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Article

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International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2022, 12(5), 425-431.

The Effects of Shale Oil and Gas Endowments on Regional Labor Markets

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Received: 18 May 2022 **Accepted:** 23 August 2022 **DOI:** https://doi.org/10.32479/ijeep.13320

ABSTRACT

We analyze the effects of shale oil development on regional labor markets. By exploiting the exogenous geographic endowment of shale oil and gas, we find that shale endowments have differential impacts on workers in and out of the labor market. After introducing new shale technologies in 2006, shale oil and gas significantly increased the local share of high school graduates participating in the labor force. Yet, shale endowments decreased the percentage of nonworking college graduates who do not participate in the labor force. Our results suggest that shale oil and gas could increase the demand for high school graduates but create disamenities for college graduates who are not in the labor force.

Keywords: Skill Aggregation, Shale Oil Development, Regional Growth
JEL Classifications: J21, R11, R12

1. INTRODUCTION

Shale oil and gas development can have substantial economic (Fleming et al., 2015; Shakya et al., 2022; Weber, 2012), social (Fleming et al., 2015), and environmental impacts (Lechtenböhmer et al., 2012). The possibility of a "resource curse" arising from shale development is an important topic (Fleming et al., 2015; Weber, 2014): a concentration of the resource extraction industry in a given region may be detrimental to that region's future economic growth (Douglas and Walker, 2017; Weber, 2014). The sources of this resource curse are diverse, but one major channel is a decrease in human capital, which is critically important for regional growth (Abel et al., 2012; Fleming et al., 2015; Glaeser and Resseger, 2010), in regions that depend heavily on the resource extraction industries (Papyrakis and Gerlagh, 2007; Weber, 2014). This is mainly because the resource extraction industries may decrease the return to schooling.

In this paper, we analyze the impacts of shale endowment on labor markets. We use commuting zones (CZs) developed by Tolbert and Sizer (1996) to define regional labor markets. We then compare the labor markets in regions with and without shale endowment. First, we show strong evidence that shale endowment is associated with positive employment growth in the oil and gas extraction industries. Then, we examine the effects of shale oil and gas on general labor markets. After introducing new shale technologies in 2006, we find that shale endowments increased the population share of high school graduates participating in the labor market but reduced the population share of labor force nonparticipants holding a college degree. Our results suggest that shale oil and gas could increase the demand for high school graduates but create disamenities for college graduates, especially for labor force nonparticipants.

We use regions' shale oil development potential (i.e., shale oil reserves) instead of the realized quantity of shale oil extraction. This strategy allows for exogenous variation of the shale oil and gas development (Fleming et al., 2015; Michaels, 2011). To be more specific, we employ location of shale oil and gas plays to assign "treatment" status to regions in a difference-in-differences method that looks before and after the introduction of fracking technology. This strategy has been used previously to analyze the impact of shale oil development on the likelihood of dropping out of high school (Cascio and Narayan, 2015).

Our paper is critically important for predicting the future economic outlook of regions with shale development. It also has an important policy implication. If the average human capital decreases in regions that depend on shale oil and gas development, then governments may need to intervene to mitigate the negative impact on future economic outlooks. Our paper finds that shale endowments increases the share of high school graduates among those in the labor market. On the other hand, they decrease the share of nonworking college graduates. These results are consistent with the interpretation that shale oil development creates not only more economic opportunities for less-educated workers but also disamenities for high-educated people. Therefore, shale development could attract less-educated workers who participate in the labor market but drive out high-educated people who don't participate in the labor market. That is, college graduates only get the disutility from the disamenities generated by shale oil development, and not the benefits from the increase in wages. This result implies that the impact of new industries on the local human capital level may be very different for populations, depending on their labor market participation status and education level.

Existing studies analyze the impact of the resource extraction industry on human capital. Kumar (2015; 2017) analyzes the impact of an oil boom on human capital investment in Texas and finds a negative effect. Rickman et al. (2017) analyze the impact of shale oil development on educational attainment in the United States and find similar results. Cascio and Narayan (2022) also identify a negative impact of shale oil development on high school graduation rates. These studies all identify an impact on individuals' level of education. However, given high labor mobility within the United States, the individual outcome is not necessarily connected to the aggregate outcome.

Shale oil and gas development may decrease the incentive for individual residents to stay in school. However, the average human capital level might decrease in the region. For instance, oil companies may want to hire manual workers in a particular region where they operate but still want to hire experienced engineers and geologists in other regions. In other words, the unskilled labor market may be more localized than the skilled labor market. In this case, the negative impact of shale oil and gas development on young locals' education could be accompanied by no change-or even an increase-in the average human capital at the regional level. Also, the expected wage level is not the only factor that influences migration decisions. Any changes in local consumer amenities due to shale development could also attract or drive away less- or high-educated people and influence the average human capital level.

An additional line of research analyzes the impact of shale oil development (or resource extraction industries generally) on the aggregate-rather than individual-human capital level. The results are mixed. For instance, Papyrakis and Gerlagh (2007) show a negative relationship between resource dependence and the level of average human capital in U.S. regions. On the other hand, Weber (2014) analyzes the impact of shale oil development on the average human capital level in Arkansas, Louisiana, Oklahoma, and Texas and finds no significant negative impact. Measham and Fleming (2014) also report an increase in skill aggregation in regions with shale oil development.

The rest of the paper is organized as follows. Section 2 discusses our data. Sections 3 and 4 show a regression analysis and the results, respectively. Finally, Section 5 concludes.

2. DATA

We obtain shale endowment data from the U.S. Energy Information Administration (EIA). In our analysis, we use EIA data published March 11, 2016, on sedimentary basin boundaries in the lower 48 states. Figure 1 shows the geographical distribution of shale oil endowments. Our data on annaual employment and labor force participation rates is sourced from the 2000 Census and the 2005–2011 American Community Surveys (ACS). The unit of analysis is the commuting zone, which is based on commuting patterns and used in the investigation of local labor markets (Autor et al., 2013; Tolbert and Sizer, 1996). Following Autor et al. (2013), we use a crosswalk from Public Use Microdata Areas (PUMA) to obtain data at the commuting-zone level.[1] We exclude commuting zones with populations more than 500,000, because large commuting zones are generally located in very large metropolitan areas and less likely to be influenced by shale oil development.[2] Tables 1 and 2 shows summary statistics for labor force participants and nonparticipants, respectively.

1 For more details about PUMA, see https://www.census.gov/programs-surveys/geography/guidance/geo-areas/pumas.html

2 As a robustness check, even including these large CZs in our analysis, the results are qualitatively similar to the baseline results. This sensitivity analysis is available upon request.

Table 1: Summary statistics for labor force participants

Obs	Variable	Mean	Std. Dev.	Min.	Max.
Commuting zones with endowments of shale oil and gas					
1864	Share of college graduates	0.2256	0.0606	0.0933	0.4889
	Share of people with some college education	0.3094	0.0455	0.1611	0.4491
	Share of high school graduates	0.3483	0.0647	0.1670	0.5408
	Share of high school dropouts	0.1012	0.0500	0.0148	0.3334
Commuting zones without endowments of shale oil and gas					
Obs	**Variable**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
4064	Share of college graduates	0.2373	0.0689	0.0819	0.5236
	Share of people with some college education	0.3229	0.0477	0.1904	0.4657
	Share of high school graduates	0.3323	0.0605	0.1508	0.5368
	Share of high school dropouts	0.0921	0.0457	0.0138	0.3421

Figure 1: Geographic distribution of U.S. Shale oil endowments (shale plays: Lower 48 states)

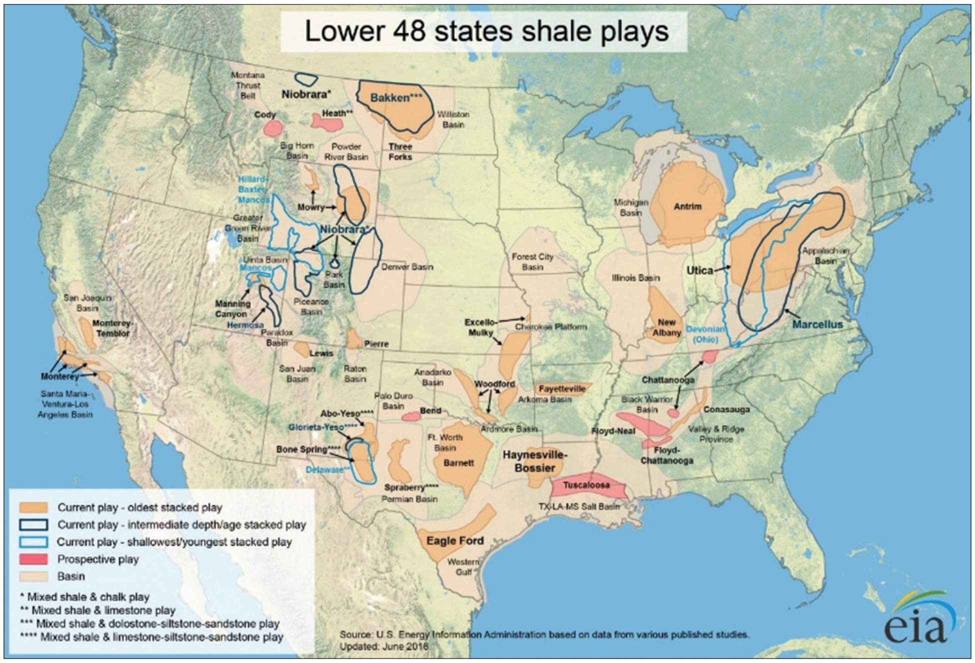
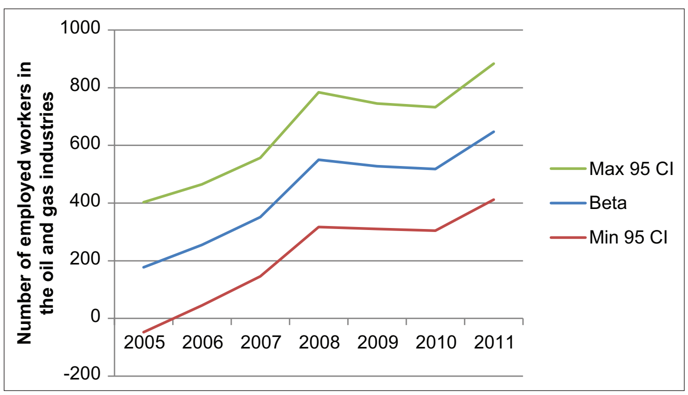


Figure 2: Estimated changes in the total employment in the oil and gas extraction industries



The figure illustrates the estimated change in the share of employment in the oil and gas extraction industries each year (i.e., β_{ts} reported in Table 3) with the 95% confidence interval (CI).

3. EMPIRICAL SPECIFICATION

It is widely accepted that 2006 was the beginning of widespread diffusion of fracking technology (Cascio and Narayan, 2022). To measure the effects of shale oil and gas endowments on regional labor markets, we employ the following regression specification:

$$D_{it} = \alpha + \beta_0 S_i + \sum_{t=2005}^{2011} \beta_t (S_i \circ \tau_t) + \gamma_i + \tau_t + \varepsilon_{it}.$$

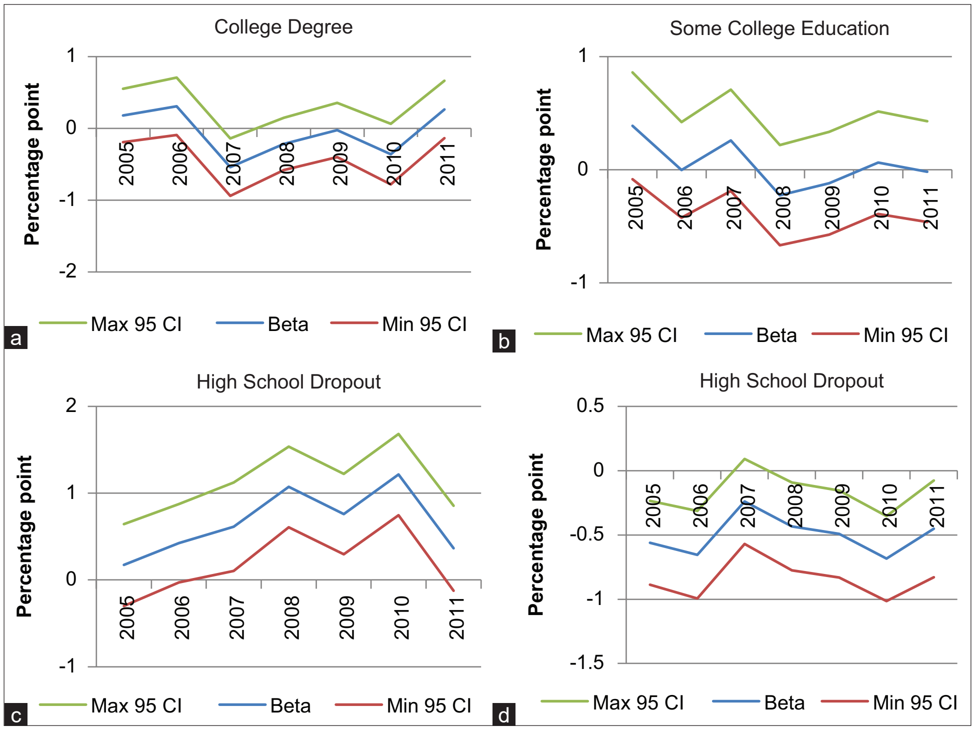
Here, D_{it} is the shares of workers aged 25 and above with different educational backgrounds in CZ i in year t. We divide these workers into four groups: College graduates, those with some college education, high school graduates, and high school dropouts. S_i is an indicator variable that equals 1 when CZ i has a nonzero endowment of gas and oil. Shale endowments could allow exogenous variation to measure the effects of shale development on economic outcomes (Fleming et al, 2015; Michaels, 2011; Cascio and Narayan, 2022).

τ_t is the year fixed effects, while γ_i is the CZ fixed effects. This regression specification is useful because it allows us to estimate the dynamic effects (i.e., β_t) of shale development over time. In this specification, 2000 is the reference year.

Table 2: Summary statistics for labor force nonparticipants

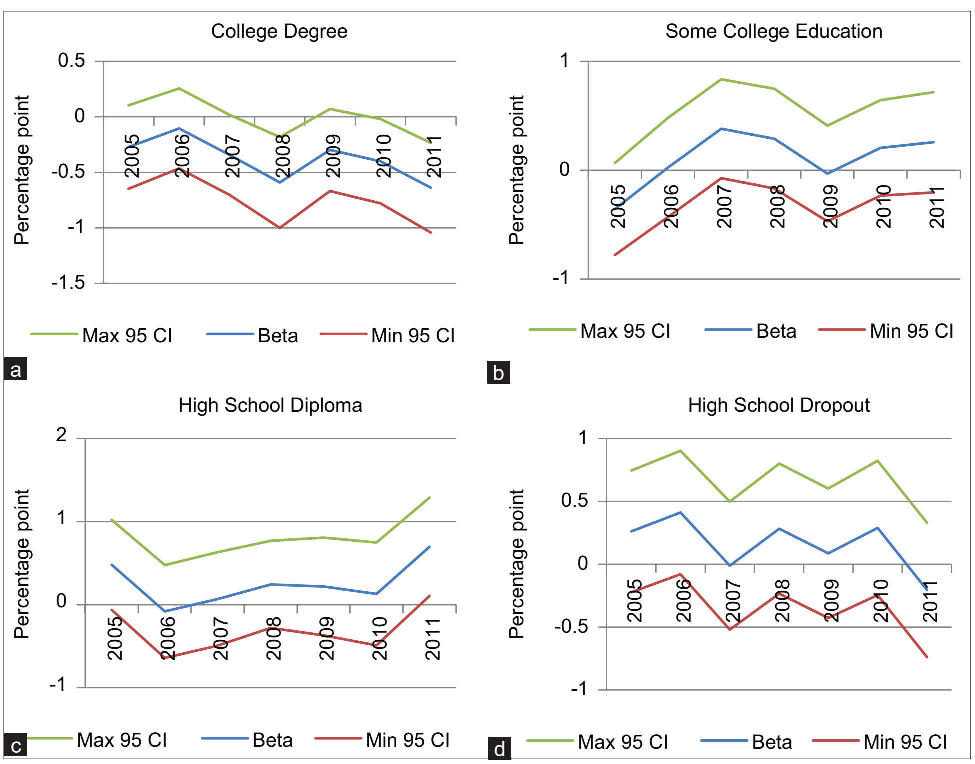
Commuting zones with endowments of shale oil and gas					
Obs	**Variable**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
1864	Share of college graduates	0.1217	0.0499	0.0368	0.4567
	Share of people with some college education	0.2125	0.0503	0.0806	0.4102
	Share of high school graduates	0.3746	0.0602	0.1802	0.5841
	Share of high school dropouts	0.2648	0.0886	0.0599	0.5782
Commuting zones without endowments of shale oil and gas					
Obs	**Variable**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
4064	Share of college graduates	0.1354	0.0563	0.0340	0.5127
	Share of people with some college education	0.2257	0.0502	0.0912	0.4204
	Share of high school graduates	0.3728	0.0553	0.1313	0.5467
	Share of high school dropouts	0.2405	0.0817	0.0451	0.5762

Figure 3: Estimated effects in employment shares by education. (a) College degree, (b) Some college education, (c) High school diploma, (d) High school dropout



The figure illustrates the estimated change in the share of employment in the oil and gas extraction industries each year (i.e., β_t's reported in Table 4) with the 95% confidence interval (CI).

Figure 4: Estimated effects of shale development on labor force participation. (a) College degree, (b) Some college education, (c) High school diploma, (d) High school dropout



The figure illustrates the estimated change in the share of employment in the oil and gas extraction industries each year (i.e.,'s β_t reported in Table 5) with the 95% confidence interval (CI).

4. EMPIRICAL RESULTS AND DISCUSSION

To analyze the impact of shale oil and gas endowment on the spatial distribution of human capital, one can begin with the spatial equilibrium proposed by Roback (1982). The spatial distribution of labor and capital should be determined by three factors: local productivity advantage, local consumer amenity, and local rent level. Shale oil and gas development can increase the productivity of unskilled workers from the shale oil industry or some other industries stimulated by shale oil development, such as construction (Fleming et al., 2015). Clearly this channel will increase the population share of less-educated workers. On the other hand, the local amenity level could decline with shale oil development due to increases in the crime rate and potential pollution (James and Smith, 2017; Lechtenböhmer et al., 2012). It is likely that high-educated people are more sensitive to any change in the amenity level because local amenities are considered normal goods. In particular, a decline in local amenities may give high-skill workers, particularly labor force nonparticipants, stronger incentive to migrate out.

Table 3: The effects of shale oil and gas on the oil and gas extraction industries

	(1) Employment in the oil and gas extraction industries
S_i	−670.4***
	(151.7)
$S_i \cdot \tau_{2005}$	177.7
	(115.0)
$S_i \cdot \tau_{2006}$	255.2**
	(107.1)
$S_i \cdot \tau_{2007}$	351.3***
	(104.7)
$S_i \cdot \tau_{2008}$	550.5***
	(119.2)
$S_i \cdot \tau_{2009}$	527.8***
	(111.0)
$S_i \cdot \tau_{2010}$	518.1***
	(109.2)
$S_i \cdot \tau_{2011}$	647.6***
	(120.2)
Year Fixed Effects	Controlled
Commuting Zone Fixed Effects	Controlled
Observations	5,928
R-squared	0.968

Robust standard errors are in parentheses. ***P<0.01, **P<0.05, *P<0.1. S_i is an indicator of whether a CZ contains a shale endowment, while τ represents a year fixed effect

First, we examine the impact of shale oil and gas on total employment in the oil and gas extraction industries. Table 3 shows that these natural resources have a significant positive effect on the total employment in these industries. Figure 2 illustrates the estimated change in the share of employment in the oil and gas extraction industries each year (i.e., β_{ts})with the 95% confidence interval. We find significant evidence that after 2005 there is an increase in the total employment in the oil and gas extraction industries in regions lying on the shale formation.

We proceed to examine the effects of shale oil and gas on labor markets for labor force participants with different educational groups. Table 4 presents regression results for each educational group (Figures 3a-d). plot the shale-year interaction coefficients (i.e., $S_i \cdot \tau_t$) for each educational attainment group, based on Table 4. Except in the case of high school graduates, there is no significant

Table 4: The effects of shale oil and gas on labor force participation

	(1) Share of college graduates	(2) Share of people with some college education	(3) Share of high school graduates	(4) Share of high school dropouts
S_i	−0.152***	−0.0517***	0.151***	0.0526***
	(0.00506)	(0.00715)	(0.00549)	(0.00542)
$S_i \cdot \tau_{2005}$	0.00142	0.00361	0.000884	−0.00447***
	(0.00172)	(0.00220)	(0.00217)	(0.00153)
$S_i \cdot \tau_{2006}$	0.00229	−0.000123	0.00365*	−0.00538***
	(0.00185)	(0.00200)	(0.00207)	(0.00158)
$S_i \cdot \tau_{2007}$	−0.00505***	0.00276	0.00478**	−0.00178
	(0.00184)	(0.00209)	(0.00233)	(0.00154)
$S_i \cdot \tau_{2008}$	−0.00182	−0.00204	0.00872***	−0.00325**
	(0.00169)	(0.00208)	(0.00214)	(0.00159)
$S_i \cdot \tau_{2009}$	−0.000518	−0.00108	0.00651***	−0.00393**
	(0.00175)	(0.00212)	(0.00213)	(0.00158)
$S_i \cdot \tau_{2010}$	−0.00301	0.000318	0.0103***	−0.00559***
	(0.00194)	(0.00212)	(0.00215)	(0.00154)
$S_i \cdot \tau_{2011}$	0.00261	−0.000308	0.00234	−0.00329*
	(0.00184)	(0.00210)	(0.00224)	(0.00174)
Year Fixed Effects	Controlled	Controlled	Controlled	Controlled
Commuting Zone Fixed Effects	Controlled	Controlled	Controlled	Controlled
Observations	5,928	5,928	5,928	5,928
R−Squared	0.935	0.836	0.896	0.920

Robust standard errors are in parentheses. ***P<0.01, **P<0.05, *P<0.1. S_i is an indicator of whether a CZ contains a shale endowment, while τ represents a year fixed effect

Table 5: The effects of shale oil and gas on labor force nonparticipation

	(1) Share of college graduates	(2) Share of people with some college education	(3) Share of high school graduates	(4) Share of high school dropouts
S_i	−0.144***	−0.120***	0.0704***	0.193***
	(0.00348)	(0.00499)	(0.00872)	(0.00932)
$S_i \cdot \tau_{2005}$	−0.00316*	−0.00271	0.00519**	0.00179
	(0.00173)	(0.00194)	(0.00248)	(0.00226)
$S_i \cdot \tau_{2006}$	−0.00116	0.00112	−0.000702	0.00314
	(0.00166)	(0.00210)	(0.00256)	(0.00229)
$S_i \cdot \tau_{2007}$	−0.00320*	0.00426**	0.000478	−0.000575
	(0.00166)	(0.00207)	(0.00256)	(0.00235)
$S_i \cdot \tau_{2008}$	−0.00568***	0.00277	0.00298	0.00219
	(0.00189)	(0.00210)	(0.00240)	(0.00239)
$S_i \cdot \tau_{2009}$	−0.00291*	−1.42e−05	0.00236	0.000536
	(0.00170)	(0.00202)	(0.00268)	(0.00239)
$S_i \cdot \tau_{2010}$	−0.00409**	0.00247	0.00153	0.00215
	(0.00175)	(0.00200)	(0.00280)	(0.00247)
$S_i \cdot \tau_{2011}$	−0.00605***	0.00342	0.00629**	−0.00245
	(0.00186)	(0.00211)	(0.00269)	(0.00248)
Year Fixed Effect	Controlled	Controlled	Controlled	Controlled
Commuting Zone Fixed Effect	Controlled	Controlled	Controlled	Controlled
Observations	5,928	5,928	5,928	5,928
R-squared	0.919	0.852	0.831	0.939

Robust standard errors in parentheses. ***P<0.01, **P<0.05, *P<0.1. S_i is an indicator of whether a CZ containing a shale endowment, while τ represents a year fixed effect

and consistent change in the share of each educational group in regions with shale oil development potential. Generally, shale oil and gas do not exert any significant impacts on workers with at least some college education. On the other hand, shale oil and gas have a significantly positive impact on the employment of workers with a high school diploma.[3] Because the shares of workers by education group add up to 100 percent, the share of high school dropouts declines when the share of high school graduates increases.

Table 5 shows the estimated effects of shale oil and gas on the people who do not participate in the labor market, while Figure 4a-d plot these estimated effects (i.e., $\beta_{t\,s}$). Shale oil and gas significantly negatively affect college graduates who do not participate in the labor force. Other groups do not show significant changes.

5. CONCLUSION

We analyze the effects of shale endowment on regional labor markets. We first show that there is a strong positive association between shale endowment and employment growth in the oil and gas extraction industries. Then, we examine the impacts of shale endowment on general regional labor markets. We find different patterns in the response of labor market participants and nonparticipants after the introduction of fracking technology in 2006. Specifically, we find that in response to shale development, the share of highly educated people among those outside of the labor market tends to decrease substantially and the share of less-educated people in the labor market tends to increase. These results highlight the importance of distinguishing between labor market participants and nonparticipants when evaluating the impact of new technologies on regional human capital. For future study, it would be worthwhile to consider the exact mechanisms behind these responses by various groups to shale development.

3 New jobs created by shale oil development don't necessarily come directly from the oil and gas extraction industries but could also come from other industries that support shale oil development, or from a general increase in economic activity (Isha, 2016).

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