Local Labor Market Shocks and Employment and Earnings Differentials: Evidence from Shale Oil and Gas Booms.

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Abstract

For decades, labor economics research has focused on explaining earnings differentials. This paper employs a novel approach by exploiting shale oil and gas developments to estimate the impact of a change in labor demand within a specific sector (oil and gas) on specific demographics of workers (male workers with high school education) on economy wide earnings differentials (male/female and college/high school). While earnings increased across the board during the "shale boom," we find that earnings differentials between workers with a high school and college education decreased by 3%, and differentials between men and women increased by 3.7%. We estimate that a 10% increase in high school employment due directly to oil and gas employment is associated with a 7.0% decrease in the college/high school earnings differential. Similarly, we estimate that a 10% increase in male employment due directly to a labor demand shock in mining is associated with a 6.4% increase in the male/female earnings differential. Results suggest that industry specific labor demand shocks for subsets of workers can have relatively large effects for economy wide earnings differentials.

1. Introduction

After many years of declining crude oil production in the United States, recent technological developments have made the extraction of previously economically inaccessible energy resources feasible at prevailing market prices. Specifically, the advent of horizontal drilling and hydraulic fracturing techniques have created historic increases in drilling activity, and therefore oil and gas production, over the past decade. An economic "boom" was created in specific geographic areas with oil and gas rich "shale" geological formations.

This research focuses on how natural resource booms have impacted local labor markets—specifically focusing on employment and earnings differentials between different groups of workers including (1) college/high school education levels, and (2) males/females.[1] Specifically, we examine the impact of shale oil and gas development on labor markets of seven geographic areas, namely: *Bakken, Eagle Ford, Haynesville, Marcellus, Niobrara, Permian* and *Utica.*[2] Figure 1 shows the location of these "shale plays."

1.1. Economic Impact of Oil and Gas Booms

Starting with the advent in of the modern oil industry in 1859, the U.S. experienced consistent year over year increases in oil production for over a century. But in 1970, this age of increasing domestic oil production reached its end and for the first time, production began a period of decline that continued for the next four decades. However, over the last decade, the oil landscape has changed both suddenly and dramatically as illustrated in Figure 2. By 2007, after decades of declining production, a technological breakthrough allowed oil and gas to be extracted from "shale" geological formations; the "shale boom" was underway.[3] Through a combination of horizontal drilling and hydraulic fracturing (informally referred to as "fracking") the U.S. is now experiencing production at levels not seen since "peak oil" of the 1970s. There has been a growing body of work that quantifies the effects of localized natural resource based booms. While this literature began before the specific shale boom of this past decade (Black et al, 2005), this new E*ra of Shale* has created a significant resurgence in this literature.

Recently, Feyrer et al. (2017) finds that the shale boom created significant economic shocks to local labor markets. Every million dollars of oil and gas extracted

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[1] Hereafter we will refer to college educated workers as all workers with a college degree or more. We will refer to high school educated workers as workers with a high school degree or less.

[2] According to EIA, more than 90% of oil production growth as well as all natural gas production growth in the U.S. during 2011-2014 are attributed to these seven regions.

[3] For the main empirical specifications, the shale boom will begin in 2007 consistent with the time that EIA began tracking shale production in its *Drilling Productivity Reports*. We will consider the specific timing of treatment in alternative specifications.

is estimated to generate $243,000 in wages, $117,000 in royalty payments, and 2.49 jobs within a 100-mile radius. In total, the authors estimate that the shale boom was associated with 725,000 jobs in aggregate and a 0.4 percent decrease in the unemployment rate during the Great Recession. Marchand (2012) similarly finds both direct and indirect impacts of the shale boom on employment; for every 10 jobs created in the energy sector, 3 construction, 4.5 retail, and 2 service jobs are created. Agerton et al. (2017) find that one additional rig results in the creation of 31 jobs immediately and 315 jobs in the long-run. Other studies corroborated the positive impact of the shale boom on local labor markets (Weber, 2012; Marchand and Weber, forthcoming, Fleming et al., 2015; Komarek, 2016; Bartik et al., 2017; McCollum & Upton, 2017; Decker et. al 2017).[4] While positive effects associated with the economic activity associated with the drilling and production have been documented extensively, negative effects might also be observed, specifically in the manufacturing sector (see Cosgrove et al. 2015 and Freeman 2009).

In addition, there has been an emerging literature that considers the potential implications of resource booms on a number of other local outcomes. Bartik et al. (2017) finds local governments experience revenue increases that are greater than expenditure increases. Marchand and Weber (2015) focus specifically on Texas and find that some of these increases in revenues were spent on local school districts, in particular on investment in fixed assets (e.g. new school buildings). Fedaseyeu et al. (2015) present evidence that these resource booms can also impact voter behavior, specifically increasing support for conservative policies and Republican political candidates. Cosgrove et al. (2015) and Bartik et al (2017) find evidence of increases in the local political population likely due to temporary migration of workers to these areas.

Finally, there has been interest in how shale booms impact local financial conditions. Gilje (forthcoming) and Gilje et al. (2016) focus on the impact of the shale boom on local banks. Related, Brown (2017) finds evidence that local residents increase both expenditures (that can account for some of the more general economic effects), but also observes increases in consumer debt. Specifically, each well drilled as result of shale boom is associated with an increase in consumer debt od $6,750.

The prior literature has been primarily focused on the impact of the shale boom on some outcome—whether it be in the labor market, financial market, housing markets, etc. But this is the first paper to examine the effects of energy-related shocks on employment and earning differentials between different groups of workers in local

[4] It should be noted that after the oil and natural gas price drop, there is an emerging literature on the "bust" side of the cycle that will likely grow in upcoming years. For instance, Brown (2015) finds that elimination of each active rig eliminates 28 jobs in the first month and this increase to 171 jobs eliminated in the long-run.

economies. While many workers have been shown to benefit from a local natural resource boom, the magnitude of these benefits might vary across subsets of workers. For instance, the mining sector (sectors that includes oil and gas extraction and support for oil and gas activities) is a male dominated industry.[5] Thus, women might be impacted very differently from the emergence of this new source of labor demand than their male counterparts. For this reason, we will consider how aggregate earnings differentials change in shale areas relative to plausible control counties that were not impacted directly by the shale boom. We will pay special attention to earnings differentials within non-mining sectors; we will refer to these as *intra-industry* earnings differentials of non-mining sectors.

Exploiting the plausibly exogenous local labor market shocks associated with the production of oil and natural gas in seven shale plays in the U.S., we estimate the impact of oil and gas booms on local labor markets.[6] By comparing the counties within the seven "shale" regions to non-shale counties, we analyze how the booms affect employment and earnings in local economies and whether the booms affect the employment and earnings differentials between college educated (or more) and high school educated (or less) and male and female works.

1.2. Earnings Differentials

For decades, earnings inequality has been a major focus of the labor economics literature, both focusing on differentials across the income spectrum (Mincer, 1970; Maddison, 1987; Levy & Murnane, 1992; Katz, 1999; to name a few), as well as male and female differentials (Blau & Kaun, 2017; Goldin, 2014; O'Neill, 2003; Gunderson, 1989). Economy wide earnings inequality and inequality between men and women, though, have experienced very different trends and have been impacted by very different factors over the past century in the United States.

Levy & Murnane (1992) describe five district time periods of changes in economy wide income inequality. First, between the Civil War and World War I (WWI), earnings inequality was both high relative to modern day standards and was relatively stable. After WWI, the U.S. entered into a period of rapidly declining inequality. But this period of declining inequality was temporary, and by the beginning of the Great Depression (starting in 1929), earnings inequality was back to pre-WWI levels

[5] Nationally, there are more than 5 men are employed in the mining sector for every woman. Source: QWI average employment by sex from Q1 2000 until Q2 2016.

[6] Recently, EIA has made changes to it's drilling productivity reports, which we use to define these shale plays. Specifically, the Marcellus and Utica basins have been combined into the Appalachian basin. Also, the Anadarko basin has been added. We will consider the definitions during the time of running this analysis—early to mid 2017—that does not include Anadarko and includes Marcellus and Utica separately.

(Williamson & Lindert 1980). The onset of the Great Depression again caused a break in trend, and the U.S. entered into the third distinct period that has been called a "golden age"; a 20-year period of sharply declining earnings inequality. This golden age lasted through World War II. But then in the early 1950s, the trend of declining inequality ended and for the next three decades inequality rose slightly. The final (and fifth) distinct period began in the 1980s, as the economy moved from a period of relatively stable and modest increases in earnings inequality to a time of rapid increase. This increase in income inequality has persisted to the present day (Attanasio, Hurst & Pistaferri, 2012).

But earnings differentials between men and women have experience a very different history. Unlike earnings differentials across the income spectrum that have been generally increasing for decades, men and women have experienced a significant convergence in earnings. In fact, the converging roles of men and women over the past century has been called the "Grand Gender Convergence" (Goldin 2014). While differences in pay for men and women still persist today, typically at least two-thirds of this differential can be explained due to combined factors such as occupation differences (Blau & Kahn 2017), career interruptions and hours worked per week (Bertrand, Goldin & Katz 2010), inter-firm mobility (Bono & Vuri 2011), among others. Residuals in earnings differentials that cannot be explained by these factors are typically then attributed to psychological attributes, unobservable noncognitive skills and/or discrimination (Blau & Kahn, 2017; Manning & Swaffield, 2008; Wood et al., 1993). Thus, while earnings differentials between men and women still persist today, the trend has been in stark contrast to economy wide-earnings inequality.

While the goal of this research is not to explain broadly the contributing factors to differences in earnings, we will contribute to this literature by understanding specifically how a labor demand shock to a specific subset of workers might impact economy wide earnings differentials. Using a very specific labor demand shock to male and blue collar dominated industry, we provide novel estimates of the impact of a labor demand shock on earnings differentials between males/females and workers with college/high school educations.[7] We argue that the shale boom creates a unique opportunity to study earnings differentials for three reasons.

First, labor market shocks during the shale boom originated from an initial labor demand shock. Studying long-run trends in earnings differentials across decades is informative for understanding a history of differences, but it becomes difficult to tease

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[7] As previously mentioned. throughout this research we refer to the college/high school employment and earnings differentials. Specifically, we define "college" as all workers with a college degree or more. We define "high school" as all workers with a high school diploma or less.

out the mechanism for why these changes occurred over time. For instance, in the years after both WWI and WWII, the U.S. experienced declines in economy wide earning inequality (Levy & Murnane, 1992). But during these times, there were a number of both labor supply and labor demand shocks that could have contributed. For instance, men were returning from war and re-entering the private sector labor market. Women might have substituted into or out of the labor market associated with husbands returning from war. Simultaneously, families were choosing to have children, driving demand for a broad range of goods and services. Thus, while we can document changes in earnings differentials between men/women and workers with college/high school educations, it is less clear the causal impact of each factor on these differentials.

Second, the labor demand shocks that occurred due to the shale boom overwhelmingly impacted one demographic of workers, male workers with a high school education.[8] Therefore, we can estimate the impact of a labor demand shock to a specific demographic of workers to earnings differentials in non-oil and gas related sectors. This is the first of this type of empirical estimate for which we are aware within the literature.

Finally, these labor demand shocks associated with the shale boom are conveniently concentrated in very specific geographic areas that happened to have geological formations thousands of feet below the earth's surface. And the timing of these shocks all coincided with technological advancements that allowed for extraction from these formations. Thus, it allows researchers to identify the areas that received the labor demand shock, and still have access to plausible control areas that are similar along pre-treatment characteristics that were not directly impacted by the shale boom due to their lack of specific geological features largely unknown to the residents of the areas.

Thus, we exploit a plausibly exogenous labor demand shock to a specific demographic of workers that was restricted to specific geographic areas for which the timing is well understood to estimate earnings differentials elasticities with respect to changes in direct employment. More specifically, we will estimate the sensitivity of male/female earnings differentials to a change in male oil and gas employment. Similarly, we will estimate the sensitivity of college/high school earnings differentials to a change in high school oil and gas employment. While the generalizability of these elasticity estimates to other contexts will be discussed, we present the first such

[8] Of course, many female workers and workers with college degrees are employed by the up-stream oil and gas sector, but these jobs are primarily office positions in larger cities such as Houston or Oklahoma City, where these companies' headquarters are located. The areas of interest in this study are the areas where the hydrocarbons themselves are actually extracted. And as well be shown, these jobs primarily when to male workers without a college education.

parameter estimates for which we are aware.

Specifically, we estimate that a 10% increase in direct employment of workers with a high school diploma or less induced by a labor demand shock leads to a 7.4% decrease in the college/high school earnings differential in the overall economy. A 10% increase in male employment induced by a labor demand shock leads to a 6.4% increase in the male/female earnings differentials in the overall economy. These effects are both statistically and economically significant.

We also estimate that approximately 85% of the change in earnings differentials comes about due to changes in intra-industry earnings differentials in non-oil and gas related fields. In other words, only about 15% of the estimated change in earnings differentials induced by the shale boom come from increases in earnings in the oil and gas sector and/or workers substituting to the high paying sector. Thus, these results show that labor demand shocks to specific subsets of workers can have significant impacts on earnings differentials within other seemingly unrelated industries.

2. Factors Explaining Earnings Differentials

We continue by decomposing earnings differentials between two groups into (a) the relative employment levels across industries and (b) the earnings differentials within these industries as illustrated in Equation (1). In this example, we consider college (c) and high school (hs) education earnings differentials. Thus, N_i and N are total employment in industry i and the whole economy, respectively. same framework will also be applied to male and female workers.

$$\frac{e_c}{e_{hs}} = \sum_i \frac{N_i}{N} \frac{e_{c,i}}{e_{hs,i}} \qquad (1)$$

Where $e_{c,i}$ and $e_{hs,i}$ are the earnings of workers with a college degree and high school diploma, respectively in industry i. When considering the labor market shocks associated with shale oil and gas extraction, we can consider two aggregated industries—oil and gas extraction and all non-oil and gas extraction industries. Thus, we can re-write equation (1) as:

$$\frac{e_c}{e_{hs}} = \frac{N_{oil}}{N} \frac{e_{c,oil}}{e_{hs,oil}} + \frac{N_{other}}{N} \frac{e_{c,other}}{e_{hs,other}} \qquad (2)$$

where N_{oil} and e_{oil} are employment and earnings in the oil and gas extraction sector respectively and N_{other} and e_{other} are, similarly, employment and earnings in all other (non-oil and gas extraction) sectors. From looking at equation (2), we will focus on two potential sources of changes in earnings differentials.

First, a change in the earnings differential can come from a change in the composition of workers within the economy within the oil and gas sector, $\frac{N_{oil}}{N}$ (and thus by extension $\frac{N_{other}}{N} = 1 - \frac{N_{oil}}{N}$). Thus, if more workers substitute into the oil and gas sector, and this sector has larger earnings differentials than other sectors, this can cause an increase in the economy wide earnings differential.

But also, a change in economy wide earnings differentials can come from a change in the earnings differentials either within the oil and gas sector and/or the non-mining (other) sectors. Thus if $\frac{e_{c,oil}}{e_{hs,oil}}$ and/or $\frac{e_{c,other}}{e_{hs,other}}$ change, these too can lead to changes in the aggregate earnings differentials. We will refer to changes in these as *intra-industry earnings differentials*, as these are earnings differentials that come about via changes in earnings differentials *within* specific sectors (in contrast to differences in earnings across sectors).

Thus, we introduce two factors that might be impacted by a shale oil and gas shock that can impact economy-wide earnings differentials. First, a change in the relative size of the mining and non-mining industries. Second, the earnings differentials *within* these respective industries, i.e. intra-industry earnings differentials.

3. Hypotheses

Next, we proceed by discussing what a basic labor market model would predict for earnings, employment, and earnings differentials given the shale boom.

3.1. Male/Female Differentials

First, we consider how the shale boom might impact earnings of male and females differently. Consider the following anecdotal, and albeit stereotypical, example. Consider James and Jenna who both work at a chain sit-down restaurant. James is a "bus boy" whose job is to clean tables after customers have finished their meals. Bus boys, by the very name, are primarily males. Jenna, on the other hand, also has a job at earning the same amount at the same restaurant. But instead of bussing tables, Jenna is a hostess who greets customers and sits them at their table upon arrival. As a corollary to the bus boy, hostesses are primarily females.

If jobs in the mining sector are primarily available to male workers (or males more heavily select into these jobs) then the market for bus boys might experience a leftward shift in labor supply as male workers substitute away from bussing tables to higher paying jobs in the oil field. But female workers in the restaurant industry do not experience this shift in labor supply.

But, on the demand side, the restaurant industry will experience an increase in business associated with the economic boom. Thus, the market for both bus boys and hostesses will experience a rightward shift in labor demand induced by the mining workers' increase in employment and earnings associated with the boom.[9]

This very simply labor supply and demand model yields the following predictions. First, while both male and female workers will experience increases in earnings in the non-mining (restaurant in this example) industries, the model predicts that male workers will experience a *larger* increase. Thus, the earnings differential between male and female workers might increase within the non-mining industries. Second, while we expect for female employment to increase in the restaurant industry, the change in male employment within this industry is ambiguous as it will be determined by the relative magnitude of the labor supply and labor demand shifts (these are drawn to perfectly offset one another in Figure 3). Third, the composition of males and females within the restaurant industry itself might also change. Potentially, we start seeing more female bus boys as young males are increasingly difficult to find.[10] This will create a change in the employment differential in the non-mining industries.

3.1. College/High School Differentials

A similar thought experiment can be conducted for college/high school earnings differentials, also illustrated in Figure 3. Consider two workers; a blue-collar worker with a high school degree and a white-collar worker with a college degree. For this stereotypical and anecdotal example, we will consider workers at a car dealership; the white-collar worker being a car salesman and the blue-collar worker being a mechanic.

The shale boom will create a significant source of labor demand for blue collar workers, as workers will be needed to work the rigs and as part of the "fracking crews". While some white-collar jobs might be created locally, anecdotal evidence suggest (and results of this research will corroborate) that workers with a high school diploma or less experienced the lion's share of localized increases in employment in the mining industries during the shale boom.

So again, a leftward labor supply shock will occur for the blue-collar workers within the non-mining industry. Simultaneously, though, labor demand will increase at the car dealership, as more people are purchasing and maintaining vehicles. Thus, our prediction for blue collar (workers with a high school diploma) and white collar (workers with a college degree) earnings and employment differentials are parallel to the predictions made for male/female differentials. We hypothesize that earnings

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[9] Local landowners receiving royalty payments will also stimulate demand for the restaurant industry. This will be discussed in more detail below.

[10] We should note that this market might also be impacted by household level joint labor market decisions. The obvious example in this scenario might be that the male (husband) receives a significant increase in earnings in the oil and gas sector and therefore the female (his wife) decides to exit the labor force. While this very well might be the case, we would expect for this to further exacerbate the male/female earnings and employment differentials presented above.

differentials between white collar and blue collar workers will decrease in non-mining industries.

4. Data

Data on employment and earnings are from the Quarterly Workforce Indicator (QWI). QWI contains information on county level average employment and earnings by county. We utilize a quarterly panel from the first quarter of 2001 until the fourth quarter of 2013.[11]

In order to mitigate potential concerns of spillovers, we do not include counties that are in geographic proximity to counties with shale oil and gas extraction as potential control counties. Specifically, we remove all counties in shale states, but that themselves do not have shale oil and gas resources. In addition, states that directly border counties with shale activity are removed from the potential control group.[12] Thus, control groups will be chosen from non-shale counties in states that did not experience shale activity. More specifics on the creation of the control group will be provided below.

The data on number of active rigs and total production of oil and gas for each county are from the 2016 EIA Drilling Productivity Report (DPR). Consistent with when EIA's DPR began tracking shale production and rig counts, we consider 2007 the "treatment" date. The price of crude oil and natural gas used for calculating the value of total production are WTI crude oil spot price and Henry Hub natural gas spot price collected from EIA.[13]

Table 1 and Figure 4 show the labor market characteristics in the counties with shale oil and/or gas activity compared to the propensity score matched control group. Visual inspection of Figure 4 reveals that employment increases in shale areas is not obvious without further analysis. But, on the other hand, a clear increase in earnings can be observed relative to the control group. Similarly, earnings in shale counties grew faster for all subsets of workers relative to control groups over this time period.

Table 1 shows the change in employment and earnings for the treated (shale) counties and the propensity score matched control counties.[14] We present employment

[11] Ninety percent of the states (and approximately 90 percent of employment) has data availability starting in the year 2001 or earlier. States for which data availability began post 2001 are not included. These states include the District of Columbia, Arizona, Mississippi, New Hampshire, Arkansas, Massachusetts. The fourth quarter of 2013 was the most recent consistently available quarter at the time of running the analysis (data pulled in mid-2017). While some states do have more recent data, we used this cutoff in order to preserve a balanced panel and also be able to include the states above.

[12] After applying these decision rules, control counties are pulled from the following 20 states: AL, AZ, CA, CT, DE, FL, GA, HI, ID, IL, IN, IA, ME, MI, MN, MS, MO, NV, NH, NJ, NC, OK, OR, RI, SC, TN, VT, WA, and WI.

[13] EIA reports monthly prices. We utilize the average by quarter to match the quarterly QWI data.

[14] See Appendix Tables A1 and A2 for more detailed summary statistics including standard deviations and

and earnings in the pre-shale (2001 to 2006) and post shale (2007 to 2013) time periods. In the control counties, overall employment actually decreased by an average of 3.3 percent. This is unsurprising as the Great Recession of 2009 coincided with the time period of the shale boom. In the shale counties, though, employment remained relatively flat, changing by less than ½ percent. Earnings, on the other hand, increased in the control areas by about 18 percent in nominal dollars between the pre-and-post 2007 time periods, while earnings in shale areas increased by an even larger 28 percent. Thus, earnings growth in shale areas outpaced non-shale area earnings growth by about 10 percentage points.

Table 1 also breaks down these relative changes by demographic of workers. We point out two notable items. First, the relative employment and earnings growth is largest for workers with a high school diploma or lower and male workers. More specifically, male workers and workers with a high school diploma or less experienced a 5.7-percentage point faster increase in employment and a 13-percentage point faster increase in earnings relative to control groups. Second, while relative changes in employment are modest for some groups of workers (for instance, college employment actually decreased by less than ½ percent in shale areas relative to control areas), we find relatively large increases in earnings across all demographics of workers in shale areas. This is consistent with the basic economic theory presented above. In fact, even female workers with a college degree—the group least likely effected directly by the shale boom—experienced a 4-percentage point increase in earnings relative to control areas.

5. Empirical Specification

5.1. Differences-in-differences

We utilize a difference-in-differences approach to test for the impact of shale oil and gas booms on local labor markets. Specifically, we consider the following specification:

$$Y_{i,t} = \beta_0 + \beta_1 Shale_C + \beta_2 Shale_T + \beta_3 (Shale_C * Shale_T) + \beta_2 \Omega_{i,t} + \varepsilon_{i,t} \quad (1)$$

where $Y_{i,t}$ is the outcome of interest, either employment or earnings, in county i and quarter t. We will consider employment and earnings of workers across sectors, education level, gender, and seven shale plays across the U.S. $Shale_C$ is an indicator equal to 1 if county i is a county which locates within one of the seven key shale regions; otherwise $Shale_C$ equals to 0. Similarly, $Shale_T$ is a dummy variable indicating whether time t is prior or post to the shale boom. For purposes of the main

observations, and summary statistics aggregated over the entire sample time period.

specifications, and for simplicity of interpreting the coefficient estimates, the shale boom begins in 2007 and continue until the end of the sample period (Q4 of 2013). $\Omega_{i,t}$ is a vector of controls including year, quarter, and county fixed effects that will be included in all regressions. Thus, β_3 is our parameter of interest which shows the estimated impact of the shale booms on various outcomes of our interest.

When using the difference-in-difference approach, it is important to find appropriate counterfactual county for each boom county. We utilize propensity score matching to identify a control group of counties whose demographic characteristics are similar to the boom counties in the pre-boom time. In particular, we select the counties that are similar to the treated counties in employment counts, aggregate earnings, share of workers with a college degree, and the share of white workers in the county pre-2007.

Next, in order to take into account differential timing and size of the shock across regions, we will scale the treatment effect by total rig counts in operation and estimated value of oil and gas production. This will provide a generalized parameter estimate on a per rig count and per value of production that will allow for comparison to other studies in the literature and for purposes of predicting impacts of future oil and gas booms. Finally, we will show that results are robust to alternative choice of control groups and placebo tests.

5.2. Instrumental Variables

Next, utilizing an instrumental variable estimation strategy, we will construct an estimate of the impact of a direct labor demand shock to both males and workers with a high school education on aggregate labor market earnings differentials. In other words, we ask the following questions. *If a labor demand shock increases male employment by 10 percent, what is the economy wide impact on male female earnings differentials?* A corollary question is asked for a labor demand shock for workers with a high school education on college/high school earnings differentials. This will provide an elasticity estimate of the sensitivity of economy wide earnings differentials based on a percent increase in employment induced by the oil and gas mining sector. Per Section 2 above, we hypothesize that $\varepsilon_{c,hs} < 0$ and $\varepsilon_{m,f} > 0$.

Specifically, Equations (2) and (3) describe the percent change in the college/high school and male/female earnings differentials associated with a change in direct employment increase associated with the shale boom; $\varepsilon_{c,hs}$ and $\varepsilon_{m,f}$.

$$\frac{\Delta ln\left(\frac{e_c}{e_{h.s.}}\right)}{\%\Delta e_{h.s.}} = \varepsilon_{c,hs} \qquad (2)$$

$$\frac{\Delta ln\left(\frac{e_m}{e_f}\right)}{\%\Delta e_m} = \varepsilon_{m,f} \qquad (3)$$

We will estimate $\varepsilon_{c,hs}$ and $\varepsilon_{m,f}$ using an instrumental variable approach. Equation (4) presents the first stage equation that will be estimated. $H.S.Mining\ Emp_{i,t}$ is mining employment of high school workers in quarter t and county i and $\overline{Pre\ Shale\ H.S.Emp_\iota}$ is the average employment level of high school workers in the pre-shale time period. We use high school mining as a share of pre-shale high school employment for two reasons. First, the empirical estimate of interest is the impact of a mining industry specific labor demand shock on aggregate earnings differentials. Thus, we index to pre-shale high school employment to allow for interpretation.[15]

But more importantly, and as discussed in Section 2 above, high school employment might increase in non-shale industries due to indirect and induced economic impacts of the oil and gas boom (and as have been extensively document in a number of papers above). Thus, we are interested in isolating the impact of rig counts on high school mining employment indexed to pre-shale high school employment that cannot be impacted through another channel associated with the shale boom.

$Rig_{s,t}$ is the rig counts is rig counts for the shale boom associated with each county.[16]

$$\boldsymbol{First\ Stage}: \quad \frac{H.S.Mining\ Emp_{i,t}}{\overline{Pre\ Shale\ H.S.Emp_\iota}} = \alpha + \beta_1 Rig_{s,t} + \ \beta_2 \Omega_{i,t} + \varepsilon_{i,t} \qquad (4)$$

Equation (5) presents the second stage where we test the impact of the predicted H.S. mining employment as a share of pre-shale employment on earnings differentials. Where γ is the coefficient of estimate that is comparable to $\varepsilon_{c,hs}$ from Equation (2) above.

$$\boldsymbol{Second\ Stage}: \quad ln\left(\frac{e_c}{e_{h.s.}}\right) = \gamma \frac{\widehat{H.S.Mining\ Emp_{\iota,t}}}{\overline{Pre\ Shale\ H.S.Emp_\iota}} + \ \beta_2 \Omega_{i,t} + \varepsilon_{i,t} \qquad (5)$$

Corollary estimates, of course, are presented for the impact of male mining employment shocks on male/female earnings differentials, where γ provides an alterative estimate of $\varepsilon_{m,f}$ in Equation (3) above.

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[15] Results are robust to choosing ln (male employment) and ln(male mining employment), but the specification presented above allows for coefficient estimates to be interpreted intuitively.

[16] It should be noted that rig counts do not vary across counties within a play, but instead vary across plays. Much consideration has been given to this point. Because rig counts in one county can impact employment in adjacent counties, as documented in Feyrer et al. (2017), we consider the shale play as a whole as inducing the shock overall to counties within the play.

The identifying assumption of this IV strategy is that the shale boom does not impact *earnings differentials* through a channel other than the shock to mining employment. While it is not possible to test the instrument exogeneity assumption in this context, we can discuss potential threats to this assumption and readers can assess for themselves the plausibility of the assumption.

There are two channels through which the shale boom can impact the labor market other than the direct labor demand shock to the mining industry. The first channel is through the multiplier (i.e. indirect and induced) effects of the oil and gas operations on the local economy; Marchand (2012) finds that for every 10 jobs create in the energy sector, 3 construction, 4.5 retail, and 2 service jobs are created. This is a threat to identification if these indirect and induced effects are also asymmetrically borne by male workers with a high school education. If this is the case, then our IV estimate will over-estimate the elasticity of economy wide earnings differentials on direct employment.

The second channel through which the shale boom can impact local labor markets is through royalty payments received by local land owners. When an oil and gas company wants to drill, they will pay bonus payments (at the time of a lease being signed) and royalty payments (for the value of the oil and gas extracted) to local landowners. These local residents might then spend these dollars in the local economy, thus also stimulating economic activity. Similarly, for this to be a threat to our identification, these "induced" economic effects must impact the earnings *differentials* between men/women and/or college/high school education levels.

6. Results

6.1. Employment and Earnings

Table 2 shows the estimated increase in employment and earnings by aggregated industry groups; total, mining and non-mining. For total earnings, we presented two estimates. First, we show an estimated impact using the largest balanced panel of counties available in QWI. But when we subset by industry, some counties become censored in the data. This is particularly problematic for our specification, as we do not want to include or exclude a county-quarter observation because is just above or just below the censorship threshold. For this reason, we next present the "small sample" that only includes all counties in the shale areas for which mining employment and earnings data was available throughout the entire sample time period.

In aggregate, we estimate that employment increased by an average of 588 workers in shale counties relative to non-shale counties. Comparing this to the pre-shale average employment in Table 1 (29,731), this yields an estimated treatment effect of about 2 percent. The estimated treatment effect for earnings is $250 in the full sample, and $239 in the small sample, or about a 12 percent increase relative to pre-shale levels.

We find that mining employment increased by 304 workers, and this result is statistically significant at p=.01. While this is only about 1 percent of total employment, this is about a 38.6 percent increase above pre-shale mining employment. We estimate a non-mining employment treatment effect that is larger in absolute value, 438 workers, but is not statistically significant and is relatively smaller share of total non-mining employment; or also about 1 percent increase above pre-shale non-mining employment.

For workers with a college degree or higher, we estimate that employment increased by 30 workers in the mining sector, but no statistically significant effect in the full sample or non-mining sample. On the other hand, earnings of workers with a college degree increased by about $280 per month for the entire sample, with workers in the mining sector experiencing a relatively large $709 per month increase, while non-mining workers experienced a relatively smaller $193 per month. All estimated treatment effects for earnings for workers with a college degree or higher are statistically significant at p=.01, and also economically significant.

Workers with a high school diploma or less experienced increases in employment, but these are driven primarily by the mining sector. Interestingly, in counties with mining employment disclosed throughout the entire sample time period, we estimate that all of the increase in employment is driven by the mining sector. But, including the larger sample of counties, we find that overall employment increased by 429 workers, or about 4 percent of pre-treatment levels. This provides evidence of spillovers into counties that are geographically in proximity to these plays, but that historically have not had significant mining employment.

Again, in contrast to employment, we find that earnings increased for workers across industries with a high school diploma or less. Total earnings increases ranged from $251 (small sample) to $261 (full sample) per month, and were largest for workers in the mining sector who experienced a $626 increase in earnings per month.

Next, Table 2 breaks out results by male and female workers. Male workers experienced increases in employment across all sectors, while we do not find evidence of changes in female employment. But earnings increased for both male and female workers, with earnings increases being larger for males in all four regressions.

6.2. Employment and Earnings Differentials

Table 3 shows results for the estimate effect on employment differentials. Instead of estimating a treatment effect on total employment and earnings (in employment counts and dollars) as show in Table 2, we now consider the log difference in employment and earnings for each respective group across industries.

We find that college (+) / high school (-) employment differentials decreased by about 5.6% in the full sample, and 3.1% in the small sample. These employment differentials decreases were found in both the mining (4.1%) and non-mining (2.8%) industries. For earnings differentials, we estimate a 3% decrease (in both the large and small sample), but this is driven almost entirely by the non-mining sector, for which we estimate a 2.6% decrease. While the point estimate for the mining sector is also negative (2.3%), it is not statistically significant.

We find a similar result for male/female employment and earnings differentials. Employment differentials increased by 3.5 to 3.7%. Point estimates for the mining and non-mining industries are similar (at about 2%) but are weakly significant or statistically insignificant. Earnings differentials, between male and female workers increased by 3.6 to 3.7%, and are driven almost entirely by an increase in the non-mining earnings differentials. Thus, two important conclusions are reached here. First, that male female earnings differentials changed not only due to a movement of male workers into the high paying mining industry, but also due to changes in earnings differentials within non-mining industries. Thus, we estimate that a male worker in a non-mining industry experienced a 2.9% increase in earnings relative to his female counterpart, while total economy wide earnings differentials increased by about 3.6%.

To put this result into perspective, we can estimate the relative contribution of the change in earnings differentials due to (a) changes in earnings differentials within non-mining industries and (b) substitution of workers into the high paying mining industry.

For college high school earnings differentials, we estimate that of the 3% increase in earnings differentials 2.548% of this increase is associated with changing intra-industry earnings differentials within non-mining sectors, while only the remaining .452 percent is associated directly with the mining industry itself.[17]

We complete a similar calculation for male/female earnings differentials. We estimate that of the 3.6% increase in earnings differentials, 2.842% is associated with changing intra-industry earnings differentials within the non-mining industries.[18]

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[17] $3\% = 2.6\% \times 98\% + Y\% \Rightarrow .452\%$ where the non-mining sectors makes up 98% of the pre-shale employment, and mining sectors account for the remaining 2% (From Table 1). The economy wide estimated shale induced earnings differential is 3% (From Table 3) and the non-mining earnings differential is 2%. Solving for Y (the change economy wide earnings differentials associated with the mining sector itself), we find: .452 percent associated with substitution across sectors; 2.548 percent associated with change in non-shale sectors

[18] $3.6\% = 2.9\% \times 98\% + Y\% \Rightarrow .758\%$ where the non-mining sectors makes up 98% of the pre-shale employment, and mining sectors account for the remaining 2% (From Table 1). The economy wide estimated shale induced earnings differential is 3.6% (From Table 3) and the non-mining earnings differential is 2.9%. Solving for Y (the change economy wide earnings differentials associated with the mining sector itself), we find: .758 percent associated with substitution across sectors; 2.842 percent associated with change in non-shale sectors

Thus 85% and 80% of the earnings differentials observed between college/high school workers and male/female workers can be explained by changes in intra-industry earnings differentials within non-mining industries. This puts into the perspective the importance labor demand shocks for specific subsets of workers on earnings differentials for workers in non-related industries.

Finally, Table 3 breaks down results by male/female earnings differentials by education level. Economy wide male/female employment differential changes are largest for workers with a college degree or more (3.4 percent vs 2.8 percent for college or less), while earnings differentials are largest for workers with a high school diploma or less (2.9 percent vs 3.7 percent).

6.3. Indexing Results to Rig Count and Value of Production

Tables 4 and 5 index results to both rig counts and estimated value of oil and gas production. We do this, as there are two direct channels through which an oil and gas boom can stimulate the local economy. First, economic activity is stimulated because local landowners receive bonus and royalty checks for oil and gas production that occurs beneath their land. A bonus check is given to the landowner at the time that a lease is signed as a lump sum payment. But also, once production begins landowners receive royalty payments that is some shale of the value of the oil and gas produced.[19] These royalty payments might only continue for a short time if the well is relatively unsuccessful, or can continue for years and decades as the well continues along its long tail of production. Thus, when local residents receive, sometimes large, payments this can stimulate the local economy through spending.

The second direct channel through which oil and gas operations can stimulate a local economy is through the drilling activities themselves. In the case of the shale plays, the operator typically contracts out a service company to both drill the well and complete the hydraulic fracturing needed to stimulate the well to begin production. These workers will earn income directly, and then will spend some share of these earnings in the local economy.

Thus, policy makers interested in understanding likely labor market implications of an oil and gas boom can scale the size of the shock to two benchmarks; rigs and value of production. Rig counts are a measurement of the current drilling activity, and value of production is an indicator of the amount of royalties going to landowners. It should be noted that these results do not intend to disentangle these two effects from one

[19] The landowner for which the actual well is drilled also typically receives a “rental” payment that is the value of renting that land to the company for production. Most landowners, though, receive a bonus and royalty payment even though there is no actual drilling activity physically on their land.

another, nor is it to describe the channel through which these effects occur. The specific channel driving employment differentials will be discussed below in the IV empirical results. Instead, these are meant to scale these effects such that they can be used to estimate impacts of a different oil and gas play not included in this analysis and provide for comparison to other estimates.

Tables 4 and 5 show results on earnings differentials indexed to rig counts and value of production respectively. Table 4 shows that for every 100 rig counts, we estimate a 2.6% and 1.7% decrease in the employment and earnings differential respectively between college or more and high school or less. For every 100 rig counts, we estimate a 2.6% and 1.5% increase in employment and earnings differentials between male and female workers.

Similarly, Table 5 shows results for value of production. For every hundred million dollars of production, we estimate an 8.54% and 5.39% decrease in the employment and earnings differentials for college/high school workers and a 8.68% and 4.55% increase in employment and earnings differentials for male and female workers.

Corollary results for the mining and non-mining sectors and breakdowns for male and female workers by education level are also shown in Tables 4 and 5.

6.4. Employment and Earnings Differentials by Region

Tables 6 presents results for earnings differentials each shale play separately (for brevity, results for employment differentials can be found in Appendix Table A3). We focus on the *Bakken*, *Eagle Ford*, *Haynesville*, *Marcellus*, *Niobrara*, *Permian*, and *Utica* regions consistent with the definitions of EIA's Drilling Productivity Reports.[20]

For college/high school earnings differentials, we estimate a negative treatment effect in six of the seven regions (Utica is a statistically insignificant 0.7% increase). Of these seven regions, three (including Bakken, Eagle Ford, and Permian) have statistically significant negative treatment effects ranging from a 13.9% treatment effect in Bakken to a -4.6% treatment effect in Permian.

Similarly, we estimate a positive treatment effect for male/female earnings differentials in all seven of the regions, with six of the seven regions being statistically significant at different levels of significance ranging from p=.01 to p=.1. Point estimates range from 10.1% (Bakken) to 2.3% (and weakly significant at p=.1 in Niobrara). Thus, our main results are robust across shale plays in geographically very different parts of the country and with different potential timings of the treatment effects (i.e. gas plays boomed earlier than oil plays, for instance).

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[20] During the preparation of this analysis, EIA has now made slight changes to these regions. Thus, these are as were defined by EIA in mid 2016.

Tables A4 and A5 in the Appendix provide rig count and value of production elasticities by region, thus combining results from Sections 5.3 and 5.4.

6.5. Robustness Tests – Alternative Control Groups and Placebos

We next implement two additional robustness checks.

First, we test the sensitivity of our results to alternative control groups by randomly choosing 20 control groups. Table 7 shows the results for employment and earnings differentials using 20 random control groups taken from all counties in the United States not in proximity to shale counties.[21] The process of generating a random control group is performed 20 times, and for each of these iterations we estimate a treatment effect. In total, the 160 treatment effects estimated are presented. For instance, the average treatment effect for earnings differentials between workers with a college and high school diploma range from -2.3% to -4.1%, with the average treatment effect of -3.1%. Comparing this to the estimated average treatment effect on Table 3 of earnings differentials of 3.0%, we see that the random control group treatment effects provide a very similar estimated treatment effect to the propensity score matched control group. Estimated treatment effects from Table 3 using the propensity score match control group are listed on the bottom of Table 8 for easy comparison. As seen, some treatment effects are very similar, while others, are quite different. For instance, the estimated treatment effect for employment differentials for workers with college and high school education using the random control groups range from -3.3 to -4.6%, while the treatment effect obtained with the propensity score matched control group is -5.6%. Thus, Table 8 shows that while results are generally robust to choice of treatment group, specific point estimates can vary based on which control group is used. This points to the importance of choosing a proper control group in obtaining unbiased treatment effect estimates.

Finally, Tables 8 shows results for two placebo tests. The first column show results from the first placebo test, that randomly assigns actually treated counties into either a treatment or control group. The second column shows results of the second placebo test, that randomly assigns propensity score matched control counties into either a treatment or control group. Of the twenty placebo tests shown, none are significant at p=.1.

6.6. Instrumental Variable Results

In sections 6.1-6.5 we presented a number of coefficient estimates of interest to

[21] Similar to the main specification, potential control counties are pulled from the following 20 states: AL, AZ, CA, CT, DE, FL, GA, HI, ID, IL, IN, IA, ME, MI, MN, MS, MO, NV, NH, NJ, NC, OK, OR, RI, SC, TN, VT, WA, and WI.

economists studying the impact of oil and gas shocks to labor markets alongside a number of robustness checks. Next, we provide an estimate of the sensitivity of earnings differentials to changes in direct employment within the oil and gas sector for male workers and workers with college degrees. This approach will provide a general elasticity estimate that can be used in other contexts, not necessarily related to a mining industry employment shock.

These results are presented in Table 9. For the first stage, we estimate the impact of rig counts on high school mining employment. We estimate that 100 rigs in operation are associated with a 2.7% increase in high school employment induced by the mining industry shock. In the second stage, we estimate that a 10% increase in the high school employment is associated with a 7.04% decrease in the earnings differential. Given that high school employment is only about one third of the labor force before the shock, this suggests that relatively small shocks to labor demand for workers with high school education can have significant impacts on economy wide earnings differentials.

Results for male/female earnings differentials are also presented in Table 9. In the first stage, we estimate that 100 rigs are associated with a 3.4% increase in male employment associated with the mining sector shock. In the second stage, we estimate that a 10% increase in male employment is associated with a 6.7% increase in male/female earnings differentials. Again, given that men make up approximately half of the work force, this result suggests that relatively small shocks to male demand for male workers can have significant impacts on economy wide earnings differentials. These results highlight the importance of labor demand shocks that might asymmetrically impact different groups of workers on economy wide differentials.

7. Conclusions

This paper examines the impact of plausibly exogenous labor market shocks associated with shale oil and gas production that was made possible due to technological advancements that allowed for large increases in drilling in specific geographical areas with specific geological formations thousands of feet below the earth's surface. We find evidence that earnings increased in both mining and non-mining industries for all workers, regardless of education or gender. But we also find evidence that both employment and earnings differentials between workers with a college and high school education decreased by 5.6%, respectively, due to the shale boom. On the other hand, we find that male/female employment and earnings differentials increased by about 3.7%.

While it might be unsurprising that earnings differentials changed overall due to substitutions of male workers with high school educations into the high paying mining sector, we also find evidence that earnings differentials changed within non-mining sectors. Specifically, college/high school earnings differentials increased by 2.6% in non-mining sectors, while male female earnings differentials increased by 2.9% in non-mining sectors. Even more interesting, is the relative contribution of these two effects on economy wide earnings differentials. We present evidence that approximately 80% and 85% respectively of the change in college/high school and male/female earnings differentials is due to changes in earnings differentials within non-shale industries. In other words, the effects on intra-industry earnings differentials in non-mining industries accounts for the lion's share of economy wide differentials—not the obvious fact that earnings increase in the mining industry and male workers with high school education substitute into that expanding high paying sector. This has significant policy implications, in that labor demand shocks specific to a demographics of workers might explain a large share of economy wide earnings differentials.

We also provide novel generalized elasticities of labor demand shocks on earnings differentials. Specifically, we find that a 10% increase in the high school employment is associated with a 7.04% decrease in the college/high school earnings differential, and that a 10% increase in the male employment is associated with a 6.7% increase in male/female earnings differentials. These elasticities are quite large considering the fact that within the sample studies, high school and male employment makes up approximately one third and one half, respectively, of the labor force in the pre-shale time period. Thus, this suggests that relatively small labor demand shocks can have significant implications for earnings differentials within the overall economy.

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9. Tables and Figures

Figure 1: U.S. Shale Plays

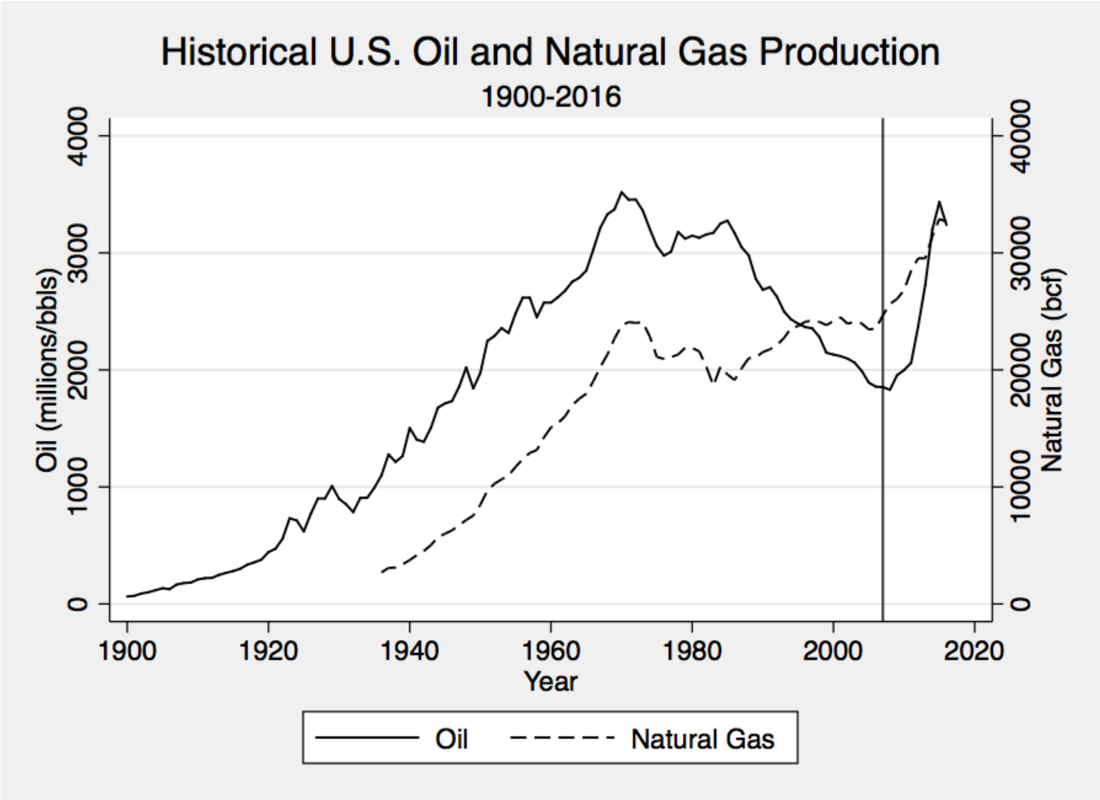
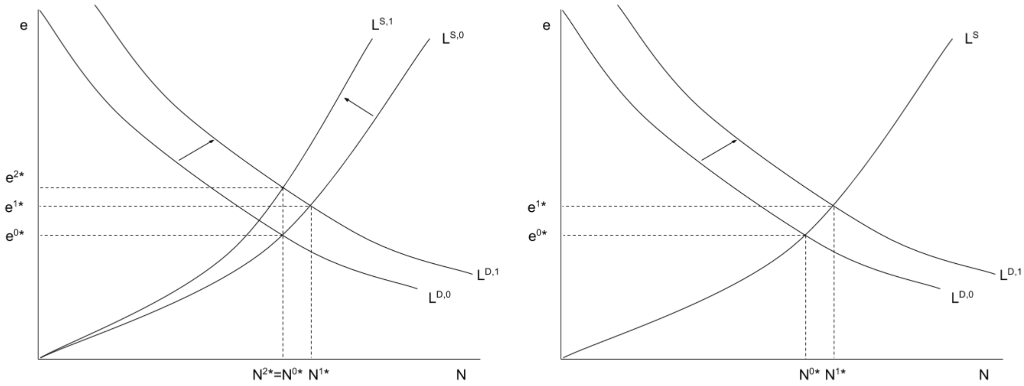


Figure 2: History of U.S. Oil and Natural Gas Production



(a) Male/ High School Educated (b) Female / College Educated

Figure 3: Impact of Shale on Non-Mining Labor Market

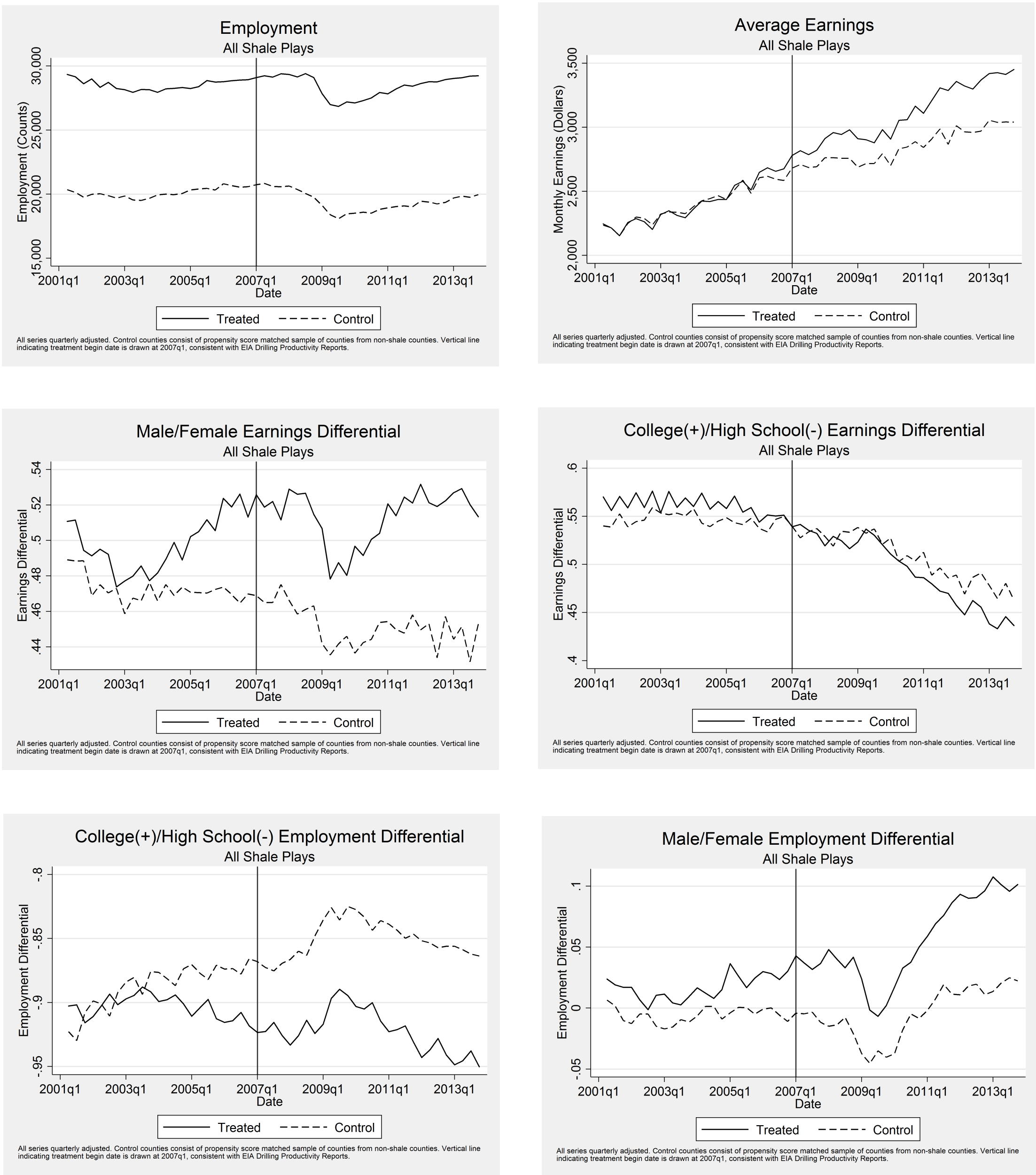


Figure 4: Changes in Employment, Earnings, and Employment and Earnings Differentials in Shale and Propensity Score Matched Control Groups.

Table 1
Summary Statistics - Pre vs. Post Treatment

	Treatment Group			Control Group			
	Pre 2007	Post 2007	Percent Change	Pre 2007	Post 2007	Percent Change	%∆Treatment - %∆ Control
Employment							
All	29,731	29,621	-0.37%	21,302	20,603	-3.28%	2.91%
College +	5,880	5,884	0.07%	3,942	3,953	0.28%	-0.21%
High School (-)	10,513	10,861	3.31%	7,742	7,661	-1.05%	4.36%
Male	15,184	15,117	-0.44%	15,941	15,401	-3.39%	2.95%
Female	14,441	14,398	-0.30%	15,259	15,169	-0.59%	0.29%
Male College (+)	2,976	2,931	-1.51%	3567	3,518	-1.37%	-0.14%
Female College (+)	2,885	2,934	1.70%	3429	3,539	3.21%	-1.51%
Male High School (-)	5,735	5,951	3.77%	4,231	4,150	-1.91%	5.68%
Female High School (-)	4,778	4,810	0.67%	3,510	3,511	0.03%	0.64%
Small Sample - All Sectors	42,810	42,745	-0.15%	61,061	60,228	-1.36%	1.21%
Mining Sector	787	1,213	54.13%	440	536	21.82%	32.31%
Non-Mining Sector	42,023	41,532	-1.17%	60,622	59,692	-1.53%	0.37%
Earnings							
All	$2,473	$3,168	28.10%	$2,467	$2,913	18.08%	10.02%
College +	$3,726	$4,545	21.98%	$3,719	$4,258	14.49%	7.49%
High School (-)	$2,171	$2,850	31.28%	$2,196	$2,612	18.94%	12.33%
Male	$3,067	$3,931	28.17%	$3,055	$3,586	17.38%	10.79%
Female	$1,854	$2,326	25.46%	$1,899	$2,273	19.69%	5.76%
Male College (+)	$4,630	$5,724	23.63%	$4,652	$5,374	15.52%	8.11%
Female College (+)	$2,851	$3,402	19.33%	$2,825	$3,258	15.33%	4.00%
Male High School (-)	$2,705	$3,526	30.35%	$2,686	$3,150	17.27%	13.08%
Female High School (-)	$1,536	$1,981	28.97%	$1,624	$1,966	21.06%	7.91%
Small Sample - All Sectors	$2,611	$3,369	29.03%	2,619	$3,139	19.85%	9.18%
Mining Sector	$4,040	$5,512	36.44%	3,874	4,807	24.08%	12.35%
Non-Mining Sector	$2,475	$3,117	25.94%	2,553	3,027	18.57%	7.37%
Matching Variables							
Share White	0.923	0.923	0.00%	0.921	0.921	0.00%	0.00%
College Share	0.16	0.16	0.00%	0.159	0.159	0.00%	0.00%
Scaled Treatment Variables							
Rig Counts	-	1.37	-	-	-	-	-
Value of Production (billions USD)	-	0.04	-	-	-	-	-

Detailed summary statistics available in Appendix Tables A1-A2. Employment is beginning of quarter counts. Earnings are average monthly earnings of full time stable workers.

Table 2
Impact of Shale Boom on Employment and Earnings

	Employment Counts				Average Monthly Earnings			
	Full Sample	Small Sample	Mining	Non-Mining	Full Sample	Small Sample	Mining	Non-Mining
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All								
Treatment	588.24**	768.13	304.03***	438.31	249.80***	238.52***	579.64***	168.466***
	(294.06)	(624.48)	(83.76)	(603.69)	(26.29)	(34.98)	(95.70)	(27.20)
N	28,560	17,748	17,748	17,748	28,560	17,748	17,748	17,748
College or Higher								
Treatment	-6.723	-121.661	30.125**	-160.943	280.114***	263.192***	709.726***	193.329***
	(58.90)	(138.83)	(12.79)	(138.09)	(34.27)	(43.79)	(203.33)	(36.92)
N	28,560	17,748	17,748	17,748	28,560	17,748	17,748	17,748
High School or Lower								
Treatment	429.082***	34.126	151.895***	-124.722	261.485***	250.722***	625.970***	175.298***
	(124.41)	(249.49)	(39.12)	(235.04)	(27.12)	(36.90)	(72.81)	(28.53)
N	28,560	17,748	17,748	17,748	28,560	17,748	17,748	17,748
Male								
Treatment	473.381*	1,163.917***	284.685***	887.823**	333.660***	318.766***	561.975***	242.495***
	(242.74)	(414.28)	(72.40)	(395.73)	(32.93)	(44.72)	(109.41)	(38.34)
N	28,662	17,238	17,238	17,238	28,662	17,238	17,238	17,238
Female								
Treatment	46.386	185.723	24.369	160.686	97.249***	75.523***	417.837***	67.004***
	(171.95)	(259.69)	(16.11)	(257.83)	(12.98)	(16.38)	(70.01)	(12.77)
N	28,662	17,238	17,238	17,238	28,662	17,238	17,238	17,238

The dependent variables are quarterly employment counts and earnings, respectively. Employment is beginning of quarter counts. Earnings are average monthly earnings of full time stable workers. Year, quarter and county fixed effects in all regressions but coefficient estimates not shown. In columns (1) and (5) we use the full sample of balanced counties available. For other columns, we use the sample of counties for which a balanced panel of data is available for each set of respective regressions to allow for comparisons. Standard errors are in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3
Impact of Shale Boom on Employment and Earnings Differentials

	Employment Differentials				Earnings Differentials			
	Full Sample	Small Sample	Mining	Non-Mining	Full Sample	Small Sample	Mining	Non-Mining
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
College (+) / High School (-)								
Treatment	-0.056***	-0.031***	-0.041**	-0.028***	-0.030***	-0.030***	-0.023	-0.026***
	(0.006)	(0.008)	(0.020)	(0.008)	(0.005)	(0.006)	(0.015)	(0.006)
N	28,560	17,748	17,748	17,748	28,560	17,748	17,748	17,748
Male / Female								
Treatment	0.037***	0.035***	0.018	0.020*	0.037***	0.036***	-0.025	0.029***
	(0.009)	(0.012)	(0.028)	(0.010)	(0.005)	(0.006)	(0.017)	(0.006)
N	28,662	17,238	17,238	17,238	28,662	17,238	17,238	17,238
Male / Female - with College (+)								
Treatment	0.034***	0.021	-0.028	0.018*	0.029***	0.022***	-0.003	0.024***
	(0.009)	(0.013)	(0.032)	(0.011)	(0.006)	(0.007)	(0.025)	(0.007)
N	28,650	11,802	11,802	11,802	28,662	11,802	11,802	11,802
Male / Female - with High School (-)								
Treatment	0.028**	0.071***	0.013	0.053**	0.037***	0.028**	0.03	0.029**
	(0.011)	(0.027)	(0.048)	(0.024)	(0.005)	(0.011)	(0.020)	(0.012)
N	28,560	4,998	4,998	4,998	28,560	4,998	4,998	4,998

The dependent variables are logged differentials in quarterly employment counts and earnings, respectively. Employment is beginning of quarter counts. Earnings are average monthly earnings of full time stable workers. Year, quarter and county fixed effects in all regressions but coefficient estimates not shown. In columns (1) and (5) we use the full sample of balanced counties available. For other columns, we use the sample of counties for which a balanced panel of data is available for each set of respective regressions to allow for comparisons. Standard errors are in parentheses. $*$ $p < 0.05$, $**$ $p < 0.01$, $***$ $p < 0.001$.

Table 4
Sensitivity of Earnings Differentials to Rig Counts

	Employment Differentials				Earnings Differentials			
	Full Sample	Small Sample	Mining	Non-Mining	Full Sample	Small Sample	Mining	Non-Mining
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
College (+) / High School (-)								
Rig Counts	-0.026***	-0.026***	-0.044***	-0.022***	-0.017***	-0.019***	-0.014**	-0.018***
	(0.003)	(0.003)	(0.009)	(0.004)	(0.003)	(0.004)	(0.007)	(0.003)
N	28,560	17,748	17,748	17,748	28,560	17,748	17,748	17,748
Male / Female								
Rig Counts	0.026***	0.036***	-0.002	0.026***	0.015***	0.022***	-0.001	0.024***
	(0.005)	(0.006)	(0.011)	(0.006)	(0.003)	(0.003)	(0.006)	(0.003)
N	28,662	17,238	17,238	17,238	28,662	17,238	17,238	17,238
Male / Female - with College (+)								
Rig Counts	0.026***	0.029***	-0.024**	0.030***	0.014***	0.013***	-0.004	0.021***
	(0.004)	(0.005)	(0.012)	(0.005)	(0.004)	(0.003)	(0.008)	(0.004)
N	28,650	11,802	11,802	11,802	28,662	11,802	11,802	11,802
Male / Female - with High School (-)								
Rig Counts	0.022***	0.038***	-0.013	0.037***	0.015***	0.016**	0.013**	0.024***
	(0.005)	(0.012)	(0.013)	(0.013)	(0.003)	(0.006)	(0.006)	(0.006)
N	28,560	4,998	4,998	4,998	28,560	4,998	4,998	4,998

The dependent variables are logged differentials in quarterly employment counts and earnings, respectively. Employment is beginning of quarter counts. Earnings are average monthly earnings of full time stable workers. Rig counts is average rigs in operation in quarter of interest scaled to 100 rigs. Only rigs drilling in shale plays per definition of EIA's Drilling Productivity Reports are included. Year, quarter and county fixed effects in all regressions but coefficient estimates not shown. In columns (1) and (5) we use the full sample of balanced counties available. For other columns, we use the sample of counties for which a balanced panel of data is available for each set of respective regressions to allow for comparisons. Standard errors are in parentheses.$*$ $p < 0.05$, $**$ $p < 0.01$, $***$ $p < 0.001$.

Table 5
Sensitivity of Earnings Differentials to Value of Production

	Employment Differentials				Earnings Differentials			
	Full Sample	Small Sample	Mining	Non-Mining	Full Sample	Small Sample	Mining	Non-Mining
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
College (+) / High School (-)								
Value of production	-0.854***	-0.815***	-0.738***	-0.815***	-0.539***	-0.558***	-0.402**	-0.583***
	(0.094)	(0.112)	(0.112)	(0.112)	(0.081)	(0.106)	(0.197)	(0.089)
N	28,560	17,748	17,748	17,748	28,560	17,748	17,748	17,748
Male / Female								
Value of production	0.868***	1.114***	-0.238	0.846***	0.455***	0.638***	0.072	0.704***
	(0.158)	(0.194)	(0.346)	(0.193)	(0.086)	(0.095)	(0.180)	(0.090)
N	28,662	17,238	17,238	17,238	28,662	17,238	17,238	17,238
Male / Female - with College (+)								
Value of production	0.877***	1.002***	-0.864	1.025***	0.409***	0.403***	-0.074	0.600***
	(0.150)	(0.167)	(0.407)	(0.157)	(0.106)	(0.093)	(0.246)	(0.107)
N	28,650	11,802	11,802	11,802	28,662	11,802	11,802	11,802
Male / Female - with High School (-)								
Value of production	0.769***	1.130***	-0.543	1.129***	0.454***	0.491***	0.394**	0.721***
	(0.177)	(0.380)	(0.440)	(0.422)	(0.084)	(0.177)	(0.180)	(0.174)
N	28,560	4,998	4,998	4,998	28,560	4,998	4,998	4,998

The dependent variables are logged differentials in quarterly employment counts and earnings, respectively. Employment is beginning of quarter counts. Earnings are average monthly earnings of full time stable workers. Value of production is total value in quarter of interest scaled to billions of dollars and is calculated by multiplying estimated production of oil and gas per EIA's Drilling Productivity Reports by WTI and Henry Hub spot prices by month for oil and gas respectively. Year, quarter and county fixed effects in all regressions but coefficient estimates not shown. In columns (1) and (5) we use the full sample of balanced counties available. For other columns, we use the sample of counties for which a balanced panel of data is available for each set of respective regressions to allow for comparisons. Standard errors are in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 6
Impact of Shale Booms on Earnings Differentials by Region

Variables	(1) Bakken	(2) Eagle Ford	(3) Haynesville	(4) Marcellus	(5) Niobrara	(6) Permian	(7) Utica
College (+) / High School (-) Earnings Differential							
Treatment	-0.139***	-0.084***	-0.012	-0.011	-0.016	-0.046***	0.007
	(0.029)	(0.017)	(0.015)	(0.008)	(0.013)	(0.014)	(0.015)
N	2,040	2,346	2,244	10,812	3,570	5,508	2,040
Male / Female Earnings Differential							
Treatment	0.101***	0.069***	0.02	0.040***	0.023*	0.040***	0.031**
	(0.030)	(0.019)	(0.015)	(0.008)	(0.012)	(0.012)	(0.014)
N	2,040	2,346	2,244	10,812	3,570	5,610	2,040
Male / Female Earnings Differential - with College (+)							
Treatment	0.028	0.056**	0.003	0.036***	0.023	0.056***	0.016
	(0.042)	(0.022)	(0.019)	(0.009)	(0.016)	(0.017)	(0.018)
N	2,040	2,346	2,346	10,812	3,570	5,610	2,040
Male / Female Earnings Differential - with High School (-)							
Treatment	0.133***	0.065***	0.023*	0.036***	0.025*	0.033**	0.029**
	(0.026)	(0.021)	(0.013)	(0.009)	(0.013)	(0.013)	(0.014)
N	2040	2346	2244	10812	3570	5508	2040

The dependent variable is logged differentials in quarterly earnings. Earnings are average monthly earnings of full time stable workers. Year, quarter and county fixed effects in all regressions but coefficient estimates not shown. Standard errors are in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 7
Impact of Shale Boom on Employment and Earnings Differentials - Random Control Groups

	Employment Differentials				Earnings Differentials			
	College/High School	Male/Female	Male/Female (College+)	Male/Female (HS-)	College/High School	Male/Female	Male/Female (College+)	Male/Female (HS-)
Iteration	(1)	(2)	(4)	(5)	(6)	(7)	(9)	(10)
1	-0.033***	-0.035***	0.036***	0.034***	-0.027***	0.015	0.031***	0.034***
2	-0.043***	-0.038***	0.022**	0.041***	-0.033***	0.021**	0.032***	0.037***
3	-0.040***	-0.02	0.024***	0.033***	-0.028***	0.023***	0.030***	0.033***
4	-0.036***	-0.025*	0.040***	0.035***	-0.041***	0.020**	0.023***	0.037***
5	-0.044***	-0.015	0.032***	0.043***	-0.034***	0.015*	0.022***	0.041***
6	-0.034***	-0.029**	0.022**	0.033***	-0.025***	0.011	0.033***	0.032***
7	-0.035***	-0.025*	0.021**	0.022*	-0.025***	0.035***	0.031***	0.038***
8	-0.040***	-0.023*	0.025***	0.037***	-0.023***	0.019**	0.037***	0.039***
9	-0.045***	-0.034**	0.032***	0.042***	-0.027***	0.015*	0.033***	0.038***
10	-0.043***	-0.026**	0.028***	0.042***	-0.036***	0.01	0.025***	0.040***
11	-0.037***	-0.026*	0.032***	0.038***	-0.029***	0.022**	0.034***	0.039***
12	-0.046***	-0.012	0.034***	0.033***	-0.031***	0.016*	0.029***	0.039***
13	-0.037***	-0.028**	0.026***	0.036***	-0.027***	0.016*	0.021***	0.030***
14	-0.042***	-0.015	0.029***	0.030***	-0.034***	0.025***	0.024***	0.037***
15	-0.039***	-0.026**	0.029***	0.033***	-0.031***	0.029***	0.030***	0.040***
16	-0.039***	-0.034**	0.024***	0.033***	-0.029***	0.030***	0.026***	0.036***
17	-0.042***	-0.023*	0.030***	0.042***	-0.032***	0.024***	0.023***	0.033***
18	-0.040***	-0.021	0.022**	0.038***	-0.031***	0.014	0.021***	0.034***
19	-0.042***	-0.038***	0.033***	0.037***	-0.026***	0.016*	0.031***	0.037***
20	-0.039***	-0.024*	0.020**	0.027**	-0.030***	0.020**	0.033***	0.039***
Average	-0.040	-0.026	0.028	0.035	-0.030	0.020	0.028	0.037
Min	-0.046	-0.038	0.02	0.022	-0.041	0.01	0.021	0.03
Max	-0.033	-0.012	0.04	0.043	-0.023	0.035	0.037	0.041
PS Match (Table 3)	-0.056***	0.037***	0.034***	0.028**	-0.030***	0.037***	0.029***	0.037***

Table 8
Placebo Test

Variables	(1) Treatment Group Placebo	(2) Control Group Placebo	(1) Treatment Group Placebo	(2) Control Group Placebo
	Employment Differentials		Earnings Differentials	
College (+) / High School (-) Earnings Differential				
Treatment	0.001	0.009	0.001	0.009
	(0.008)	(0.007)	(0.008)	(0.007)
N	14,280	14,280	14,280	14,280
Male / Female Earnings Differential				
Treatment	0.000	-0.008	0.000	-0.008
	(0.008)	(0.005)	(0.008)	(0.005)
N	14,331	14,331	14,331	14,331
Male / Female Earnings Differential - with College (+)				
Treatment	0.004	-0.004	0.004	-0.004
	(0.009)	(0.008)	(0.009)	(0.008)
N	14,331	14,331	14,331	14,331
Male / Female Earnings Differential - with High School (-)				
Treatment	-0.003	-0.006	-0.003	-0.006
	(0.009)	(0.006)	(0.009)	(0.006)
N	14280	14,280	14,280	14,280

In this table, we only use counties which are located in the shale plays. Half of the counties are randomly picked as the treated group, the other half are then picked as the control group. We only report the coefficients of the treatment here. Standard errors are in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 9
Elasticity of Earnings Differentials in Response to Direct Employment Shocks. Instrumental Variables Estimate

	College / H.S.		Male/Female	
	First Stage	Second Stage	First Stage	Second Stage
	H.S. Employment Mining/Total	Ln (College/H.S.) Earnings	Male Employment Mining/Total	Ln (Male/Female) Earnings
	(1)	(2)	(5)	(6)
Rig Count (100 units)	0.027***		0.034***	
	(0.007)		(0.009)	
Employment Mining/Total		-0.704***		0.637***
		(0.184)		(0.172)
County Year Fes	Y	Y	Y	Y
F-Test	16.53		15.32	
N	17,748	17,748	17,238	17,238

Standard errors are in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A1
Summary Statistics - Treatment Group - Pre vs. Post Treatment

	All			Pre 2007			Post 2007			
	Mean	Std	N	Mean	Std	N	Mean	Std	N	% Change
Employment										
All	29,671	71,192	14,280	29,731	72,193	6,440	29,621	70,364	7,840	-0.37%
College +	5,882	17,344	14,280	5,880	17,599	6,440	5,884	17,133	7,840	0.07%
High School (-)	10,704	23,240	14,280	10,513	23,128	6,440	10,861	23,331	7,840	3.31%
Male	15,147	35,921	14,331	15,184	36,654	6,463	15,117	35,310	7,868	-0.44%
Female	14,418	35,236	14,331	14,441	35,493	6,463	14,398	35,026	7,868	-0.30%
Male College (+)	2,951	8,840	14,330	2976	9089	6,463	2,931	8,631	7,867	-1.51%
Female College (+)	2,912	8,490	14,320	2885	8496	6,457	2,934	8,486	7,863	1.70%
Male High School (-)	5,854	12,543	14,280	5,735	12,514	6,440	5,951	12,567	7,840	3.77%
Female High School (-)	4,851	10,735	14,280	4,778	10,648	6,440	4,810	10,807	7,840	0.67%
Small Sample - All Sectors	42,775	87,155	8,874	42,810	88,444	4,002	42,745	86,091	4,872	-0.15%
Mining Sector	1,021	1,881	8,874	787	1,416	4,002	1,213	2,173	4,872	54.13%
Non-Mining Sector	41,754	87,026	8,874	42,023	88,368	4,002	41,532	85,917	4,872	-1.17%
Earnings										
All	$2,855	$727	14,280	$2,473	$494	6,440	$3,168	$738	7,840	28.10%
College +	$4,176	$1,098	14,280	$3,726	$822	6,440	$4,545	$1,157	7,840	21.98%
High School (-)	$2,544	$676	14,280	$ 2,171	$409	6,440	$2,850	$699	7,840	31.28%
Male	$3,541	$973	14,331	$ 3,067	$666	6,463	$3,931	$1,011	7,868	28.17%
Female	$2,113	$427	14,331	$ 1,854	$314	6,463	$2,326	$389	7,868	25.46%
Male College (+)	$5,231	$1,627	14,331	$ 4,630	$ 1,170	6,463	$5,724	$ 1,777	7,868	23.63%
Female College (+)	$3,153	$646	14,331	$2,851	$528	6,463	$3,402	$629	7,868	19.33%
Male High School (-)	$3,156	$852	14,280	$2,705	$533	6,440	$3,526	$886	7,840	30.35%
Female High School (-)	$1,780	$361	14,280	$1,536	$233	6,440	$1,981	$320	7,840	28.97%
Small Sample - All Sectors	$3,027	$730	88,74	$2,611	$459	4,002	$3,369	$733	4,872	29.03%
Mining Sector	$4,848	$1,558	88,74	$4,040	$1,157	4,002	$5,512	$1,531	4,872	36.44%
Non-Mining Sector	$2,827	$629	88,74	$2,475	$413	4,002	$3,117	$628	4,872	25.94%
Matching Variables										
Share White	0.923	0.084	14,280	0.923	0.084	6,440	0.923	0.084	7,840	0.00%
College Share	0.16	0.033	14,280	0.16	0.033	6,440	0.16	0.033	7,840	0.00%
Scaled Treatment Variables										
Rig Counts	0.75	1.11	14,280	-	-	-	1.37	1.18	7,840	-
Value of Production (billions USD)	0.02	0.04	14,280	-	-	-	0.04	0.04	7,840	-

Employment is beginning of quarter counts. Earnings are average monthly earnings of full time stable workers.

Table A2
Summary Statistics - Control Group - Pre vs. Post Treatment

	All			Pre 2007			Post 2007			
	Mean	Std	N	Mean	Std	N	Mean	Std	N	% Change
Employment										
All	20,918	35,197	14,280	21,302	35,879	6,440	20,603	34,627	7,840	-3.28%
College +	3,948	8,224	14,280	3,942	8,275	6,440	3,953	8,183	7,840	0.28%
High School (-)	7,698	12,394	14,280	7,742	12,420	6,440	7,661	12,372	7,840	-1.05%
Male	15,645	39,691	14,331	15,941	40,471	6,463	15,401	39,039	7,868	-3.39%
Female	15,210	38,431	14,331	15,259	38,399	6,463	15,169	38,459	7,868	-0.59%
Male College (+)	3,540	12,423	14,331	3567	12647	6,463	3,518	12,238	7,868	-1.37%
Female College (+)	3,489	11,710	14,331	3429	11649	6,463	3,539	11,761	7,868	3.21%
Male High School (-)	4,187	6,873	14,280	4,231	6,974	6,440	4,150	6,789	7,840	-1.91%
Female High School (-)	3,511	5,556	14,280	3,510	5,481	6,440	3,511	5,618	7,840	0.03%
Small Sample - All Sectors	60,604	118,813	8,874	61,061	120,155	4,002	60,228	117,710	4,872	-1.36%
Mining Sector	493	1,150	8,874	440	1,024	4,002	536	1,242	4,872	21.82%
Non-Mining Sector	60,111	118,631	8,874	60,622	119,991	4,002	59,692	117,512	4,872	-1.53%
Earnings										
All	$2,712	$580	$14,280	$2,467	$467	$6,440	$2,913	$586	7,840	18.08%
College +	$4,015	$913	$14,280	$3,719	$784	$6,440	$4,258	$938	7,840	14.49%
High School (-)	$2,425	$485	$14,280	$2,196	$360	$6,440	$2,612	$493	7,840	18.94%
Male	$3,346	$792	$14,331	$3,055	$659	$6,463	$3,586	$812	7,868	17.38%
Female	$2,105	$446	$14,331	$1,899	$356	$6,463	$2,273	$441	7,868	19.69%
Male College (+)	$5,048	$1,290	$14,331	$4,652	$1,100	$6,463	$5,374	$1,342	7,867	15.52%
Female College (+)	$3,063	$657	$14,331	$2,825	$552	$6,463	$3,258	$671	7,868	15.33%
Male High School (-)	$2,941	$589	$14,280	$2,686	$448	$6,440	$3,150	$609	7,840	17.27%
Female High School (-)	$1,811	$326	$14,280	$1,624	$240	$6,440	$1,966	$305	7,840	21.06%
Small Sample - All Sectors	$2,904	$576	$8,874	$2,619	$450	$4,002	$3,139	$562	4,874	19.85%
Mining Sector	$4,387	$1,559	$8,874	$3,874	$1,150	$4,002	$4,808	$1,717	4,874	24.11%
Non-Mining Sector	$2,813	$533	$8,874	$2,553	$450	$4,002	$3,027	$501	4,874	18.57%
Matching Variables										
Share White	0.921	0.082	14,280	0.921	0.082	6,440	0.921	0.082	7,840	0.00%
College Share	0.159	0.031	14,280	0.159	0.031	6,440	0.159	0.031	7,840	0.00%

Employment is beginning of quarter counts. Earnings are average monthly earnings of full time stable workers.

Table A3
Impact of Shale Booms on Employment Differentials by Region

Variables	(1) Bakken	(2) Eagle Ford	(3) Haynesville	(4) Marcellus	(5) Niobrara	(6) Permian	(7) Utica
College (+) / High School (-) Employment Differential							
Treatment	-0.141***	-0.155***	-0.041**	-0.008	-0.047**	-0.112***	0.024
	(0.025)	(0.025)	(0.020)	(0.010)	(0.019)	(0.017)	(0.034)
N	2,040	2,346	2,244	10,812	3,570	5,508	2,040
Male / Female Employment Differential							
Treatment	0.345***	0.062*	0.04	-0.015	0.039*	0.052**	0.010
	(0.063)	(0.032)	(0.035)	(0.012)	(0.020)	(0.022)	(0.014)
N	2,040	2,346	2,244	10,812	3,570	5,610	2,040
Male / Female Employment Differential - with College (+)							
Treatment	0.228***	0.059**	0.027	-0.007	0.029	0.057**	0.005
	(0.057)	(0.028)	(0.034)	(0.011)	(0.022)	(0.022)	(0.016)
N	2,040	2,346	2,244	10,812	3,570	5,598	2,040
Male / Female Employment Differential - with High School (-)							
Treatment	0.394***	0.048	0.036	-0.031**	0.019	0.026	0.007
	(0.070)	(0.037)	(0.038)	(0.014)	(0.025)	(0.025)	(0.016)
N	2,040	2,346	2,244	10,812	3,570	5,508	2,040

The dependent variable is logged differentials in quarterly employment. Employment is beginning of quarter counts. Year, quarter and county fixed effects in all regressions but coefficient estimates not shown. Standard errors are in parentheses.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A4
Earnings Differentials by Region, Using Rig Counts as A Measure of Treatment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Bakken	Eagle Ford	Haynesville	Marcellus	Niobrara	Permian	Utica
College (+) / High School (-) Earnings Differential							
Treatment	-0.105***	-0.050***	-0.009	-0.017**	-0.017	-0.012***	0.017
	(0.027)	(0.009)	(0.006)	(0.008)	(0.012)	(0.004)	(0.076)
N	2,040	2,346	2,244	10,812	3,570	5,508	2,040
Male / Female Earnings Differential							
Treatment	0.070***	0.036***	0.004	0.039***	0.026**	0.013***	0.141**
	(0.024)	(0.009)	(0.007)	(0.009)	(0.012)	(0.004)	(0.068)
N	2,040	2,346	2,244	10,812	3,570	5,610	2,040
Male / Female Earnings Differential - with College (+)							
Treatment	0.017	0.025**	-0.005	0.034***	0.025*	0.018***	0.085
	(0.032)	(0.012)	(0.008)	(0.010)	(0.015)	(0.005)	(0.103)
N	2,040	2,346	2,244	10,812	3,570	5,610	2,040
Male / Female Earnings Differential - with High School (-)							
Treatment	0.092***	0.036***	0.006	0.037***	0.027**	0.011***	0.121*
	(0.022)	(0.010)	(0.006)	(0.009)	(0.013)	(0.004)	(0.066)
N	2,040	2,346	2,244	10,812	3,570	5,508	2,040

The dependent variables are logged earnings differentials between two types of workers. Treatment is measured by the actual number of rigs working in the fields. In each column, we use the largest balanced panel available (for all the variables used in the specific model) from the QWI dataset. We only report the coefficients of the treatment here. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A5
Earnings Differentials by Region, Using Total Value of Oil and Gas Production as A Measure of Treatment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Bakken	Eagle Ford	Haynesville	Marcellus	Niobrara	Permian	Utica
College (+) / High School (-) Earnings Differential							
Treatment	-2.650***	-1.339***	-0.359	-0.535*	-0.389	-0.384***	0.125
	(0.698)	(0.224)	(0.383)	(0.281)	(0.307)	(0.115)	(5.308)
N	2,040	2,346	2,244	10,812	3,570	5,508	2,040
Male / Female Earnings Differential							
Treatment	1.614**	0.889***	0.607	1.304***	0.558*	0.374***	11.754**
	(0.618)	(0.222)	(0.374)	(0.281)	(0.283)	(0.103)	(5.219)
N	2,040	2,346	2,244	10,812	3,570	5,610	2,040
Male / Female Earnings Differential - with College (+)							
Treatment	0.342	0.547*	0.155	1.059***	0.569	0.503***	4.122
	(0.844)	(0.295)	(0.487)	(0.338)	(0.380)	(0.150)	(6.954)
N	2,040	2,346	2,244	10,812	3,570	5,610	2,040
Male / Female Earnings Differential - with High School (-)							
Treatment	2.140***	0.915***	0.689*	1.209***	0.591*	0.312***	11.176**
	(0.566)	(0.237)	(0.344)	(0.304)	(0.318)	(0.108)	(5.143)
N	2,040	2,346	2,244	10,812	3,570	5,508	2,040

The dependent variables are logged earnings differentials between two types of workers. Treatment is measured by the total value of crude oil and natural gas production. In each column, we use the largest balanced panel available (for all the variables used in the specific model) from the QWI dataset. We only report the coefficients of the treatment here. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.