strongest effect among the experience measures is for

postings now requiring up to 5 years of experience, though smaller positive effects exist for higher experience requirements.

In the remaining sections, 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 two 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. [18]

These basic correlations are robust to baseline controls for simple intuitive covariates that capture differences across state-occupations cells. Occupations may have different baseline skill trends, and state-occupation cells have different initial skill requirements. These cells may also differ in their coverage rates in the BGT dataset, and state labor markets differ in the availability of the skill categories we examine. In the last four columns in Panels A and B of Table 2, we show that the relationship between employer requirements and the degree of labor market slack is robust to including these baseline covariates as well as occupational fixed effects.[19]

To give one a sense of the magnitude of this relationship, Figure 2 plots the change in employer requirements versus the change in the unemployment rate by state for our sample of middle-skill occupations. 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 0.44

[18] 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.

[19] 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).

percentage points and increases the fraction of openings requiring 2 or more years of experience by 0.79 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 and experience requirements within middle-skill occupations by 2.0 percentage points and 3.5 percentage points respectively. Among the middle-skill occupations in our sample, these increases are relative to the initial share of jobs requiring these skills of 24.1 percent for a bachelor's degree of greater and 22.8 percent for two or more years of experience in 2007.

B. Alternative Labor Supply Measures and Fixed Effects for Aggregate Conditions

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 aggregate conditions like labor demand. 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 in the American Community Survey to the number of postings using data from both BGT and HWOL.[20] This methodology follows that used by HWOL to create their published supply/demand ratios at the state level. The last two rows of Table 2 demonstrate that

[20] 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.

we continue to find a positive and significant relationship between employer requirements and labor market slack using these alternative measures.

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. We use differenced specifications, which means that these fixed effect allow differential trends across states. Tables 2 and 3 report the coefficients from this exercise using our supply/demand indices calculated from HWOL and BGT. Despite the addition of state fixed effects in Table 3, 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. Again, the magnitude of these relationships remains virtually unchanged, further verifying that the results are not simply driven by changes in the composition of vacancies that reflect pre-existing trends.

IV. Accounting for Endogeneity: Local Demand Shocks and Identification from a Natural Experiment

Although the specification and results above indicate a positive correlation between changes in employer requirements for skill and the availability of skilled labor, even within state, we still need to address two econometric concerns to reliably establish a causal relationship. Specifically, 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 reverse causality.

A. Local Demand Shocks: Within Firm-Job Title Results and Traded versus Non-Traded Employment

A natural worry is that changes in labor supply are correlated with changes in labor demand, leading our regressions to produce biased estimates. For example, local demand shocks might alter the composition of jobs requiring a bachelor's degree even within an occupation.[21] If that were the case then rising skill requirements would be correlated with changes in the unemployment rate, without a causal impact via labor supply.

To test this, we look at changes in employer requirements within an individual firm and job title over time using the Minnesota Job Vacancy Survey. The Minnesota Job Vacancy Survey is one of twelve state job vacancy surveys conducted in the United States. It is a biannual survey of employers designed to estimate hiring demand and job vacancy characteristics by industry and occupation.[22] More importantly, a unique identifier is assigned to each employer that allows one to track postings by job title for the same employer. Table 4 demonstrates that the share of jobs requiring a college degree or related experience increases significantly with the local unemployment rate—even when controlling for **the same job title at the same employer.** This

[21] For example, suppose there are two kinds of homebuilders: luxury home builders, which require skilled craftsmen with more than 2 years of experience, and low cost builders, which have no experience requirement for their workers. Demand shocks might differentially reduce the demand for low cost homes such that employer skill requirements for craftsmen would be correlated with unemployment, though the mechanism is driven by demand, not labor supply.

[22] 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.

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. In addition, the magnitude of the effect is similar to what we find using the BGT data.

As an additional test of confounding effects via labor demand, we also compare the relationship between employer requirements and the supply of skilled workers for non-traded industries versus traded industries that are less subject to local demand shocks. Specifically, we split our sample and explore upskilling in "traded" occupations where the share of employment in traded industries is above the 75th percentile in our sample, typically reflecting occupations commonly found in industries like Agriculture, Mining, and Manufacturing. The results reported in Table 5 show that upskilling has occurred across both traded and non-traded industries, suggesting that our results are not driven by changes in local demand conditions. We similarly find no effect when testing a continuous traded-share interaction. In fact, if anything there appears to be a stronger correlation between employer requirements and the cyclical component in the traded industries than in the non-traded industries, but this difference is not statistically significant.

B. Natural Experiment: Troop Withdrawals from Iraq and Afghanistan

As a source of exogenous variation, we make use of the 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 Iraqi Freedom (2003), Operation New Dawn (2010), and/or Operation Enduring Freedom (2001). The U.S. began withdrawing troops from Iraq in 2009, and by September 2012 approximately 1.6 million veterans had returned home and left active duty (Bilmes 2013).

To capture the exogenous variation 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.[23] According to this data, an additional 200,000 to 300,000 post 9/11 veterans joined the labor force each year between 2009 and 2012.[24] We also use ACS data to estimate veteran concentration within and across occupations, calculating the occupation share of veteran employment and the veteran share of occupation employment.[25]

Figure 3 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. In our data, 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. To better capture this targeted impact of the increase in the supply of post 9/11 veterans on the labor market, we also include specifications that aim to capture the increase in the supply of veteran labor relative to demand—similar to our earlier supply/demand ratios that varied by state and broad occupation group. We define the numerator as the change in the number of veterans at the state-level × the broad occupation group share of veteran employment.[26] This numerator measures the intensity of the

[23] Appendix Table A.4 reports summary statistics for the veteran supply shock measures.
[24] 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
[25] These occupation shares are calculated using ACS 3yr 2007 PUMS to reflect pre-recession trends.
[26] Broad occupation group shares of veteran employment are calculated at the national level in order to obtain reliable estimates.

shock at the state-occupation level. We then divide this by the BGT denominator from our earlier supply/demand ratio: the initial number of total openings by broad occupation group.

As a first pass, we include a measure of the state level veteran supply shock (the log difference in the number of post 9/11 veterans) in our model for our pooled sample of 73 occupations. The results of this exercise are reported in Panel A of Table 6 which demonstrates that there is a significant and positive relationship between the veteran supply shock and the change in employer requirements. This is true even when controlling for state fixed effects to account for local demand shocks and occupational fixed effects to control for national trends. Not surprisingly, the relationship between veteran shocks and skill requirements is more precise when we switch from statewide measures to the veteran BGT supply/demand ratio that reflects the concentrated variation in veteran share of employment across occupations. Veteran intensive occupations in veteran intensive locations are more affected by the veteran shock. Appendix Table A.5 provides further evidence of this effect, by demonstrating that our state-level veteran shocks have much larger effects on skill requirements in veteran intensive occupations than in occupations with low veteran shares.

However, it could be the case that when veterans return to the U.S. they choose to migrate to locations where there is a higher chance of employment (e.g. where the unemployment rate is low). If this is the case, then returning post-911 veterans would self-select into states where the supply of available workers is lower, creating a countervailing influence on the existing supply/demand forces. This self-selection among returning veterans would serve to produce a downward bias on our OLS coefficients. To remedy this, we use veteran **state of birth** to

instrument for veteran **state of residence**.[27] Although the state of birth instrument measures are highly correlated with the state of residence measures, this correlation is not perfect. More importantly, veteran state of birth is not correlated with the state of the labor market. As such, using the geographic variation among veterans related to state of birth should eliminate the downward bias associated with self-selection into state of residence upon return to the U.S. Indeed, Panel B of Table 6 shows that when we instrument for state of residence, the impact of post-911 veterans returning to the labor force on employer requirements increases in both magnitude and significance.[28]

How do these results compare to our state fixed effects specifications using the BGT supply/demand ratio listed in Table 3? For comparison purposes, we also present results where we instrument for our earlier BGT supply/demand ratio using our birthplace instrument, rather than just the veteran concentrated index. Doing so yields larger coefficients for both the change in education and experience requirements—yet still very similar in magnitude to the effect related to increasing the supply of unemployed persons from our earlier specifications.

V. Mechanisms

A. The College Wage Premium for New Hires

Our results thus far suggest a fairly robust relationship between increasing supply of workers and rising employer demand for skills that is not driven by local demand factors. What forces might be driving this employer behavior? Figure 4 shows that during a recession, the

[27] Specifically, we instrument for the log difference in number of veterans by state of residence using the log difference of in the number of veterans by state of birth. Similarly, we instrument for the veteran-intensive labor supply and demand ratio by state of residence using the veteran-intensive labor supply and demand ratio by state of birth.

[28] In general, the IV results are larger and more significant than the OLS result. This is expected if veterans' state of residence is partially determined by economic factors. If veterans select into labor markets with lower unemployment rates (and less upskilling) then the OLS estimates will be smaller than the birthplace IV estimates, as is the case in Table 7.

average wage of newly-hired high-skill workers falls relative to that of newly hired low-skill workers, causing the college wage premium for newly hired workers to decrease during a downturn.

To calculate this, we use the multi-month matched CPS sample based on a matching algorithm similar to that proposed by Madrian and Lefgren (1999).[29] This multi-month matched sample enables us to observe labor market transitions over the eight periods that an individual is 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.[30] We measure the college wage premium as the log difference in these hourly wages.

Indeed, the negative relationship between the college wage premium for new hires and the unemployment rate is quite strong, with a correlation coefficient of 0.9. This could reflect the greater heterogeneity in wages across high-skill versus low-skill workers or 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.

B. Predictions from Employer Search Theory Applied to Upskilling

In this section we show that the strength of this relationship varies along dimensions predicted by a standard stopping problem model of employer job search. Specifically, we test

[29] The matching algorithm is based on a series of household identifiers and demographic characteristics including sex, age, and race.

[30] 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.

whether the degree of employer upskilling in slack labor markets is consistent with a causal effect on employer searching. .

Before proceeding, it is important to be explicit about the limited nature of this exercise. There is a large, sophisticated literature modeling employer search in general equilibrium labor markets, and analyzing these models lies beyond the scope of this paper. Nevertheless, we think it is worthwhile to consider a simplified, partial equilibrium model of employer search and the ways in which its predictions map into the data.

For example, suppose there are a fixed number of middle-skill firms each posting a vacancy *V*. 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- γ). Firms are characterized by the premium they attach to high skilled workers over low skilled worker θ, the exogenous turnover rate 1-δ of their employment relationships, and the urgency of their hiring need modeled via their discount rate 1-β.[31] Further, we assume within each of these dimensions firms are further characterized by a fixed cost of maintaining a vacancy for a period c_i distributed with a uniform density function. 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. 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.

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

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

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

It is straightforward to show that, in this environment, firms' decisions follow a cutoff rule in their costs of maintaining a vacancy c^*. 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 $1-\beta$. 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.

The magnitude of the upskilling effect depends on the parameters θ, δ, *and* β. The model's cross-partials demonstrate[32] that extent of upskilling that increases with the college premium θ, decreases with the turnover rate $1-\delta$, and decreases with the urgency of hiring $1-\beta$.

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 β. 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 from the 75% to the 25% in the 2007 Occupational Employment Statistics Report. We measure δ using replacement rates in the Employment Projections Survey. To proxy for the urgency of hiring $1-$

[32] 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.

β, we use data from the 2007 Recruitment Metrics and Performance Benchmark Report, which is published by the consulting firm NAS Recruitment Communications. This report lists average "Time to Start" data for vacancies in different industries and occupations. This measure was available for most, but not all, of the data in our sample. We explore how these proxies moderate upskilling in Table 7. The results in columns (1)–(3) and (5)–(7) indicate that upskilling is more prevalent when average turnover rates are lower, when time-to-start horizons are more delayed, and when average skill premiums are higher.

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. [33] 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 7. We use data from the CPS on union coverage across occupations. [34] 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

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

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

production. In Columns (4) and (8), we show that, indeed, the upskilling margin is larger in industries with greater wage rigidity.

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

VI. Conclusion

While the unemployment rate for low-skilled workers is typically higher than that for the college-educated, during recessions low-skilled workers tend to fare even worse. One potential explanation that has been suggested for the differential impact of the Great Recession is that employers have increased skill requirements for middle- and low-skilled jobs during the downturn.

This paper demonstrates and quantifies this *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 (2007–2010) and subsequent recovery (2010–2012). We find that, in bad 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, is robust to numerous controls, and occurs even within firm-job title pairs. Unemployment-related-upskilling is also comparable across traded and non-traded industries, and therefore not likely to be driven by local demand or credit shocks. We also find a similar pattern of employer upskilling

associated with a natural experiment using 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 labor supply.

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 time-to-start horizons are more delayed, 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, our results indicate that much 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 actually at least partially cyclical. In addition, 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.

Our results suggest several key implications for the dynamics of the middle-skill labor market going forward. Although the lack of data prior to 2007 prevent us from directly identifying the secular trend in upskilling in our data set, we can compare the labor market effect to the baseline increase in skill requirements observed for this set of occupations. Our IV results

indicate that opportunistic upskilling on the part of employers could account for roughly 30 percent of the total increase in education and experience requirements between 2007 and 2010.

Finally, our results imply that the demand for skilled workers is perhaps more dynamic and responsive to labor market conditions than previously thought, suggesting the need for workforce development policies that can be more adaptive to changing labor market conditions. Despite its reauthorization, the Workforce Investment Act (WIA) has recently been criticized for its lack of effectiveness stemming from the inability of the program to efficiently match unemployed workers with training opportunities that lead to future jobs. This failure could be the result of unexpected shifts in labor demand during recessions with regard to skill requirements on the part of employers, suggesting that worker training and education programs need to be increasingly targeted and nimble at a local level.

REFERENCES

Albrecht, James, and Susan Vroman. 2002. "A Matching Model with Endogenous Skill Requirements" *International Economic Review* 43.1 (2002): 283–305.

Autor, David H., Lawrence F. Katz, and Melissa S. Kearney. 2008. "Trends in U.S. wage Inequality: Revising the Revisionists." *The Review of Economics and Statistics* 90.2: 300–323.

Autor, David H., and David Dorn. 2013. "The Growth of Low-Skill Service Jobs and the Polarization of the U.S. Labor Market." *American Economic Review* 103(5): 1553–1597.

Bagues, Manuel F., and Mauro S. Labini. 2009. "Do On-line Labor Market Intermediaries Matter? The Impact of *Almalaurea* on the University-to-Work Transition." In *Studies of Labor Market Intermediation,* ed. David H. Autor, 127–154. Chicago: University of Chicago Press.

Beaudry, Paul, David A. Green, and Benjamin M. Sand. 2013. "The Great Reversal in the Demand for Skill and Cognitive Tasks." Working Paper 18901. Cambridge, MA. National Bureau of Economic Research.

Belasco, Amy. 2009. "Troop Levels in the Afghan and Iraq Wars, FY2001–FY2012: Cost and Other Potential Issues." Washington, DC. Congressional Research Service. CRS Report for Congress No. R40682.

Bilmes, Linda J. "The Financial Legacy of Iraq and Afghanistan: How Wartime Spending Decisions Will Constrain Future National Security Budgets." Harvard Kennedy School Faculty Research Working Paper Series RWP13-006, March 2013.

CareerBuilder. 2014. "Education Requirements for Employment on the Rise, According to CareerBuilder Survey." March.

Carnevale, Anthony, Tamara Jayasundera, and Ban Cheah. 2012. *The College Advantage: Weathering the Economic Storm.* Washington, DC: Georgetown University Center on Education and the Workforce.

Carnevale, Anthony, Tamara Jayasundera, and Dimitri Repnikov. 2012. *Understanding Online Job Ads Data.* Washington, DC: Georgetown University Center on Education and the Workforce.

Charles, Kerwin Kofi, Erik Hurst, and Matthew J. Notowidigdo. 2013."Manufacturing Decline, Housing Booms, and Non-Employment." Working Paper No. 18949. Cambridge, MA: National Bureau for Economic Research.

Davis, Stephen J., Jason Faberman, and John C. Haltiwanger. 2012. "The Establishment-level Behavior of Vacancies and Hiring." NBER Working Paper No. 16265.

Faberman, Jason, and Bhash Mazumder. 2012. "Is There a Skills Mismatch in the Labor Market?" Federal Reserve Bank of Chicago, Essays on Issues No. 300.

Foote, Christopher, and Richard Ryan. 2012. "Labor-Market Polarization over the Business Cycle." Federal Reserve Bank of Boston Working Paper No. 12-8.

Galston, William. 2014"Welcome to the Well-Educated-Barista Economy." *The Wall Street Journal*, April 30.

Ganong, Peter. 2014 "How Well Do Online Job Postings Reflect Labor Demand?"

Ganong, Peter, and Daniel Shoag. "2012. "Why Has Regional Convergence in the US Stopped?" HKS Faculty Research Working Paper Series RWP 12-028. Cambridge, MA: Harvard University John F. Kennedy School of Government.

Gautier, Pieter A. 2002. "Unemployment and Search Externalities in a Model with Heterogeneous Jobs and Workers." *Economica* 69(273): 21–40.

Gautier, Pieter A., J. van den Berg, Jan C. van Ours, and Geert Ridder. 2002. "Worker Turnover at the Firm Level and Crowding Out of Lower Educated Workers." *European Economic Review* 46(3): 523–538.

Goos, Maarten, and Alan Manning. 2007. "Lousy and Lovely Jobs: The Rising Polarization of Work in Britain." *The Review of Economics and Statistics* 89(1): 118–133.

Green, Alison. 2009. "How the Recession Has Changed Hiring." *USNews*, June 15

Jaimovich, Nir, and Henry E. Siu. 2014. "The Trend Is the Cycle: Job Polarization and Jobless Recoveries." Working Paper No. 18334. Cambridge, MA: National Bureau of Economic Research.

Katz, Lawrence, and Kevin Murphy. 1992 "Changes in Relative Wages, 1963–1987: Supply and Demand Factors." *The Quarterly Journal of Economics* 107(1): 35–78.

Kuhn, Peter J., and Mikal Skuterud. 2004. "Internet Job Search and Unemployment Durations." *American Economic Review* 94(1): 218–232.

Lazear, Edward P., and James R. Spletzer. 2012. "The United States Labor Market: Status Quo or New Normal?" Working Paper No. 18386 Cambridge, MA: National Bureau of Economic Research.

Madrian, Brigitte C. and Lefgren, Lars John, A Note on Longitudinally Matching Current Population Survey (CPS) Respondents (November 1999). NBER Working Paper No. t0247.

Marinescu, Ioana, and Ronald Wolthoff. 2012. "Wages, Applications, and Skills. "Unpublished working paper. Available at http://individual.utoronto.ca/wolthoff/pdf/MarinescuWolthoff.pdf.

Merkl, Christian, and Thijs van Rens. 2012. "Selective Hiring and Welfare Analysis in Labor Market Models." Working Papers No. 1752. Kiel, Germany, Kiel Institute for the World Economy.

Mian, Atif R., and Amir Sufi. 2014. "What Explains the 2007–2009 Drop in Employment?" *Econometrica* Forthcoming.

Modestino, Alicia Sasser. 2010. "Mismatch in the Labor Market: Measuring the Supply of and Demand for Skilled Labor in New England." Federal Reserve Bank of Boston, New England Public Policy Center Research Report No. 10-2.

Mortensen, Dale T., and Christopher A. Pissarides. 1994. "Job Creation and Job Destruction in the Theory of Unemployment." *The Review of Economic Studies*, 61(3), 397–415.

Rampell, Catherine. 2012. "Degree Inflation? Jobs That Newly Require B.A.'s" *The New York Times*, December 4.

Rothwell, Jonathan. 2012. "Education, Job Openings, and Unemployment in Metropolitan America." Washington, D.C.: Brookings Institution Metropolitan Policy Program.

Saiz, Albert. 2010. "The Geographic Determinants of Housing Supply." *Quarterly Journal of Economics* 125(3): 1253–1296.

Sahin, Aysegul, J. Song, G. Topa, and G. Violante. 2014. "Mismatch Unemployment." *American Economic Review* Forthcoming.

Templin, Thomas, and Lesley Hirsch. 2013. "Do Online Job Ads Predict Hiring?" New York: New York City Labor Market Information Services.

Tüzemen, Didem, and Jonathan Willis. 2013. "The Vanishing Middle: Job Polarization and Workers' Response to the Decline in Middle-Skill Jobs." Federal Reserve Bank of Kansas City. *Economic Review Q*1.

Table 1. Summary Statistics

Mean:	2007	2010	2012	Δ2007–10	Δ2010–12
Employer Education and Experience Requirements					
Total Number of Job Posting Ads	1,255.77	1,179.79	1,309.78	-75.97	136.38
Share of Job Postings Requesting:					
No Educational Requirement	74.40	58.35	52.08	-16.05	-6.29
A Bachelor's Degree	10.97	17.92	20.96	6.95	3.08
A Graduate Degree	3.15	5.12	5.97	1.97	0.85
A Bachelor's or Greater	12.59	20.43	24.07	7.84	3.67
Share of Job Postings Requesting:					
No Experience	72.18	55.82	52.23	-16.36	-3.66
Less Than Two Years of Experience	14.25	22.75	24.93	8.50	2.20
Two to Five Years of Experience	10.51	16.59	17.99	6.08	1.44
Five to Eight Years of Experience	1.42	2.48	2.58	1.06	0.10
Greater Than Eight Years of Experience	1.63	2.35	2.27	0.72	-0.08
Average Years of Experience	0.73	1.16	1.23	0.42	0.07
Measures of Labor Market Slack					
State Unemployment Rate	4.34	8.79	7.33	4.45	-1.45
State UR for Workers with a Bachelor's Degree of Greater	2.56	4.46	3.77	1.90	-0.69
State UR for Workers Aged 35 Plus	3.07	6.89	5.62	3.82	-1.26
HWOL Broad Occ. Group Labor Supply/Demand Ratio	5.26	8.28	5.29	3.02	-3.02
BGT Broad Occ. Group Labor Supply/Demand Ratio	10.29	14.69	10.82	4.40	-3.89
Observations	3357	3376	3376	3357	3376

Notes: Observations are State × 5/6-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. See the data appendix for additional details on variable construction.

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	Bachelor's Degree	Grad/Prof Degree	Bachelor's Degree or Greater				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ State UR	-1.539***	0.614***	-0.0227	0.508***	0.440**			
	(0.555)	(0.146)	(0.162)	(0.185)	(0.170)			
Δ State UR: Bachelor's or Greater						1.106***		
						(0.253)		
Δ HWOL Labor Supply/Demand Rate							0.142***	
							(0.0503)	
Δ BGT Labor Supply/Demand Rate								0.136***
								(0.0392)
Occ Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Baseline Controls	No	No	No	No	Yes	Yes	Yes	Yes
Observations	6848	6848	6848	6848	6733	6733	6733	6733

Panel B: Experience Qualifications

Percentage Point Change in the Share of Postings Requesting:	No Exp.	>0 to ⩽ 2 Yrs.	>2 to ⩽ 5 Yrs.	>5 to ⩽ 8 Yrs.	>8 Yrs.	Avg Num Yrs	2 or More Years of Experience				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Δ State UR	-1.554***	0.743*	0.661***	0.0867***	0.0644*	0.0413***	0.812***	0.794***			
	(0.532)	(0.376)	(0.173)	(0.0287)	(0.0358)	(0.0114)	(0.205)	(0.172)			
Δ State UR: Workers 35 Plus									0.786***		
									(0.173)		
Δ HWOL Labor Supply/Demand Ratio										0.262***	
										(0.0526)	
Δ BGT Labor Supply/Demand Ratio											0.182***
											(0.0372)
Occ. Fixed Effects	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Baseline Controls	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Observations	6848	6848	6848	6848	6848	6848	6848	6733	6733	6733	6733

Notes: The dependent variables for Panel A columns (1)–(3) are percentage point changes in the share of posting listing no educational requirement, a Bachelor's degree, and a Graduate/Professional degree respectively. The dependent variable for columns (4)–(7) 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, greater than 2 to 5 years, greater than 5 years to 8 years, and greater than 8 years respectively. The dependent variable for column (6) is the percentage point change in the average years of experience requested. Average years of experience calculated by assigning the mid-point of each experience category (8 years of experience used for the greater than 8 years category) and computing a weighted average for all postings within each state × occ × year cell. The dependent variable for columns (7)–(11) is the percentage point change in the share of posting requesting 2 or greater years of experience. 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. All specifications an indicator variable to control for differences between the two time periods, 2007–2010 and 2010–2012. 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). See the data appendix for additional details on variable construction. 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.

	Change in Share of Postings Requesting a Bachelor's Degree or Greater						Change in Share of Postings Requesting 2 or More Years of Experience					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Δ HWOL Labor Supply/Demand Ratio	0.142***	0.169***	0.180*				0.262***	0.197***	0.219**			
	(0.0503)	(0.0626)	(0.0943)				(0.0526)	(0.0643)	(0.0959)			
Δ in BGT Labor Supply/Demand Ratio				0.136***	0.126**	0.152*				0.182***	0.145***	0.178**
				(0.0392)	(0.0503)	(0.0810)				(0.0372)	(0.0450)	(0.0739)
Occ Fixed Effects	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
State Fixed Effects	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No
State × Occ FE	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Observations	6733	6733	6733	6733	6733	6733	6733	6733	6733	6733	6733	6733

Notes: Dependent variable for columns (1)–(6) is the percentage point change in the share of posting requesting a Bachelor's degree or greater; dependent variable for columns (7)–12 is the the percentage point change in the share of postings requesting 2 or more years of experience. See Table 2 notes for details on construction of the HWOL and BGT broad occupation group labor supply/demand rates. All specifications an indicator variable to control for differences between the two time periods, 2007–2010 and 2010–2012 and the baseline controls listed in Table 2 notes. 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, Controlling For Job Title × Firm Pair Effects, Minnesota Job Vacancy Survey,2001–2012.

	Requires a College Degree		Requires *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)
Employer/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 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 these specifications are reported at the lowest level of geographic detail provided for each job opening in a given year. All specifications 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 *Source:* Authors' analysis using data from Minnesota Department of Employment and Economic Development (MNDEED) Job Vacancy Survey, 2001–2012.

Table 5. Changes in Employer Requirements and Labor Market Slack, Comparing Traded vs. Non-Traded Industries

	Change in Share of Postings Requesting a Bachelor's Degree or Greater			Change in Share of Postings Requesting 2 or More Years of Experience		
	Traded	Non-traded	All	Traded	Non-traded	All
Δ State UR	0.731***	0.326**	0.412**	0.894***	0.742***	0.810***
	(0.267)	(0.156)	(0.173)	(0.324)	(0.134)	(0.171)
Traded Share × Δ State UR			0.121			-0.0691
			(0.137)			(0.120)
Occ Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1311	5422	6733	1311	5422	6733

Notes: The sample for columns (1) and (4) includes occupations with 75 percent or more of employment concentrated in traded industries and the sample for columns (2) and (5) includes the occupations with less than 75 percent of employment concentrated in traded industries. Trade industry share of occupation employment is constructed at the minor occupation code level using the American Community Survey 2007 3yr PUMS. Traded industries are defined at the 2-digit NAICS level as agriculture, forestry, fishing, and hunting; mining; manufacturing; and wholesale trade. See data appendix for additional details. The dependent variable for columns (1)–(3) 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 2 or greater years of experience for columns (4)–6. All specifications an indicator variable to control for differences between the two time periods and the baseline controls listed in the notes of Table 2. See Table 2 notes for details on construction of the HWOL and BGT broad occupation group labor supply/demand rates. 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 6. Relationship Between the Change in Employer Requirements and Veteran Supply Shocks

Panel A: OLS Results, Veteran Supply Shocks

	Change in Share of Postings Requesting a Bachelor's or Greater			Change in Share of Postings Requesting 2 or More Years of Experience		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Difference in Number of Veterans in State	2.800			2.889*		
	(2.208)			(1.585)		
Δ Veteran Labor Supply/Demand Ratio		1.254***	1.357**		1.177***	1.137**
		(0.338)	(0.536)		(0.344)	(0.475)
Occ Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	No	No	Yes	No	No	Yes
Observations	6733	6733	6733	6733	6733	6733

Panel B: IV Results, Veteran Birthplace Instruments

	Change in Share of Postings Requesting a Bachelor's or Greater			Change in Share of Postings Requesting 2 or More Years of Experience		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Difference in Number of Veterans in State	8.405**			7.761*		
	(3.884)			(4.263)		
Δ Veteran Labor Supply/Demand Ratio		2.279***			1.991***	
		(0.609)			(0.552)	
Δ BGT Labor Supply/Demand Ratio			0.432***			0.377***
			(0.0830)			(0.0789)
F-Test of Exc. Instruments	8.558	153.1	26.13	8.497	153.2	26.13
Occ Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	No	Yes	Yes	No	Yes	Yes
Observations	6629	6629	6629	6629	6629	6629

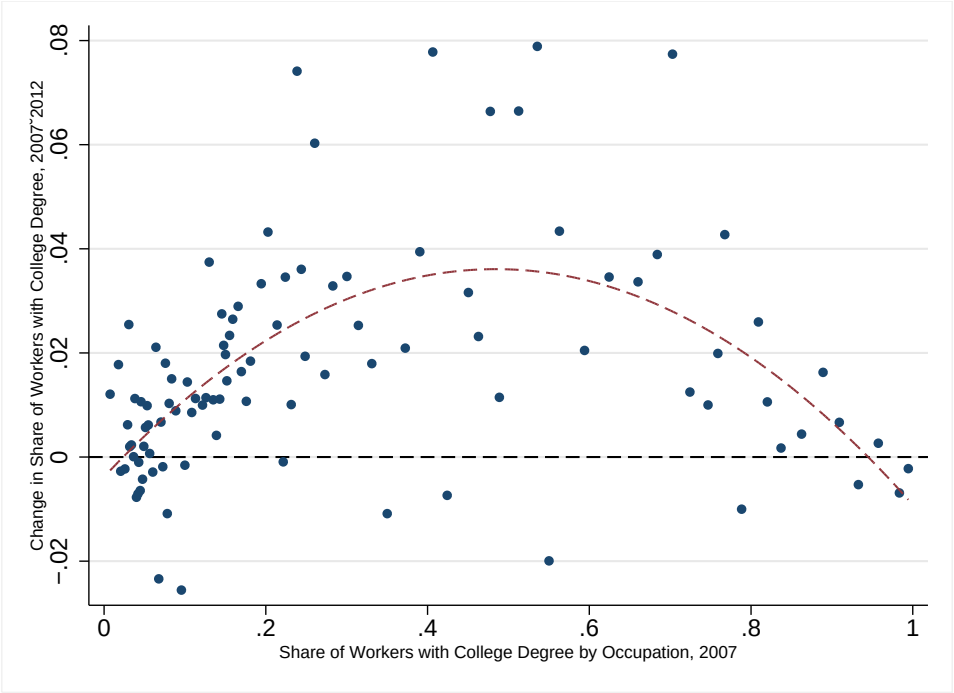
Notes: The dependent variable for columns (1)–(3) is the percentage point change in the share of posting requesting a Bachelor's degree or greater and the percentage point change in the share of postings requesting 2 or greater years of experience for columns (4)–(6) in Panels A and B. Log difference in the number of veterans in the labor force is estimated using the ACS 1yr. PUMS and is defined as the $\ln(\text{number of veterans})_{i,t}$–$\ln(\text{number of veterans})_{i,t-n}$,where i denotes state and t, t-n denote the two time periods for which the change is measured. The BGT Veteran Broad Occupation Group Labor Supply/Demand Rate is an annual, state-level measure for the average number of veterans per job posting within six broad occupation groups. This measure is constructed by taking the state level estimate for the number of veterans in the labor force multiplied by a national estimate for each broad occupation's share of veteran employment and dividing this estimate by the average monthly count of job postings reported by BGT within a broad occupation group for a given year. The covariate included in Panel A columns (2), (3), (5), and (6) measures the change in this rate over the two time periods in our sample. In Panel B columns (1), (2), (4), and (5) we instrument for these two veteran supply shock by estimating each measure analogously using veteran's birthplace, rather than current residence, as reported in the ACS. In columns (3) and (6) we use the change in the veteran birthplace labor supply/demand rate measure to instrument for the change in the BGT broad occupation group labor supply/demand rate, first reported in Table 2. See data appendix for more details on the creation of the veteran supply shocks. All specifications include a control for differences between the two time periods, 2007–2010 and 2010–2012. 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 the Change in Employer Requirements and Labor Market Slack by Firm Characteristics

	Change in Share of Postings Requesting a Bachelor's Degree or Greater				Change in Share of Postings Requesting 2 or More Years of Experience			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ State UR	0.901***	0.0583	-0.0702	0.406	1.712***	-0.0753	0.476*	0.445*
	(0.260)	(0.293)	(0.320)	(0.260)	(0.236)	(0.249)	(0.275)	(0.229)
Δ State UR ×	-0.0191***				-0.0438***			
Occ. Turnover Rate	(0.00394)				(0.00403)			
Δ State UR ×		0.00769***				0.0146***		
Time to Start		(0.00205)				(0.00209)		
Δ State UR ×			1.066***				0.517	
Initial Hrly. Wage Premium			(0.370)				(0.316)	
Δ State UR ×				0.0132***				0.0546***
Occ. Union Concentration				(0.00452)				(0.00626)
Occ Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6519	5567	6475	6519	6519	5567	6475	6519

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 2 or greater years of experience for columns (5)–(8) in Panels A and B. The Occupation Turnover rate is a national detailed occupation-level measure for the annual replacement needs over the period 2012-2022 as a share of 2012 employment. Time to Start is an industry level measure for the average time it takes to fill a position (in days). The industry-level estimates are matched to occupations in our sample. Occupation union concentration is a national detailed occupation-level measure for the share of employees covered by a collective bargaining agreement as reported by the Current Population Survey. 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. See the data appendix for additional details on variable construction. All specifications include a control for differences between the two time periods, 2007–2010 and 2010–2012. Columns (4) and (8) also include the initial wage premium (state by detailed occupation level of variation). 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

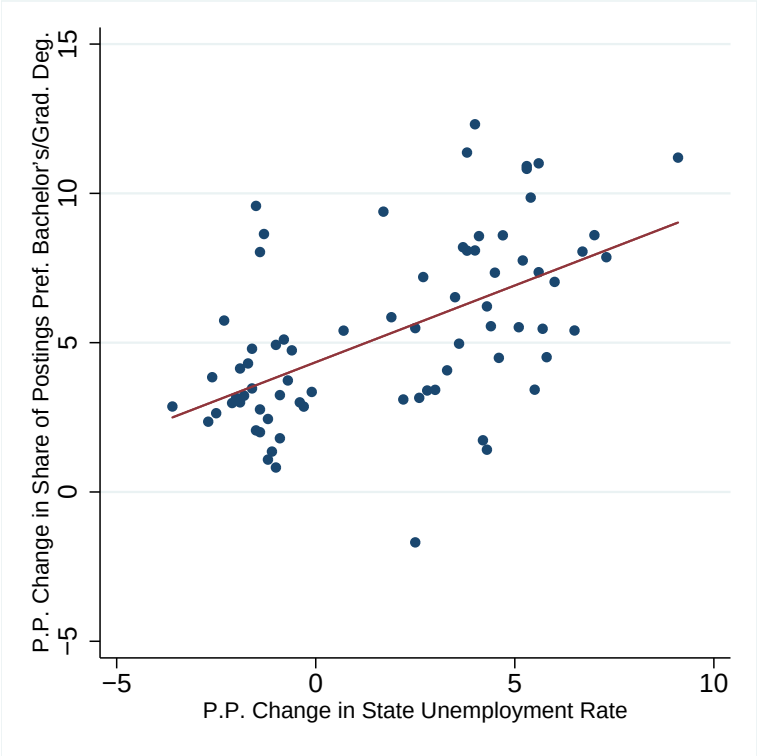
Figure 1. Change in the Share of Workers with a College Degree by Occupation, 2007–2012, versus Initial Share in 2007



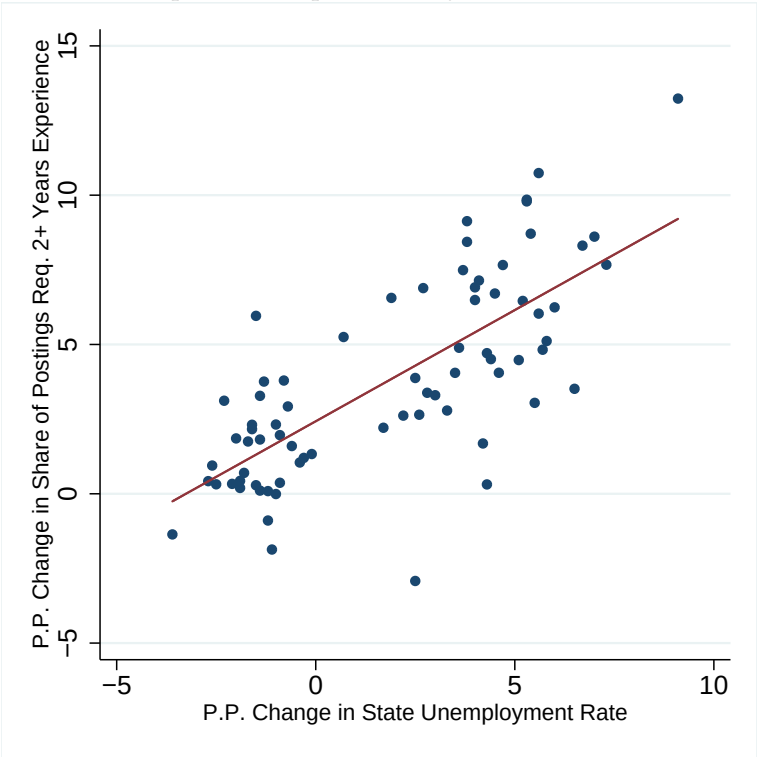
Notes: Share of worker's with a college degree by occupation calculated using the ACS 1yr PUMS, IPUMS-USA, 2007 and 2012. Figure is a binned scatter plot, N=100.

Figure 2. Relationship between Changes in Employer Requirements and Labor Market Slack

Panel A: Requested Educational Qualifications

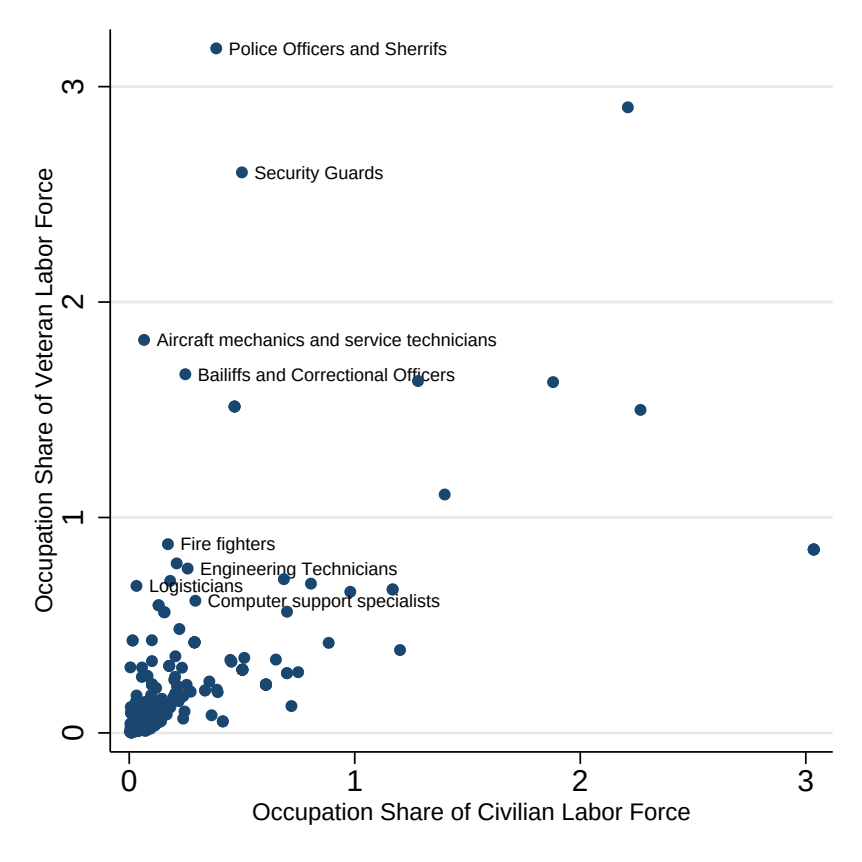


Panel B: Requested Experience Qualifications



Notes: Figure is a binned scatterplot (N=74) showing the baseline relationship between the percentage point change in employer requirements and the percentage point change in the state unemployment rate.

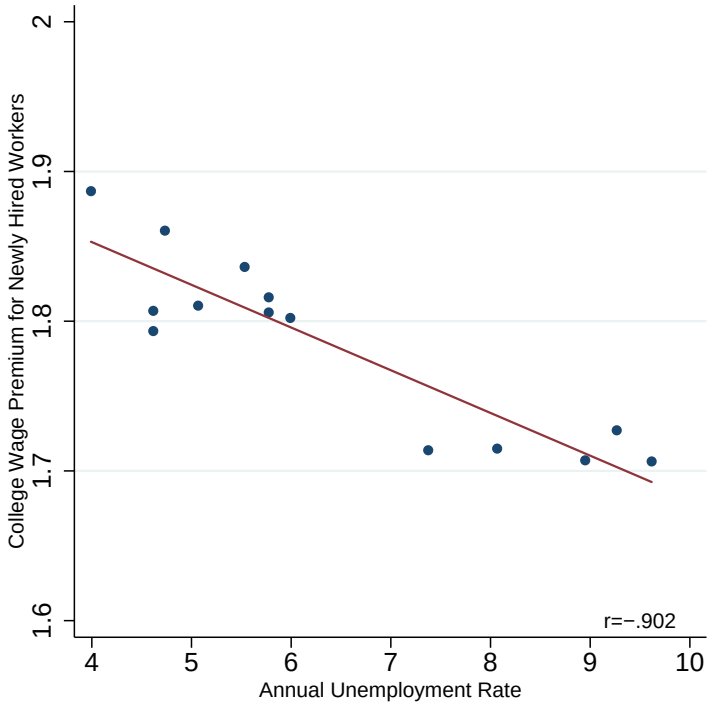
Figure 3. Relationship between Measures of Veteran and Civilian Concentration *Across* Occupations, 2007



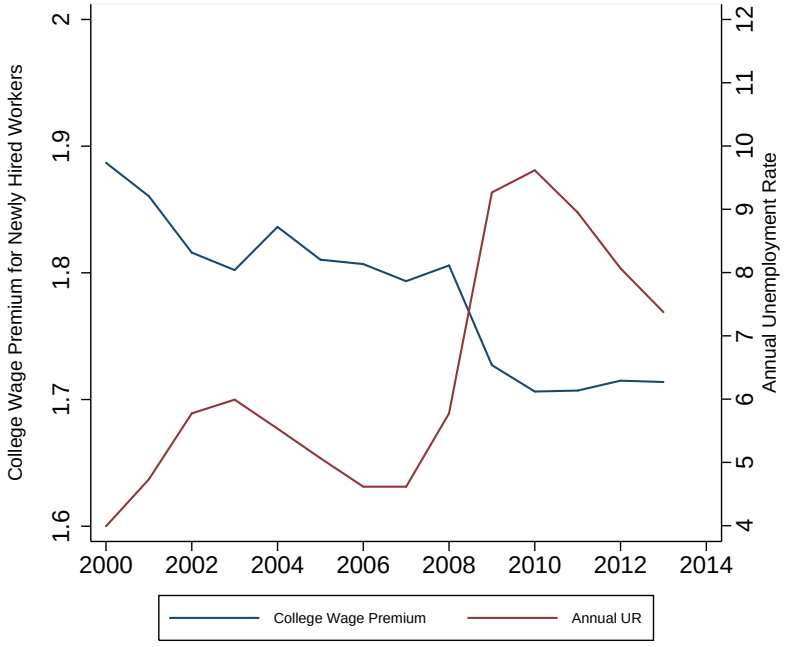
Source: The above figure displays each occupations's share of the total veteran labor force by the occupation's share of the civilian labor force. Share are calculated using the ACS 2007 3yr PUMS.

Figure 4. Relationship between College Wage Premium and Labor Market Slack

Panel A: College Wage Premium and Annual Unemployment Rate over Time



Panel B: Correlation between College Wage Premium 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. See data appendix for more details on data construction. *Source:* CPS Matched Monthly Sample, Federal Reserve Bank of Boston analysis of monthly CPS Data, 2000–2013.

Table A1. List of Occupations in Estimation Sample

	Occupation Title	Standard Occ Code
1	Administrative Services Managers	113011
2	Agricultural and Food Science Technicians	194011
3	Aircraft Mechanics and Service Technicians	493011
4	Bailiffs, Correctional Officers, and Jailers	333010
5	Bill and Account Collectors	433011
6	Billing and Posting Clerks and Machine Operators	433021
7	Bookkeeping, Accounting, and Auditing Clerks	433031
8	Business Operations Specialists, All Other	131199
9	Cardiovascular Technologists and Technicians	292031
10	Chefs and Head Cooks	351011
11	Commercial and Industrial Designers	271021
12	Computer User Support Specialists	151151
13	Construction Managers	119021
14	Customer Service Representatives	434051
15	Data Entry Keyers	439021
16	Demonstrators and Product Promoters	419011
17	Dental Assistants	319091
18	Designers, All Other	271029
19	Engineering Technicians, Except Drafters	173020
20	Executive Secretaries and Executive Administrative Assistants	436011
21	Fashion Designers	271022
22	Firefighters	332011
23	First-Line Supervisors of Helpers, Laborers, and Material Movers, Hand	531021
24	First-Line Supervisors of Mechanics, Installers, and Repairers	491011
25	First-Line Supervisors of Non-Retail Sales Workers	411012
26	First-Line Supervisors of Office and Administrative Support Workers	431011
27	First-Line Supervisors of Retail Sales Workers	411011
28	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	531031
29	Food Service Managers	119051
30	General and Operations Managers	111021
31	Graphic Designers	271024
32	Hotel, Motel, and Resort Desk Clerks	434081
33	Human Resources Assistants, Except Payroll and Timekeeping	434161
34	Industrial Production Managers	113051
35	Insurance Sales Agents	413021
36	Legal Secretaries	436012
37	Licensed Practical and Licensed Vocational Nurses	292061
38	Loan Interviewers and Clerks	434131
39	Loan Officers	132072

(continued on next page)

Table A1. List of Occupations in Estimation Sample (continued)

	Occupation Title	Standard Occ Code
40	Logisticians	131081
41	Massage Therapists	319011
42	Medical Assistants	319092
43	Medical Records and Health Information Technicians	292071
44	Medical Secretaries	436013
45	Merchandise Displayers and Window Trimmers	271026
46	Models	419012
47	Occupational Therapy Assistants	312011
48	Office Clerks, General	439061
49	Paralegals and Legal Assistants	232011
50	Payroll and Timekeeping Clerks	433051
51	Physical Therapist Assistants	312021
52	Police and Sheriff's Patrol Officers; Transit and Railroad Police	333050
53	Preschool Teachers, Except Special Education	252011
54	Production, Planning, and Expediting Clerks	435061
55	Property, Real Estate, and Community Association Managers	119141
56	Purchasing Agents, Except Wholesale, Retail, and Farm Products	131023
57	Radiologic Technologists	292034
58	Real Estate Sales Agents	419022
59	Receptionists and Information Clerks	434171
60	Respiratory Therapists	291126
61	Retail Salespersons	412031
62	Sales Representatives, Services, All Other	413099
63	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	414012
64	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	414011
65	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	436014
66	Security Guards and Gaming Surveillance Officers	339030
67	Statistical Assistants	439111
68	Telecommunications Equipment Installers and Repairers, Except Line Installers	492022
69	Telemarketers	419041
70	Tellers	433071
71	Tool and Die Makers	514111
72	Transportation, Storage, and Distribution Managers	113071
73	Waiters and Waitresses	353031

Notes: Occupations are at the 5- and 6-digit Standard Occupation Code Level.

Table A2. 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 Rate	BGT Broad Occ Group Sup/Dem Rate
State UR	1.000				
State UR for Workers with a Bachelor's Degree of Greater	0.832	1.000			
State UR for Workers Aged 35 Plus	0.964	0.856	1.000		
HWOL Broad Occ. Group Labor Supply/Demand Rate	0.747	0.629	0.676	1.000	
BGT Broad Occ. Group Labor Supply/Demand Rate	0.713	0.640	0.652	0.926	1.000

Change in:	State UR	State UR for BA+	State UR for Workers Aged 35+	HWOL Broad Occ Group Sup/Dem Rate	BGT Broad Occ Group Sup/Dem Rate
State UR	1.000				
State UR for Workers with a Bachelor's Degree of Greater	0.911	1.000			
State UR for Workers Aged 35 Plus	0.984	0.909	1.000		
HWOL Broad Occ. Group Labor Supply/Demand Rate	0.932	0.905	0.917	1.000	
BGT Broad Occ. Group Labor Supply/Demand Rate	0.900	0.892	0.874	0.956	1.000

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

Table A3. Relationship Between the Change in Employer Requirements and Labor Market Slack, Using Alternative Measures of Supply

(Standardized Coefficients Reported)

	Change in Share of Postings Requesting a Bachelor's/Graduate Degree				Change in Share of Postings Requesting >2 Years Experience			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ State UR	0.181**				0.305***			
	(0.0702)				(0.0708)			
Δ State UR for BD+/Workers Aged 35+		0.215***				0.300***		
		(0.0492)				(0.0446)		
Δ HWOL Labor Supply/Demand Rate			0.0661***				0.110***	
			(0.0234)				(0.0244)	
Δ BGT Labor Supply/Demand Rate				0.105***				0.135***
				(0.0304)				(0.0289)
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Occ Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6733	6733	6733	6733	6733	6733	6733	6733

Notes: All independent and dependent variables normalized (in the estimation sample) to have mean 0 and standard deviation 1. Dependent variable for columns (1)–(4) is the percentage point change in the share of posting requesting a Bachelor's degree or greater; dependent variable for columns (5)–8 is the the percentage point change in the share of postings requesting 2 or more years of experience. See Table 2 notes for details on construction of the HWOL and BGT broad occupation group labor supply/demand rates. All specifications an indicator variable to control for differences between the two time periods, 2007–2010 and 2010–2012 and the baseline controls listed in Table 2 notes. 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 A4. 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

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

Panel B: Veteran Supply Shocks

Mean:	2007	2010	2012	Δ2007–10	Δ2010–12
ln(State-Level Number of Veterans in Labor Force)	10.01	10.19	10.40	0.30	0.25
Veteran Broad Occ Group Labor Supply/Demand Rate	2.00	2.08	2.17	0.084	0.084
Observations	3357	3376	3376	3357	3376

Notes: Log difference in the number of veterans in the labor force is estimated using the ACS 1yr. PUMS and is defined as the ln(number of veterans)$_{i,t}$–ln(number of veterans)$_{i,t-n}$,where i denotes state and t, t-n denote the two time periods for which the change is measured. The BGT Veteran Broad Occupation Group Labor Supply/Demand Rate is an annual, state-level measure for the average number of veterans per job posting within six broad occupation groups. This measure is constructed by taking the state level estimate for the number of veterans in the labor force multiplied by a national estimate for each broad occupation's share of veteran employment and dividing this estimate by the average monthly count of job postings reported by BGT within a broad occupation group for a given year.

Table A5. Relationship Between the Change in Employer Requirements and Veteran Supply Shocks, IV Estimates using Veteran BirthPlace

Placebo Tests: Veteran versus Civilian Occupations

	Change in Share of Postings Requesting a Bachelor's or Greater		Change in Share of Postings Requesting 2 or More Years of Experience	
Veteran Share of Occupation Employment:	Lowest Vet Shares	Highest Vet Shares	Lowest Vet Shares	Highest Vet Shares
Log Difference in Number of Veterans in State	7.483	15.95**	3.535	19.77**
	(5.849)	(6.558)	(5.700)	(7.736)
F-Test Excluded Instrument	7.549	8.596	7.494	8.565
Occ Fixed Effects	Yes	Yes	Yes	Yes
Observations	858	918	858	918

Notes: The state-level log difference in the number of veterans in the labor force is estimated using the ACS 1yr. PUMS and is defined as the $\ln(\text{number of veterans})_{i,t} - \ln(\text{number of veterans})_{i,t-n}$, where i denotes state and t, t-n denote the two time periods for which the change is measured. In all specifications above, we instrument for these the log difference in the number of veterans by estimating this measure analogously using veteran's birthplace, rather than current residence, as reported in the ACS. In columns (1) and (3), we subset our estimation sample to include occupations with a veteran share of employment less than 0.3 percent. In columns (2) and (4), we subset of estimation sample to include occupations with a veteran share of employment greater than 2.8 percent. These cutoffs generate estimation samples of comparable sample size, containing occupations with the lowest and highest levels of veteran concentration. See data appendix for more details on the creation of the veteran supply shocks. All specifications include a control for differences between the two time periods, 2007–2010 and 2010–2012. 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

DATA APPENDIX

I. Dependent Variables

A. Burning Glass Technologies/Labor Insight Database

The Burning Glass Technologies (BGT) Labor/Insight analytical tool contains detailed information on the more than seven million online job openings updated daily from over 16,000 sources including job boards, newspapers, and employer sites. This collection process provides a more robust representation of hiring, including job activity posted by small employers. The BGT Labor/Insight analytical tool also enables us to access the underlying job postings for validation purposes. With this underlying data we can validate many of the important components of this data source including non-duplication and aggregation.

These data are available for detailed occupation by Standard Occupation Code (SOC) down to the six-digit level and can be drawn for arbitrarily small geographies for 2007, 2010, and 2012. BGT mines over seventy job characteristics from free-text job postings including education level and years of experience required or preferred by the employer. As such, this data allows geographical analysis of occupation-level labor demand by education level and experience level.

However, collecting these data is a time consuming process that involves manually creating queries in the Labor/Insight tool to collect reports on the number of job postings by 6-digit SOC and specific skill level (e.g. job postings requiring a high school degree). Twelve of these reports are then merged together to provide detailed information on an occupation for the specified geographies (e.g. States) in a given year.

As a result, we chose a sample of 73 of the largest "middle-skill" occupations to conduct our analysis. These occupations were chosen from a sample of 272 "middle-skill" occupations identified as employing a large share of individuals with some college or an associate's degree based on data from the American Community Survey (ACS).

We construct two dependent variables of interest that measure the percentage point change in the share of online job postings along two dimensions of skill: those requiring/preferring at least a bachelor's degree (BA) or those requiring 2 or more years of experience.

B. Minnesota Job Vacancy Survey

The Minnesota Job Vacancy Survey is one of twelve state job vacancy surveys conducted in the United States. It is a biannual survey of employers designed to estimate hiring demand and job vacancy characteristics by industry and occupation. 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. For more details see http://mn.gov/deed/data/data-tools/job-vacancy/ .

We construct two dependent variables of interest that measure the percentage point change in the share of online job postings along two dimensions of skill: those requiring/preferring a college degree or those requiring "related" experience. We also include controls for whether the job provides benefits and is full versus part-time.

II. Explanatory Variables

A. State Labor Market Conditions

We assembled several independent variables to capture changes in local labor market conditions. Our primary measure is 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 as a proxy to better capture changes in available supply specifically related to individuals with higher levels of education and experience.

In addition, we also construct two supply/demand indexes measuring the ratio of the number of unemployed individuals to the number of job postings for broad occupation groups. These groups include:

- 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)

Although the two indices differ in terms of the *level* of slack they indicate for a given occupation/state/year cell, they capture *changes* over time that are very similar. The numerator for both measures is constructed from…

The denominator for the first measure is constructed using the BGT vacancy data while the second uses vacancy data from Help Wanted OnLine (HWOL). HWOL provides regional-, state-, and MSA-level measures of labor demand at the 6-digit SOC level for certain geographies. The HWOL program collects job postings from a smaller subset of sources, using vacancies posted directly on internet job boards and online newspaper ads. HWOL does not scrape corporate websites, although some of these jobs are scraped by job boards and are present in the data count. HWOL also uses third party data from Wanted Technologies—numerous steps are taken to ensure that the counts represent unduplicated ads. In an average month, approximately 2/3 of the job postings collected are duplicates. HWOL advertises that their unduplicated ad levels "compare favorably" to JOLTS data when controlling for coverage and definitional differences.

B. Other Controls

Other variables are used to control for important differences across states or occupations such as:

- Initial share of openings requiring a particular skill in 2007: calculated from the BGT data.
- Change in total openings: calculated from the BGT data.
- Share of the state population with a bachelor's degree in 2000 as calculated from the U.S. Decennial Census.
- Average age of the state population in 2000 as calculated from the U.S. Decennial Census.

C. Instruments

Veteran supply shock: Using the 2005-2007 ACS, we estimate the number of post-9/11 veterans in the labor force at the state level each year. We then construct the state-level veteran supply shock as the change in the log number of veterans for a given time period, and express this change as a share of total postings for each state and occupation observation. We also include specifications that interact the state level veteran supply shock with the share of veterans employed in a given occupation.

D. Firm Characteristics

We test whether the degree of employer upskilling in loose slack labor markets is consistent with a causal effect on employer searching by looking at three characteristics associated with employer recruitment: such as turnover, time-to-start, and wage rigidity: unionization coverage, time to start, and the replacement rate.

- Unionization Coverage by detailed occupation: The share of employed workers within an occupation who are covered by a collective bargaining agreement. Source: http://www.unionstats.com/
- Time to Start: As reported in the "Time to Start by Industry data table" on page 24 in Staffing.Org. 2007. "2007 Recruiting Metrics and Performance Benchmark Report." New York.
- Replacement Rate: As reported by the Bureau of Labor Statistics in Column D of Table I.10 from http://www.bls.gov/emp/ep_table_110.htm.
- Wage Premium: By detailed occupation: ln(75% percentile for hourly wages)-ln(25% percentile for hourly wages) Constructed from 2007 data from the Occupational Employment Statistics: http://www.bls.gov/oes/ .

E. Wage Premium for Newly Hired Workers

We calculate the college wage premium for newly hired workers using a multi-month matched CPS sample constructed 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.

Using this sample, we are able to identify labor market transition from no employment (i.e. unemployed or NILF) to employment as well as identify individuals who transition to a new employer in a given month (i.e. employment to employment transition). Wages reported in period 4 are used for labor market transitions in months 1-4 and period 8 wages are used for period 5-8 and for transitions occurring over the eight months an individual is out of the sample between period 4 and 5.

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.