

Downskilling: Changes in Employer Skill Requirements Over the Business Cycle*

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Using a novel database of 66.8 million online job postings, we show that employer skill requirements fell as the labor market improved from 2010-2014. We find that a 1 percentage point reduction in the local unemployment rate is associated with 0.20 percentage point reduction in the fraction of jobs requiring at least a bachelor's degree and a 0.22 percentage point reduction in the fraction requiring 5 or more years of experience. This pattern is established using multiple measures of labor availability, is bolstered by similar trends along heretofore unmeasured dimensions of skill, and even occurs within firm-job title pairs. We further confirm the causal effect of labor market tightening on skill requirements using a natural experiment based on the fracking boom in the U.S. as an exogenous shock to local labor supply in tradable, non-fracking industries. These industries are not plausibly affected by local demand shocks or natural gas extraction technology, but still show fewer skill requirements in response to tighter labor markets. Our results imply this labor-market induced *downskilling* reversed much of the cyclical increase in education and experience requirements that occurred during the Great Recession. *JEL* Codes: J23, J21, J63.

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I. Introduction: Secular versus Cyclical Shifts in Skill Requirements

The persistent weakness of the U.S. labor market following the Great Recession is still poorly understood. As of 2012, two years after the official end of the Great Recession, the unemployment rate still hovered around 8 percent, despite employers reporting more vacant positions. This shift in the Beveridge curve (documented in Diamond and Sahin 2014) has highlighted the need to focus not just on the number of vacancies, but on their composition and requirements as well.

Perhaps less well-known is the fact that employer requirements for education and experience levels contained in job vacancies rose considerably during the Great Recession. Based on a database of 67 million online job ads, we show in Figure 1 that the share of vacancies requiring a bachelor's degree or more rose by more than 10 percentage points from 2007 to 2010. At the same time, the share of postings requiring 5+ years of experience rose roughly 7 percentage points. Previous work examining this dynamic found that employers raised education and experience requirements within occupations, and even within firm and job titles. (Modestino, Shoag, and Ballance 2014, Hershbein and Kahn 2014). This growth in skill levels within occupations has colloquially become known as "*upskilling*."

This massive increase in required skills raised concerns that the U.S. labor market faced a structural and persistent mismatch between workers' skills and firms' needs. Here and in Modestino, Shoag, and Ballance (2014), we argued that a significant portion of this increase in employer skill requirements reflected *opportunistic* upskilling by firms whereby firms used slack labor markets as an opportunity to hire more skilled workers. Rather than purely mismatch causing unemployment, we claimed that loose labor markets induced a significant portion of the observed changes in skill requirements. We further identified this effect by using Iraq and

Afghanistan troop draw-downs as an instrument for positive labor supply shocks in certain occupations and locations, resulting in a similar pattern of upskilling as what was observed during the Great Recession.

What we could not observe in that analysis, however, was the behavior of skill requirements as the labor market improved or tightened. Demonstrating this relationship is crucial for a number of reasons. First, falling skill requirements during the recovery provides important confirmatory evidence that prior upskilling was opportunistic. We can more convincingly identify this effect, and the post-recession data allows for new natural experiments. Second, even if skill requirements initially rose due to cyclical labor market slack, it is not immediate that they would revert during a recovery. Labor markets are prone to hysteresis, and what began as a short term response to labor market condition could have become permanent problem. Finally, the symmetry or asymmetry of the response allows us to evaluate the importance of proposed mechanisms like wage rigidity that might matter more in downturns than in recoveries.

In this paper, we build on our study of the Great Recession, with an analysis of skill trends during the subsequent recovery. To do this, we use a newly updated, comprehensive dataset of 66.8 million online job vacancy postings from Burning Glass Technologies. This job level data covers the near-universe of electronic posts across the entire U.S., and covers a much broader range of occupations and much more detailed geographies than the data used in our initial paper. The improvement in data quality qualitatively improves the analysis. In addition, this new dataset covers the entire recovery period of the Great Recession from 2010 through 2014 allowing us to test the relationship between employer job requirements and the availability of workers during a period of declining labor market slack.

These data paint a fascinating picture of skill requirements over time. As is evident in Figure 1, there has been a considerable reversal of the upskilling during the recovery. Of course, these aggregate trends could be misleading, and so we use the richness of the BGT data to analyze the relationship between the degree of labor market slack and employer requirements for education and experience at the local level. We do this using a battery of controls for occupational trends and aggregate conditions. We find that a 1 percentage point reduction in the local unemployment rate is associated with 0.20 percentage point reduction in the fraction of jobs requiring a bachelor's degree and a 0.22 percentage point reduction in the fraction requiring 5+ years of experience. This effect is present even within firm-job-title-county pairs. We also see similar trends in heretofore unmeasurable dimensions of skill, such as leadership, project planning, and software skills, recently made available by Burning Glass Technologies.

To better identify this effect, we turn to a natural experiment based on the fracking boom in the U.S. as an exogenous shock to local labor supply. Fracking enabled a rapid increase in natural gas production between 2007 and 2011 (see Figure 4), and a number of counties experienced large increases in employment in that industry. Though fracking undoubtedly affected the types of positions needed in the natural gas industry, many tradable industries like agriculture, manufacturing, and timber were not directly affected by this new technology. Moreover, these tradable industries—by virtue of being tradable – are unlikely to have been affected by local demand conditions. Therefore, for these industries, fracking represents an exogenous tightening in their local labor market. We find that both within and across individual firm-job titles, jobs experiencing an exogenous tightening of their labor markets cut education and experience requirements. The IV implied coefficients are similar to the coefficients found in our OLS regressions. Taken together, our results imply that cyclical factors account for a significant fraction of the change in employer skill requirements between 2007 and 2014.

The finding that employer skill requirements are driven—in part—by the available supply of labor has important implications for understanding the dynamics of the labor market, revealing a feedback mechanism between labor supply and the selectivity of vacancies that operates within occupations. Such a feedback mechanism between the selectivity of vacancies and labor supply is consistent with macroeconomic models of employer search decisions (Davis et al. 2012) and heterogeneous workers (Shimer 2005, Albrecht and Vrooman 2002). Similarly, a related literature has explored worker entry and mobility during recessions, particularly for college graduates. These studies typically find that workers match at lower entry wages during recessions and have less steep wage trajectories over time (e.g. Kahn 2010, Oreopoulos et al. 2012, Moscarini, 2001). Indeed, the persistence of low wages for jobs that begin when labor markets are slack has been related to jobs that offer less possibility of human capital accumulation (Okun 1973, Gibbons and Waldman 2006, Schmieder and von Wachter 2010). We find that changes in employer requirements over the business cycle is consistent with—and even serves to reinforce—this effect.

Finally, our findings inform the debate regarding the nature of unemployment in the U.S. which some have interpreted as a deterioration in the matching/hiring process in the economy. Numerous media reports and employer surveys have suggested that the lack of skilled workers has made it difficult to fill jobs that are in high demand during the economic recovery, leading to slower than expected improvement in the labor market.¹ Yet the economics literature has largely concluded that the weak labor market is largely not due to skills mismatch or other structural

¹ Bloomberg Business. 2012. “Companies Say 3 Million Unfilled Positions in Skill Crisis: Jobs.” July 25. Madigan, Kathleen. 2014. “How Some Companies are Bridging the Skills Gap.” *Wall Street Journal*, May 15. Madigan, Kathleen. 2015. “Skills Shortage Is the Worst Since 2006, Small- Business Survey Says.” *Wall Street Journal*, March 10. “Boiling Point? The Skills Gap in U.S. Manufacturing”, Deloitte and Manufacturing Institute, 2011. “Closing the Gap: 2012 Skills survey of North Carolina Employers.” Workforce Development Boards of NC, 2012. “Skilled Trades Remain Hardest Job to Fill in U.S. for Fourth Consecutive Year”, Manpower Group, 2013.

factors, but rather weak aggregate demand that increased unemployment across worker types, industry sectors, and occupation groups (Ghayad and Dickens 2012; Daly et al. 2012; Lazear and Spletzer 2012; Rothwell 2012; Carnevale et al. 2012; Sahin et al 2014, Capelli 2014; Osterman and Weaver 2014). Our results indicate that much of the observed increase in skill requirements within detailed occupations is correlated with the business cycle and are subject to reversion as the labor market tightens, suggesting that a significant portion of what is sometimes labeled as structural mismatch employment is actually cyclical. This finding helps rationalize these shifts in the Beveridge curve, as not all vacancies represent the same urgency to hire.

The relationship between employer 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. To the degree that changes in employer requirements vary with the business cycle then during slack times, we should expect those with less experience and lower levels of education to have longer spells of unemployment. It also cautions against the use of targeting high frequency changes in labor market posting information in designing training programs, since these requirements may revert during recoveries.

The paper proceeds as follows. Section II lays out a theoretical framework and model to explore the reasons why employer upskilling might be related to the business cycle. Sections III and IV describe our empirical and the unique features of the online job vacancy dataset used in our estimation. Section V reports the baseline relationship between employer skill requirements and the business cycle as well as several robustness tests for alternate interpretations, including evidence from our natural experiment related to the “fracking” boom. Section VI concludes.

II. Theoretical Framework: Measuring Shifts Along the Labor Demand Curve

Before beginning, we seek to briefly rationalize employer skill requirements and their relationship to labor market slack. A simple partial equilibrium model conveys our intuition and allows us to derive estimating equations. We begin by considering employers in labor market i choosing between posting a vacancy with a minimum skill requirement or accepting all workers. Each employer has a stochastic cost c drawn from a uniform 0-1 distribution of leaving the vacancy unfilled.). These costs may vary across firms by the premium they attach to high skilled workers over low skilled worker, the turnover rate of their employment relationships, and/or the urgency of their hiring need modeled via their discount rate.

We normalize the value to having a filled low-skilled vacancy to 1, and set the value to a filled high-skilled vacancy equal to $\theta > 1$, which is constant across labor markets. Each period, the employer is matched with a high skilled worker stochastically with probability $p_i = \vartheta U_i^\gamma$, that depends positively on the local unemployment U_i . We assume employers have a constant discount δ . Given this set up, employers in labor market i have the following value function:

$$V_i = \max \left\{ \frac{1}{1-\delta}, -c + p_i \frac{\theta}{1-\delta} + (1-p_i)V_i \right\}$$

This yields a cutoff rule c_i^* such that employers with costs below the cutoff post minimum skill requirements and employers with costs above the cutoff do not. Since costs are drawn from a uniform distribution, c_i^* (when scaled) is also the fraction of employers posting skill requirements. We can decompose changes in this fraction as:

$$\Delta c_i^* = \alpha \times \Delta \theta + \beta \times \Delta U_i + \varepsilon_i \quad (1)$$

where α measures the importance of the national structural change in the relative value of high and low skilled workers and β measures the cyclical component, wherein more slack labor markets make it easier to find high skilled workers.

With such a motivating model in mind, the following implications become clear that changes in employer skill requirements and the unemployment rate are jointly endogenously determined. Thus, our goal is to estimate movements along the labor demand curve rather than shifts in the demand curve. As such, in the empirical analysis it will be crucial to identify variation in labor supply that is not correlated with shifts in labor demand. We turn to this discussion in the next section.

III. Empirical Approach

We seek to explore this dynamic by measuring the degree to which the observed decrease in employer skill requirements is related to the degree of labor market slack during the recovery. Specifically, we begin by running regressions of the form:

$$\Delta \text{Share of Vacancies Requiring Skill } S_{ijt} = \alpha + \beta \Delta \text{Unemployment}_{jt} + \gamma X_{i,j,t} + \tau_t + e_{ijt},$$

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 during the recovery: changes from 2010-2012 and changes from 2012–2014) where τ is a dummy for the earlier period and the vector X includes various controls. The coefficient of interest is β , the increase in skill requirements related to changes in the business cycle. A larger β suggests more opportunistic down-skilling in requirements on the part of employers. A small β suggests that down-skilling is not related to employer attempts to adjust to recovering labor markets by compromising on worker's education or experience.

In the above regression, we examine changes in employer requirements across occupations and locations over time. The key identifying assumption is that different parts of the country recovered at different rates from the Great Recession, allowing us to exploit the variation in local labor markets across counties and time periods. Although the specification above may indicate a positive correlation between changes in employer requirements for skill and the availability of skilled labor, we still need to address two econometric concerns to reliably establish a causal relationship. First, although online job postings had increased in frequency by the end of the Great Recession, the BGT data collection mechanism may have changed over time, as have the types of jobs being posted online. To test whether the relationship between labor market slack and rising skill requirements is driven by composition and data issues, we make use of the geographic variation in our data while controlling for time trends.

Second, changes in the availability of skilled workers across counties and occupations are likely to be endogenous, and reliable estimates require tests to address the possibility of omitted variable bias and reverse causality. We test whether changes in the availability of skilled workers across counties and occupations are endogenous in two ways. First, we use the variation within counties across broad occupation groups to include state fixed effects to control for local demand conditions. Second, we compare changes in employer requirements *within* firms and job titles over the business cycle.

Yet it may still be the case that relying on the variation during the recovery period of the business cycle as the primary source of identification could lead to biased results given that the unemployment rate is correlated with other factors at the firm level such as product demand and access to credit. Thus, we further makes use of a natural experiment that represents a clear shock to labor supply: the “fracking” boom in oil and natural gas production that boosted wages and

attracted workers from 2007-2011, creating labor shortages in related industries in nearby states.²

The timing of the sudden surge in natural gas production was driven by the discovery of the Marcellus Shale formation along the eastern coast of the U.S. and largely orthogonal to local economic conditions. As a result, various regions of the country experienced a boom in production, raising the demand for workers with skills found in certain occupations associated with mining, agriculture, and manufacturing. We demonstrate that county-occupation cells in adjacent areas correspondingly experienced a significant *decrease* in their skill requirements as workers were lured away by the fracking industry.

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

To date, little has been written about employer job posting requirements due to a lack of detailed data. However, with the advent of online job posting and searching in the early 1990s, the collection and availability of this data has increasingly made such information available to researchers.³ Online vacancy data are increasingly being used by researchers to study labor market dynamics (e.g., Sahin et al. 2014, Marinescu and Wolthoff 2013, Lazear and Spletzer 2012, Faberman and Mazumder 2012, Rothwell 2012, Bagues and Labini 2009, Kuhn and Skuterud 2004, Gautier, van der Berg, van Ours, and Ridder 2002). 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

² See Galbraith, Kate. 2012. "In Oil Boom, a Housing Shortage and Other Issues." *The New York Times*. July 12.

³ The first online job listings were posted on Usenet, CareerMosaic, and Monster during 1990-1994. Between 1995 and 1997, additional job boards were launched (e.g. Craigslist) and newspaper job listings began to appear online. Two companies, jungle and careercast, begin scraping and aggregating online job postings. Major changes took place in the years 1998 and 1999 as the job boards industry consolidated and a few key players emerged (e.g. Monster, Career Builder, Jobsonline). After the dot-com bust, niche job boards proliferated between 2000 and 2002 for marketing, medical, sales, and accounting jobs. Between 2003-2007, the industry matured and experienced significant growth with the launch of LinkedIn and aggregators such as Top USA Jobs, indeed, and simply hired. See Garcia, Stephanie. 2013. "History & Statistics of Job Boards." Joshua Waldman's Career Enlightenment Blog, March 6th , <http://careerenlightenment.com/history-statistics-of-job-boards-infographic> .

(JOLTS). 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—including data aggregated by Burning Glass Technologies—exhibit similar trends and are closely correlated with employer surveys over time (Templin and Hirsch 2013, Ganong 2014).

A. Constructing Employer Skill Requirements and Labor Market Measures

Our basic empirical strategy is to explore the relationship between changes in employer skill requirements and changes in local labor market conditions during the Great Recession and subsequent recovery. Table 1 reports descriptive statistics for two 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 annual county unemployment rate as reported by the Bureau of Labor Statistics from the Local Area Unemployment Statistics (LAUS). Although these rates are partially model based, they represent a consistent measure of labor market slack across counties over time. As a robustness check, we also create a second measure, modeled on the Conference Board’s Labor Supply/Demand Ratio, which represents the number of unemployed individuals relative to the number of vacancies posted.⁴ Both measures of slack are used in regressions to establish the robustness of our result.

B. Constructing Employer Skill Requirements from Job Vacancy Data

Burning Glass Technologies (BGT) is one of the leading vendors of online job ads data, aggregating data from the web into a near-universe of online job postings. The data contains detailed information on the more than seven million current online job openings updated daily from over 40,000 sources including job boards, newspapers, government agencies, and employer

⁴ Specifically, the numerator is estimated using the American Community Survey while the denominator is calculated from the number of postings observed in the BGT data.

sites. 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.⁵ In the database, vacancies are reported on a monthly basis and are pooled over the year without duplication. As such, this data allows geographical analysis of occupation-level labor demand by education level and experience level over time.

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. Their Labor/Insight analytical tool enables us to access the underlying job postings to validate many of the important components of this data source including timeframes, de-duplication, and aggregation.

Using the entire universe of job vacancies collected by BGT, we construct several measures of employer skill requirements based on the education and experience fields parsed from the online advertisement. The data are available for detailed occupation by Standard

⁵ Note that the BGT data do not contain any information on the duration of the vacancy, how many applications a vacancy received, nor whether a vacancy was filled.

Occupation Code (SOC) down to the six-digit level and can be drawn for arbitrarily small geographies for 2007 and 2010 through 2014.⁶ In total, our data represent roughly 66.8 million vacancies for these years.

Table 1 provides descriptive statistics for the dependent variables constructed from the BGT data by county/occupation/year cells. On average, there are roughly 250 postings for a given cell each year (2010, 2012, and 2014). It should be noted that these data exhibit a considerable amount of variation given the different employment levels of these occupations, even at the county/occupation level. The number of underlying observations available to construct some cells varies from as few as one posting to as many as 40,000 postings at this level of dis-aggregation. To ensure that our dependent variables are capturing meaningful differences over time and accurately represent the state of the labor market, we drop observations with fewer than 15 total postings in a given cell. In addition, since we are analyzing changes in the fraction of postings requiring a particular skill, we weight the observations by the occupation's share of total openings in the county 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 county, 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 changing over time, with the majority of the decrease occurring between 2012 and 2014 during the recovery period. Our education categories of interest are defined as follows: share of postings with some education requirement, share requiring an associate's degree or greater, and the share requesting a Bachelor's degree or higher. Experience is similarly defined as some experience requested, ≥ 2 years requested, and ≥ 5 years requested.

⁶ No data are available for 2008 and 2009.

We also employ additional information on the skills listed in each job posting that is collected from the original text of the advertisement. Specifically, BGT parses each skill listed in the posting and classifies it as baseline (e.g. generic skills such as leadership, project planning and development), specialized (e.g. information security), or software (e.g. Adobe Dreamweaver). From this, we construct the share of postings requiring each type of skill. Interestingly, these more detailed skill requirements exhibit the same *downskilling* trend as that of the education and experience requirements.

V. Results

We begin by analyzing the aggregate trends in the Burning/Glass data. Figures 1a and 1b report the percentage of jobs in the data requiring a bachelor's degree and 5 years of prior experience respectively. As is evident in the figures, there is a strong time-series correlation with aggregate labor market slack. Both measure rose during the 2007-2009 recession, and then fell as the labor market recovered. There is clear evidence of down-skilling in this aggregate data with the fraction of jobs requiring these skills falling significantly during the period 2010-2014.

Of course, this correlation at the aggregate level is not necessarily causal. The BGT data collection mechanism changed over time, as have the types of jobs being posted online. To test whether the relationship between labor market slack and rising skill requirements is driven by composition and data issues, we make use of the geographic variation in our data. Specifically, we aggregate the data to the county level, and use both county unemployment rates as well as our Labor Supply/Demand Ratio to establish the robustness of our result.

A. Basic OLS Relationships

Using both of these labor market measures, Figure 2 shows that tightening labor markets are associated with falling skill requirements at the county-occupation level. These relationships are robust and show clear evidence of *downskilling*. In fact, they look only at situations in which

the labor market is weakly growing tighter. Note that these figures display the effect of labor market slack while controlling for both time fixed effects, which eliminates the potential for a confounding change in BGT data construction, as well as occupation fixed effects which control for confounding trends in postings across occupations at the three-digit level.

These relationships are further quantified in Table 2 which reports the results of our initial regressions relating changes in employer requirements and labor market slack for both education and experience levels. In all specifications for our categorical skill measures, β is positive and statistically significant, indicating that there was a decrease in the share of jobs requiring skilled workers across education and experience measures as the unemployment rate fell. The basic economic relationships show that a one percentage point reduction in the local unemployment rate is associated with 0.20 percentage point reduction in the fraction of jobs requiring a bachelor's degree and a 0.22 percentage point reduction in the fraction requiring 5 or more years of experience. Similarly, using our Labor Supply/Demand Ratio, a decrease of 1 unemployed worker per posting is associated with a 0.56 percentage point decline in the fraction of jobs requiring a BA and a 0.24 percentage point change in the fraction requiring 5+ years of experience.

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 Table 3, 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.⁷

B. Controlling for Aggregate Economic Conditions and Time Trends

While these relationships are compelling, these regressions are still open to non-causal interpretations as well. For example, changing skill requirements and local labor market trends may be driven by some local form of technological process. Alternatively, it may be the case that changes in requirements are driven by changes in job posting practices over time. The correlation between unemployment rates and skill in recovering labor markets may then be spurious.

To control for local demand shocks and technology trends, we add in controls for state fixed effects into our previous regressions. These effectively allow state-specific trends in the level of skill requirements over our relatively short time period. Despite the addition of state fixed effects in Table 4, we still see a positive and significant relationship between changes in employer requirements and tighter labor market conditions of virtually the same magnitude. Thus even controlling for differences in the state of the local economy, local labor supply decreases remain correlated with falling employer skill requirements.

One quite remarkable feature of our data is that we can explore outcomes not only for aggregate conditions at the local level, but rather can track outcomes for individual positions. In Table 5 we use postings-level data to explore the impact of local labor market conditions on skill requirements during the recovery within firm-job title- county pairs. To do this, we limit the data to observations with code-able job and employer titles. We also exclude unique firm-job title- county pairs to ease the computation. In the end we are left with over 22 million observations.

⁷ These baseline controls include the initial share of employers requiring each skill in 2010 and the change in total postings between 2010 and 2014 as a share of employment in 2010.

We then regress a dummy variable for the posting requiring a BA , and alternately 5 years experience, on firm-job title-county fixed effects and year dummies. Again, we cluster by county to account for correlation within counties across postings and over time. The resulting coefficients are remarkably close to the aggregate estimates. A 1 percent decrease in the unemployment rate makes a posting .2 percentage points less likely to require either degree of skill.

To examine whether the downskilling pattern observed for education and experience requirements reflects changes in job posting practices, we make use of additional data on actual baseline, specialized, and software skills requested collected from the advertisement. Using these three measures as well as a measure of any skill requested, Figure 3 shows that tightening labor markets are associated with falling skill requirements at the county-occupation level. Note that these figures display the effect of labor market slack while controlling for time fixed effects, which eliminates the potential for a confounding change in BGT data construction. Table 6 confirms that these results are robust to the inclusion of our baseline controls as well as occupation and state fixed effects. In all specifications for our categorical skill measures, the relationship is positive and statistically significant, indicating that there was a decrease in the share of jobs requiring skilled workers across all types of skills measures as the unemployment rate fell. The degree of reversion is strongest for baseline skills, with a one percentage point reduction in the local unemployment rate associated with 0.74 percentage point reduction in the fraction of jobs requiring baseline skills such as project management and leadership.⁸

C. Local Demand Shocks and Identification from a Natural Experiment

⁸ Moreover, data on the average number of skills requested per posting show similar downskilling trends, further evidence that postings do not simply list an ever increasing number of skills over time.

Hydraulic fracturing, or “fracking”, is the process of drilling and injecting fluid into the ground at a high pressure in order to fracture shale rocks to release natural gas inside. Advances in fracking and horizontal drilling technologies, combined with discoveries of large shale gas deposits greatly increased the scope of U.S. natural gas production in recent years between 2007 and 2011, Figure 3 shows that natural gas production increased by 26.7 percent. Using data from the USDA on county level natural gas production over this period, we explore changing skill requirements in counties experiencing this boom in production. The geographic dispersion in this increase is shown in Figure 4.

Specifically, we focus on tradable industries which were not affected by fracking directly –like agriculture, timber, metal-based mining, and manufacturing. For these industries, fracking-related increases in the demand for local labor is a relatively exogenous shock to their local labor supply. The production in these industries are not be driven by local demand and they do not use fracking in production. As a result, differential changes in skill requirements in these industries in natural gas vs. non-natural gas counties are likely to be related to an exogenous shock to labor supply, providing sufficient variation to explore downskilling.

Using posting-level data for these regression, we code each posting with a dummy outcome variable (needs BA/ needs 5). We then regress these postings data, limited to those industries in 2007 and 2011, on local unemployment rates and fixed effects for time and county. The results in columns 1-4 show a strong relationship between increases in natural gas production and falling education and experience requirements in non-fracking, traded industries. A 1 billion cubic foot increase in production is associated with a .03-.07 percentage point increase in the probability of a job needing a BA or 5 or more years’ experience. This is true

conditional on county fixed effects (Column 1-2) and even within firm-job title pairs (Column 3-4). We cluster our SE by county, and our results are highly significant. This is strong evidence of a causal effect, even within jobs, of downskilling at work.

However, many counties do not produce any natural gas such that natural gas production is skewed with a long right tail across counties. To ensure we are not driven by outliers, we recode natural gas production as a dummy variable for increases above 50 billion cubic feet. Again, this dummy is also tightly linked to changes in skill requirements.

Finally we use natural gas to instrument for local unemployment in columns 7 and 8. We get quite strong first-stage F statistics, demonstrating that natural gas production has sufficient power to identify the impact of changes in local unemployment rates. We find coefficients very similar to the aggregate regressions reported before. A 1 percentage point fall in the local unemployment rate is associated with a 0.1-0.2 percentage point fall in the probability that a local, non-fracking tradable job requires a BA or 5+ years of experience.

VI. Conclusion

After the Great Recession, Catherine Rampell of the New York Times wrote that “employers are increasingly requiring a bachelor’s degree for positions that didn’t used to require baccalaureate education. A college degree, in other words, is becoming the new high school diploma: the minimum credential required to get even the most basic, entry-level job.”⁹ This perception was correct *at that moment*, and indeed our data show that skill requirements in vacancy postings increased dramatically from 2007 through 2010.

⁹ “The college degree has become the new high school degree” NY Times (9/9/14)

The discussion regarding these changes, though, frequently missed the possibility that this increase would revert when the labor market recovered. In this paper, we demonstrated that this was indeed the case. From 2010 to 2014, the share of posting requiring a college degree or five years of experience fell by roughly 1/3rd the amount by which they increased over the recession. They fell by more in locations with higher unemployment, and this drop is evident even conditional on controls for occupation specific trends and aggregate conditions. Using natural-gas production as an instrument for labor market tightness in tradable industries, we find that this *downskilling* can be causally linked to worker availability. Tradable industries like manufacturing and agriculture, which are not impacted by fracking directly or by local demand shocks, reduced skill and experience requirements when their labor markets tightened, even within firm-job titles.

This demonstration of *downskilling* in vacancy postings, the first of which we are aware, is important for many reasons. It better identifies the opportunistic nature of skill requirements and it establishes that movements in these requirements will, at least in part, revert with the labor market. It also sheds light on the mechanism underlying these movements: a number of suggested contributors to changes in skill in poor labor markets, like as wage rigidity, and are unlikely to explain the reverse dynamic. This paper also demonstrates the relationship between labor market conditions and skill requirements using considerably better data than our previous work. We hope that future work can better flesh out the channels contributing to upskilling and the heterogeneity of effects across industries, locations, and dimensions of skill.

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Table 1. Summary Statistics

	2010	2012	2014	Δ2010-2012	Δ2012-2014
<u>Measures of Labor Market Slack</u>					
County Unemployment Rate	9.28 (2.550)	7.80 (2.260)	6.00 (1.800)	-1.48 (0.970)	-1.81 (0.820)
BGT Labor Supply / Demand Ratio	1.95 (1.420)	1.44 (1.160)	1.27 (0.890)	-0.51 (0.790)	-0.17 (0.640)
<u>Employer Education, Experience, and Skill Requirements</u>					
Total Number of Job Posting Ads	266.44 (1149.220)	306.61 (1202.680)	242.25 (845.330)	40.17 (303.440)	-64.51 (454.050)
Share of Job Posting Ads Requesting:					
Any Educational Requirement	42.92 (18.810)	47.46 (19.270)	46.46 (19.830)	4.54 (15.140)	-0.97 (15.570)
An Associate's Degree or Greater	23.29 (22.280)	25.15 (23.400)	23.56 (22.910)	1.86 (10.540)	-1.56 (10.960)
A Bachelor's Degree or Greater	20.16 (21.470)	21.67 (22.490)	20.14 (21.960)	1.51 (9.810)	-1.50 (10.150)
Share of Job Posting Ads Requiring:					
Any Experience	42.69 (18.320)	44.23 (18.510)	40.27 (18.320)	1.55 (14.780)	-3.94 (14.240)
Two or More Years of Experience	29.31 (19.080)	30.39 (19.510)	27.13 (18.610)	1.07 (11.780)	-3.24 (12.010)
Five or More Years of Experience	10.69 (11.810)	11.08 (12.040)	9.68 (11.340)	0.39 (7.670)	-1.38 (7.700)
Share of Job Posting Ads Requiring:					
Any Skills	84.90 (15.060)	88.40 (13.370)	85.40 (15.200)	3.50 (9.240)	-2.99 (10.260)
Baseline Skills	57.66 (22.080)	64.49 (21.400)	63.38 (20.980)	6.82 (13.820)	-1.09 (14.480)
Specialized Skills	78.82 (16.740)	83.70 (15.190)	80.30 (16.710)	4.88 (10.500)	-3.38 (11.150)
Software Skills	18.41 (16.890)	21.30 (17.890)	20.77 (17.300)	2.88 (10.090)	-0.50 (10.540)
Number of Observations	33,421	33,420	33,387	33,420	33,387

Sources: County unemployment rates are as reported by the Bureau of Labor Statistics Local Area Unemployment Statistics program: <http://www.bls.gov/lau/> The BGT Labor Supply/Demand Ratio is calculated using the number of unemployed as reported by the American Community Survey and the number of jobs postings as reported by Burning Glass Technologies (BGT). Employer requirements are also calculated using data from Burning Glass Technologies.

Notes: Means are reported with standard deviations in parentheses below. Observations are county x 3-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. BGT Labor/Supply Demand Ratio is a county-level measure for the average number of unemployed persons per jobs postings as reported by Burning Glass Technologies. This measure is constructed using a methodology established by the the HelpWantedOnline Labor/Supply Demand Index by dividing the number of unemployed persons from the American Community Survey by the average monthly count of job postings for a given year. See the data appendix for further details on variable construction.

Table 2. Changes in Employer Requirements and Labor Market Slack during Recovery, 2010-2014**Panel A: Education Qualifications**

Percentage Point Change in the Share of Postings Requesting:

	Any Education Level (1)	Associate's Degree or Greater (2)	Bachelor's Degree or Greater (3)
Δ County UR	0.419 ** (0.171)	0.251 *** (0.078)	0.203 *** (0.067)
R ²	0.032	0.025	0.023
Number of Observations	66,807	66,807	66,807
Δ BGT Labor Supply/Demand Ratio	1.717 *** (0.240)	0.643 *** (0.123)	0.558 *** (0.105)
R ²	0.038	0.027	0.024
Number of Observations	66,807	66,807	66,807

Panel B: Experience Qualifications

Percentage Point Change in the Share of Postings Requesting:

	Any Experience Level	2 or More Years of Experience	5 or More Years of Experience
Δ County UR	1.183 *** (0.160)	0.674 *** (0.111)	0.223 *** (0.064)
R ²	0.040	0.034	0.014
Number of Observations	66,807	66,807	66,807
Δ BGT Labor Supply/Demand Ratio	1.837 *** (0.216)	1.025 *** (0.142)	0.237 *** (0.066)
R ²	0.043	0.036	0.014
Number of Observations	66,807	66,807	66,807

Source: Authors' analysis using data from Burning Glass Technologies.

Notes: All specifications include a control for differences between the two time periods, 2010-2012 and 2012-2014. See data appendix for the construction of the BGT Supply/Demand Ratio. Sample excludes county/occupation cells with fewer than 15 postings in either period for which the change is measured. Observations are weighted by the occupation's share of each county's total postings. Standard errors (in parentheses) are clustered by county. * p<0.10, ** p<0.05, *** p<0.01.

Table 3. Changes in Employer Requirements and Labor Market Slack During Recovery, Controlling for Occupation Fixed Effects

	P.P. Change in the Share of Postings Requesting: a Bachelor's Degree or Greater				P.P. Change in the Share of Postings Requesting: 5 or More Years of Experience			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ County UR	0.225 *** (0.066)	0.304 *** (0.068)			0.232 *** (0.064)	0.216 *** (0.061)		
Δ BGT Labor Supply/Demand Ratio			0.550 *** (0.105)	0.648 *** (0.108)			0.239 *** (0.066)	0.355 *** (0.065)
Baseline Controls	X	X	X	X	X	X	X	X
Occupation Fixed Effects		X		X		X		X
R ²	0.033	0.118	0.034	0.119	0.016	0.117	0.016	0.118
Number of Observations	66,807	66,807	66,807	66,807	66,807	66,807	66,807	66,807

Source: Authors' analysis using data from Burning Glass Technologies.

Notes: All specifications include a control for differences between the two time periods, 2010-2012 and 2012-2014. See data appendix for the construction of the BGT Supply/Demand Ratio. Baseline controls include the initial (2010) share of postings requiring the skill measured as well as the change in the number of total postings, 2010-2014, as a share of total employment in 2010. Sample excludes county/occupation cells with fewer than 15 postings in either period for which the change is measured. Observations are weighted by the occupation's share of each county's total postings. Standard errors (in parentheses) are clustered by county. * p<0.10, ** p<0.05, *** p<0.01.

Table 4. Changes in Employer Requirements and Labor Market Slack During Recovery, Controlling for State Fixed Effects

	P.P. Change in the Share of Postings Requesting: a Bachelor's Degree or Greater				P.P. Change in the Share of Postings Requesting: 5 or More Years of Experience			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ County UR	0.304 *** (0.068)	0.269 *** (0.091)			0.216 *** (0.061)	0.245 ** (0.089)		
Δ BGT Labor Supply/Demand Ratio			0.648 *** (0.108)	0.525 *** (0.112)			0.355 *** (0.065)	0.279 *** (0.070)
Baseline Controls	X	X	X	X	X	X	X	X
Occupation Fixed Effects	X	X	X	X	X	X	X	X
State Fixed Effects		X		X		X		X
R ²	0.124	0.124	0.119	0.125	0.117	0.121	0.118	0.121
Number of Observations	66,807	66,807	66,807	66,807	66,807	66,807	66,807	66,807

Source: Authors' analysis using data from Burning Glass Technologies.

Notes: All specifications include a control for differences between the two time periods, 2010-2012 and 2012-2014. See data appendix for the construction of the BGT Supply/Demand Ratio. Baseline controls include the initial (2010) share of postings requiring the skill measured as well as the change in the number of total postings, 2010-2014, as a share of total employment in 2010. Sample excludes county/occupation cells with fewer than 15 postings in either period for which the change is measured. Observations are weighted by the occupation's share of each county's total postings. Standard errors (in parentheses) are clustered by county. * p<0.10, ** p<0.05, *** p<0.01.

Table 5. Changes in Employer Requirements and Labor Market Slack During Recovery, Within Firm-Job Title

	Posting Requires a Bachelor's Degree or Greater (1)	Posting Requires 5 or More Years of Experience (3)
Δ County UR	0.0020 ** -0.0010	0.0019 *** -0.0005
Firm-Job Title- County Fixed Effects	X	X
Year Fixed Effects	X	X
R ²	0.910	0.906
Number of Observations	22,492,882	22,492,882

Source: Authors' analysis using data from Burning Glass Technologies.

Notes: All specifications use posting level data from 2010-2014. We limit the data to those with codable firm names and job titles. We further omit unique firm-job title-county pairs as those yield no additional information with these fixed effects. Note that, since the dependant variable is a dummy, all coefficients should be multiplied by 100 to compare with results in other tables. Standard errors (in parentheses) are clustered by county. * p<0.10, ** p<0.05, *** p<0.01.

Table 6. Changes in Employer Requirements and Labor Market Slack During Recovery, By Type of Skills Req

Percentage Point Change in the Share of Postings Requesting:				
	Any Skills	Baseline Skills	Specialized Skills	Software Skills
	(1)	(2)	(3)	(4)
Δ County UR	0.318 ** (0.124)	0.744 *** (0.179)	0.353 ** (0.130)	0.193 * (0.101)
Δ BGT Labor Supply/Demand Ratio	1.004 *** (0.139)	1.867 *** (0.235)	1.099 *** (0.148)	0.583 *** (0.110)
Baseline Controls	X	X	X	X
Occupation Fixed Effects	X	X	X	X
State Fixed Effects	X	X	X	X
Number of Observations	66,807	66,807	66,807	66,807

Source: Authors' analysis using data from Burning Glass Technologies.

Notes: All specifications include a control for differences between the two time periods, 2010-2012 and 2012-2014. See data appendix for the construction of the BGT Supply/Demand Ratio. Baseline controls include the initial (2010) share of postings requiring the skill measured as well as the change in the number of total postings, 2010-2014, as a share of total employment in 2010. Sample excludes county/occupation cells with fewer than 15 postings in either period for which the change is measured. Observations are weighted by the occupation's share of each county's total postings. Standard errors (in parentheses) are clustered by county. * p<0.10, ** p<0.05, *** p<0.01.

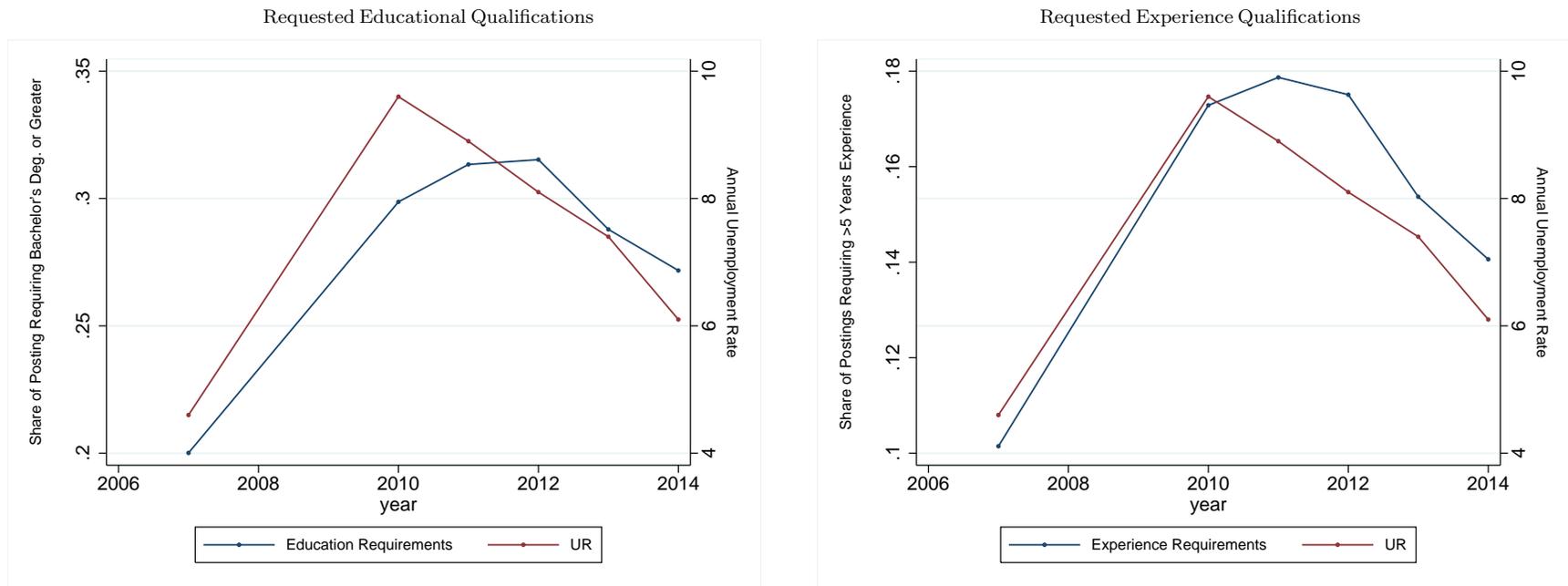
Table 7. Relationship Between Changes in Employer Requirements and Natural Gas Labor Supply Shocks

	P.P. Change in the Share of Postings Requesting:							
	5 Or More Years of Experience	Bachelor's Degree or Greater	5 Or More Years of Experience	Bachelor's Degree or Greater	5 Or More Years of Experience	Bachelor's Degree or Greater	5 Or More Years of Experience	Bachelor's Degree or Greater
	1	2	3	4	5	6	7	8
Gas Production (in Billion Cubic Feet)	-0.000267*** (0.0000267)	-0.000422*** (0.000031)	-0.000419*** (0.0000489)	-0.000713*** (0.0000806)				
Dummy (Δ Gas Prod >50 Billion Cubic Feet)					-0.0928*** (0.029)	-0.213*** (0.0727)		
Unemployment Rate (Instrumented with Gas Prod)							0.111*** (0.0378/0)	0.174*** (0.0622)
First Stage F-Statistic								
Fixed Effect	County	County	Firm-Job Title	Firm-Job Title	County	County	County	County
Observations	1,246,205	1,246,205	1,231,673	1,231,673	1,246,205	1,246,205	1,246,020	1,246,020
R-squared	0.072	0.102	0.921	0.934	0.072	0.101	0.004	-0.006
Number of Counties	2,530	2,530	2,530	2,530	2,530	2,530	2,530	2,530

Sources: Authors' analysis using data on employer requirements from Burning Glass Technologies. County level gas production data from the USDA Economic Research Service. <http://www.ers.usda.gov/data-products/county-level-oil-and-gas-production-in-the-us.aspx>.

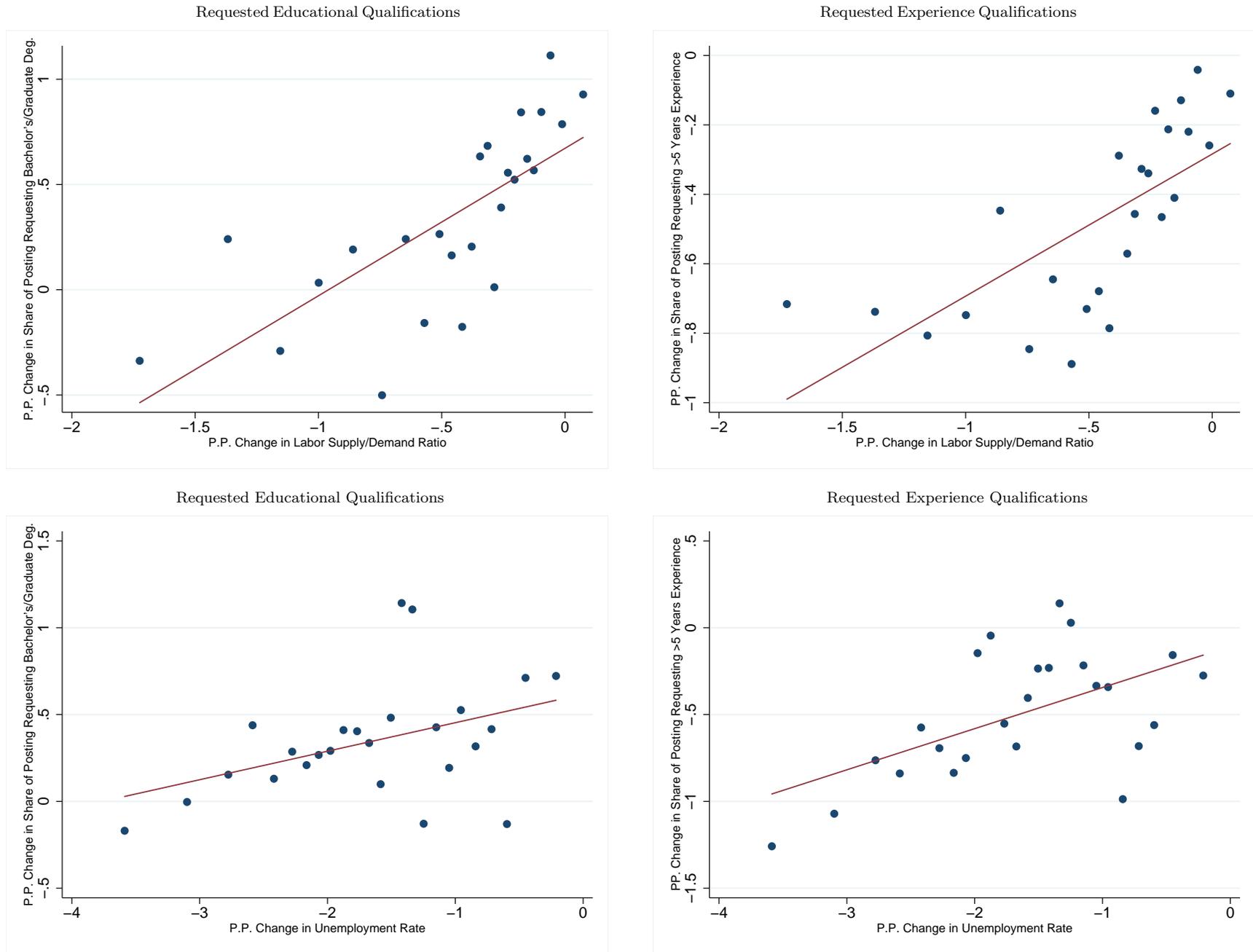
Notes: All specifications control for year dummies (2007 versus 2011). The dummy variable in specifications 3 and 4 takes a value of 0 in all 2007 observations, and 1 in counties whose production rose more than 50 billion cubic feet. We marked the following industries as tradable and non-fracking for this table: NAICS code less than 210000, NAICS codes between 212111-221330 excluding 213111 and 213113, and NAICS codes from 311111 to 339999. Standard errors (in parentheses) are clustered by county.

Figure 1. Relationship between Changes in Employer Requirements and Labor Market Slack



Source: Authors' analysis using data from Burning Glass Technologies, 2007, 2010–2014. Annual unemployment rates are as reported by the Bureau of Labor Statistics.

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

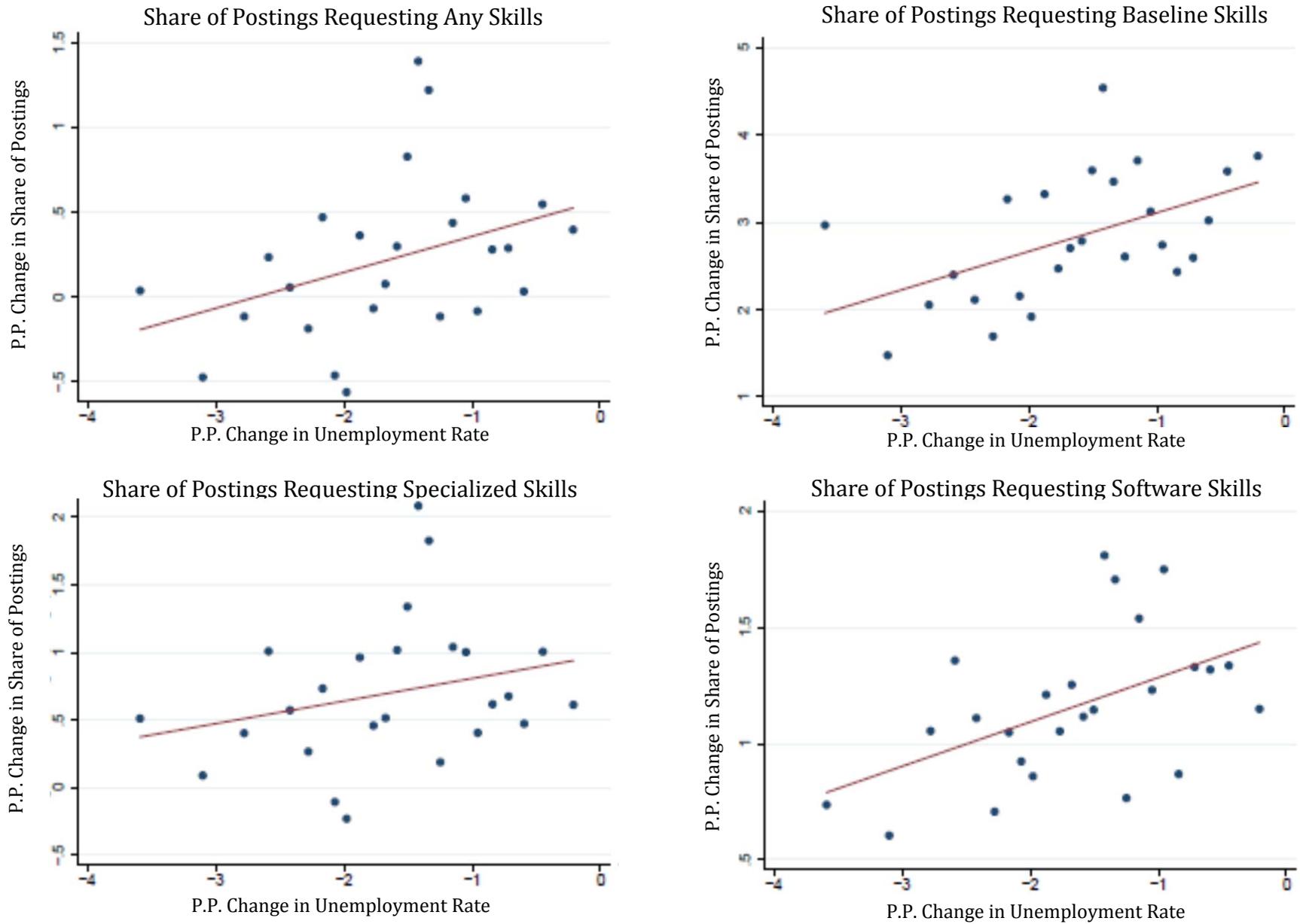


Source: Authors' analysis using data from Burning Glass Technologies, 2010–2014. County level unemployment rates are as reported by the Bureau of Labor Statistics Local Area Unemployment Statistics program.

The Labor Supply/Demand Ratio is the ratio of the number of unemployed as reported by the American Community Survey to the number of postings as reported by Burning Glass Technologies.

Note: Figure is a binned scatter plot (N=100) based on observations of county x 3-digit occupation cells.

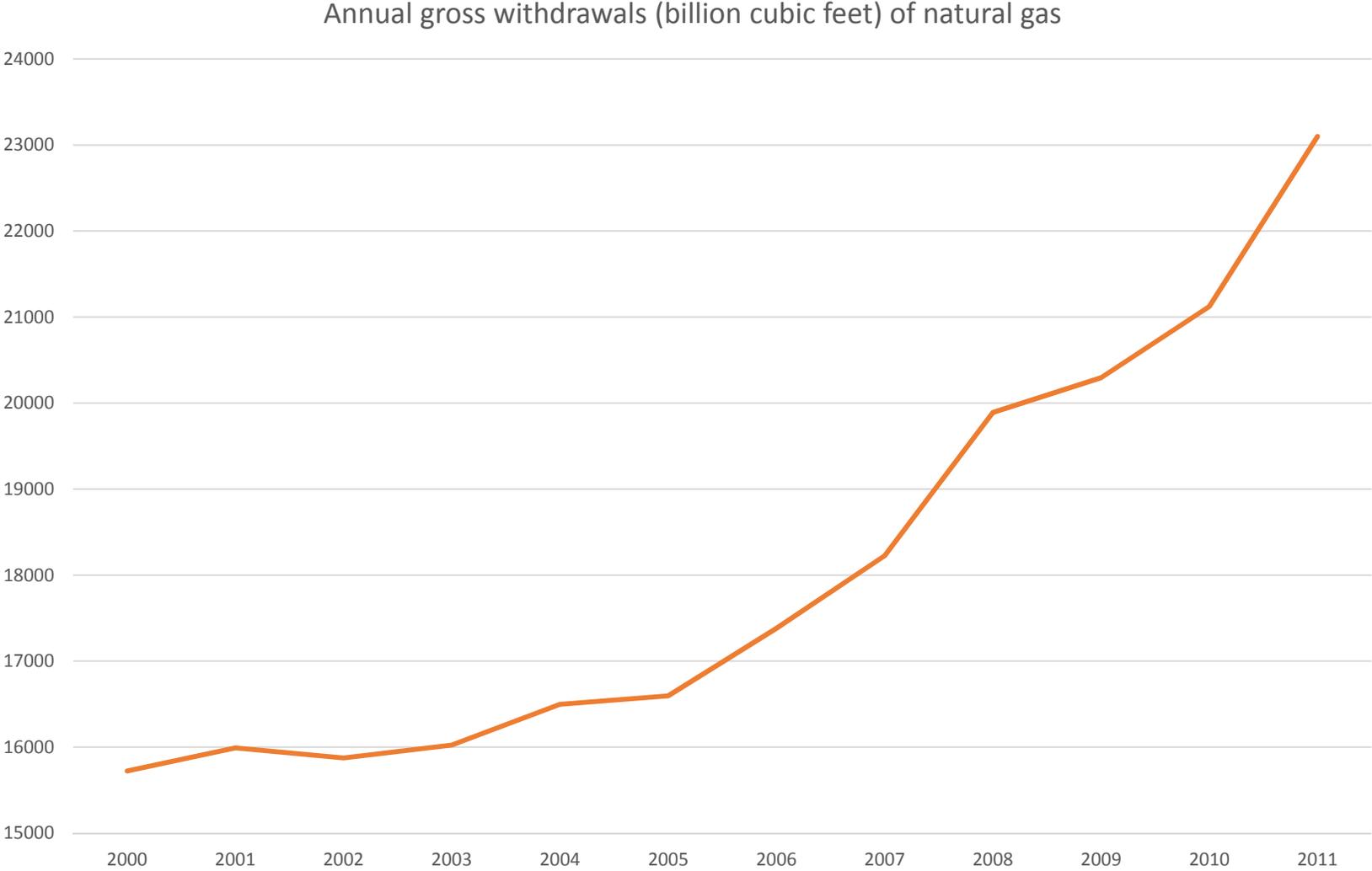
Figure 3. Relationship Between Changes in Employer Skills Requested and Labor Market Slack



Source: Authors' analysis using data from Burning Glass Technologies.

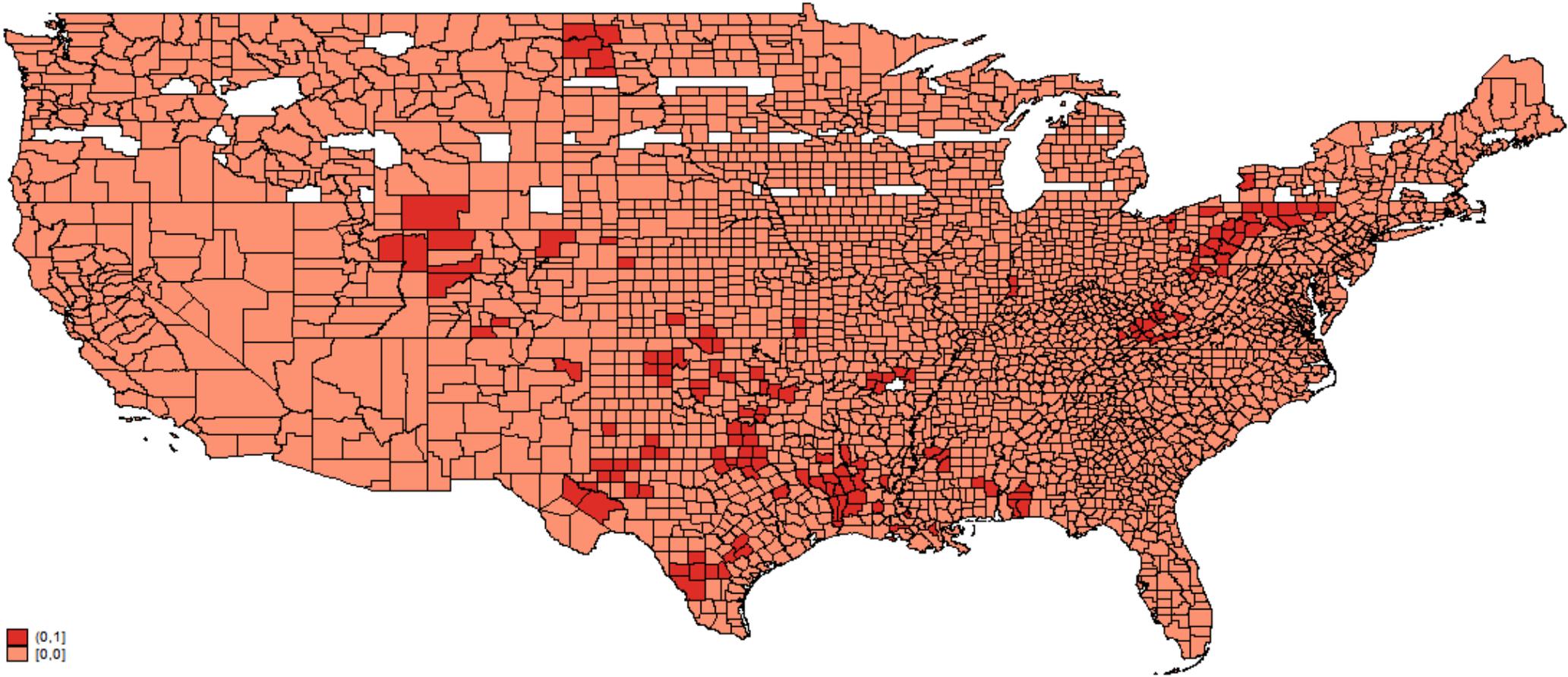
Note: Figure is a binned scatter plot (N=100) based on observations of county x 3-digit occupation cells.

Figure 4. Trend in Natural Gas Production, 200-2011



Source: USDA Economic Research Service. <http://www.ers.usda.gov/data-products/county-level-oil-and-gas-production-in-the-us.aspx>.

Figure 5. County-level Variation in Change in Natural Gas Production, 2007-2011



Note: Darker shading represents counties where natural gas production > 1 billion cubic feet

DATA APPENDIX

I. Dependent Variables

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.

The underlying data are provided by Burning Glass Technologies (BGT), a leading developer in the collection, aggregation, and de-duplication of real-time online job vacancy data. BGT collects 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. 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 and 2010 through 2014. 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.

II. Explanatory Variables

A. County Labor Market Conditions

We assembled several independent variables to capture changes in local labor market conditions. Our primary measure is the county unemployment rate as reported by the Bureau of Labor Statistics.

In addition, we also construct a supply/demand indexes measuring the ratio of the number of unemployed individuals to the number of job postings. The numerator for both measures is constructed from the American Community Survey. The denominator is constructed using the BGT vacancy data.

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.

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: $\ln(75\% \text{ percentile for hourly wages}) - \ln(25\% \text{ percentile for hourly wages})$ Constructed from 2007 data from the Occupational Employment Statistics: <http://www.bls.gov/oes/> .