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Impact of the Bakken Oil Boom on Employment and Wages in North Dakota

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Abstract
A difference-in-difference methodology is used to examine the impact of the 2008 oil boom on employment and wages in North Dakota. Finding show an 8.68 percent increase in employment and 4.85 percent increase in wages in counties producing Bakken oil relative to the rest of North Dakota. In addition, a modified Difference- in-Difference is used to examine the rate of growth in employment and wages. Results show a 0.271 percent increase in quarterly job growth in Bakken oil producing counties relative to the rest of North Dakota. No significant impact is observed in the growth of wages.

Cover Page Footnote
I would like to thank Professor Hansen and Professor Flores for their help and encouragement

Introduction

Western North Dakota is located on top of a large body of oil known as the Bakken. In 2008, an oil boom started in western North Dakota's Bakken region after technology improvements allowed firms to access oil reserves that previously could not be tapped. Technological improvements along with a jump in oil prices made it profitable to produce in the Bakken formation (Davies). This began the inflow of capital by oil firms in 2008. Due to the labor-intensive nature of the oil drilling process, demand for labor in the Bakken also increased (Wirtz).

This study uses a difference-in-difference (DD) methodology to estimate the impact of the Bakken oil boom on employment and real wages in North Dakota. In addition, a difference-in-difference methodology with a time trend is included to examine changes in the rate of change in employment and real wages.

Results suggest that employment grew 8.68% more in Bakken counties post oil boom relative to the rest of North Dakota. Real wages also grew 4.85% more in Bakken post boom compared to the rest of North Dakota. In addition, employment grew at a rate of 0.271% faster per quarter in Bakken counties post oil boom. No significant difference in the rate of growth of real wages is detected.

Background

Many countries produce large amounts of oil on various levels. The three largest oil producing countries are Russia, Saudi Arabia, and the United States, producing 10.40, 11.73, 11.11 million barrels, respectively. China is next at 4.4 million barrels a year, and then there are 16 countries that produce between one and four million barrels per year (*"Countries"*).

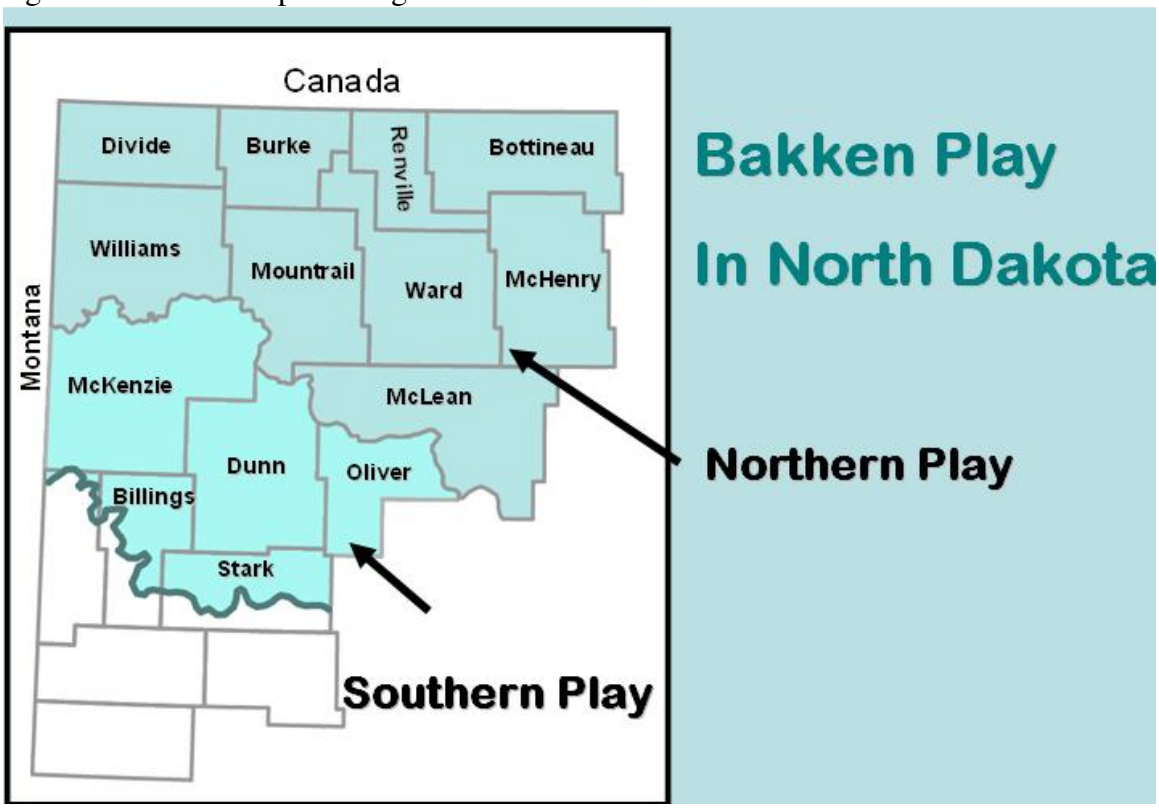
Currently, the four largest oil-producing states currently are Texas, Alaska, California, and North Dakota. North Dakota's appearance in this list reflects recent changes in the dynamics of U.S. oil production. In 2007, North Dakota was the 7th largest oil producing state (*"Crude Oil Production"*). The majority of the oil being extracted from North Dakota comes from the Bakken region. Figure 1 is a partial map of North Dakota; the shaded counties produce oil from the Bakken formation.

Oil drilling in North Dakota started in 1951. Oil production grew to 4,023,831 barrels of oil in May 1981 and stayed rather stagnate to December 2007 when oil production was 4,216,837 barrels (Department of Mineral Reserves). As of December 2012, North Dakota oil production has risen to 23,838,302 barrels (Department of Mineral Reserves).

Legislation clarifications helped pave the way for the current oil boom in western North Dakota. In 1974, the Safe Drinking Water Act (SDWA) became law. The purpose of the law is to protect the U.S. water supply and to improve public health. The component of the SDWA that affects hydraulic fracturing is the illegalization of "underground infection," injecting fluids into the ground as

propping agents for extracting resources. Historically, hydraulic fracturing was never regulated by the SDWA.

Figure 1: Bakken Oil producing Counties



Next Big Future, 2009

Hydraulic fracturing was used originally to stimulate oil production in declining wells. Now, it is used after the well is drilled and throughout the production process. Namely, Water, sand, other propping agents and chemicals are used under enough pressure to crack the rock formations containing oil and natural gas. The sand and propping agents hold the fracture open, allowing oil and gas to flow into the production well.

Environmental concerns over hydraulic fracturing have been raised. An hydraulic fracture creates new fractures in shale and other formations containing oil and natural gas and could possibly extend previously existing fractures. The concern is that chemicals, methane and contaminates, could get into the water supply.

In 1997, the United States court of appeals 11th circuit ruled that hydraulic fracturing in Alabama for coalbed methane constitutes underground injection and can be regulated by the SDWA. This ruling prompted the Environmental

Protection Agency (Tiemann and Vann) to research the dangers of hydraulic fracturing. In 2004, the EPA found the danger to water supply is small and said that it does not need to be regulated nationally. In 2005, the Bush administration passed the Energy Bill Act that clarified the language of the Safe Drinking Water Act term "underground injections". Under the Energy Bill Act, the use of water and propping agents (except diesel fuel) is exempt in the use of hydraulic fracturing (Tiemann and Vann).

Until the first decade of the twenty-first century, the gas and oil reserves in the Bakken were unable to be collected. Technological advances in hydraulic fracturing are now allowing for the production of the Bakken oil reserves that were previously inaccessible (Tiemann and Vann). Even with the technology improvements, it is expensive to drill in the Bakken. Oil firms need the price per barrel to be 75 dollars or above in order to be profitable (Davies).

Literature Review

The goal of this research is to examine the impact of the oil boom in North Dakota from a different perspective. Past research has estimated growth in housing markets and uses an input-output analysis specialized to North Dakota to examine the overall impact of the oil industry.

Bangsund, Hodur, Rathge, and Olson (2012) project future employment, population and housing in the Dickinson trade area in North Dakota to support the city's planning efforts. Housing demand is projected to be 70-140 above 2010 estimates by the year 2020.

A review of the literature reveals that Input-Output (I-O) analysis is a common methodology used to measure the direct and secondary impacts of the oil industry and oil boom on North Dakota. Bangsund and Leistritz (2007, 2007, 2009) and Bangsund and Hodur (2011) use a modified I-O analysis referred to as the North Dakota I-O to measure the impact of the oil and natural gas industry on North Dakota. The limiting feature of I-O analysis is that it examines the impact for a moment of time. Findings from the four studies show that the oil industry is over the four studies generating more taxable income, and employment opportunities each year.

The literature offers methodological approaches to study the impact of conditions of an area experiencing an oil boom. Kyle (2002) explores possible polices the government of São E Tomé Príncipe, (a small island country off the western coast of Africa), will consider to maximize the oil found off the shores supports his recommendations with economic theory. He encourages investment in human capital through education and health, and also within the agriculture sector. Agriculture is São E Tomé Príncipe's main export. The best way to position this sector for success is through the development of roads and larger ports to accommodate larger ships.

Andersen and Faris (2002) use a computable general equilibrium (CGE) model to examine the income distribution and wages of people in Bolivia when natural gas production increases. Findings indicate wages increase across all sectors; however, the income gap also increases.

Haefele and Morton (2009) use a simulation to explore the impact of an oil boom in Colorado. A simulation of a fictional city with 2,500 possible oil producing wells is conducted under five pace-of-development scenarios to show annual growth in employment and to determine how to maximize the short and long-term benefits of a natural resource discovery. They conclude that slower pace and scale will not only reduce fiscal cost, environmental damage, and social economic impact (increased housing prices because of the increased migration), but increase the economic diversity in the job market, stabilizing long run growth and minimizing the boom-bust cycle. Christa N. Brunnshweiler (2008) supports diversification as an important contributor to long-term growth.

Weber (2012) uses a triple difference-in-difference methodology to examine the impact of natural gas production from counties in Colorado, Texas, and Wyoming. Findings suggest the natural gas boom causes employment, wages and salaries, and median household income to increase. Weber (2012) also states that I-O overestimates the impact of natural gas production because of the use of multipliers on the interactions between jobs.

Marchand (2011) looks at the economic impact of an energy boom in western Canada. He finds in the energy extract industry total employment, and earnings per worker increase during booms, and are stagnant during bust cycles. In non-energy extract industries, he finds total earnings and employment rise in boom areas relative to those in non boom areas through boom and bust periods. Then he uses local job multipliers to estimate job creation during booms, noting modest job creation in non energy extraction industries.

Difference-in-difference methodology is chosen in this study because it allows for an adaption to examine not just the impact at a moment in time, but changes in the rate of growth over time. The idea for the modified difference-in-difference approach originates from Hochkiss, Moore and Zobay (2003) who examined the impact of the 1996 Olympics on employment and wages in Georgia.

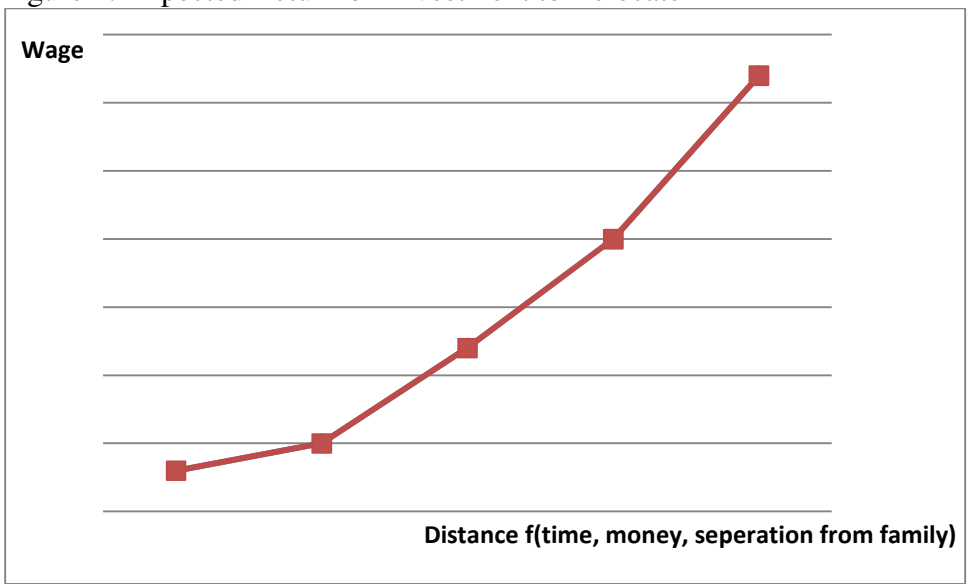
Conceptual Framework

The oil boom has increased the demand for labor in the petroleum industry. The local scarcity of labor because of the rural area that the Bakken area is located in has caused an increase in wages in the petroleum industry to entice the movement of labor to the Bakken region. This spills over to an increase in employment and wages across all job types in the Bakken region.

The scarcity of labor in western North Dakota forces the petroleum firms to pay a premium to draw labor from far distances to work on the oil rigs.

Temporarily or permanently moving your family for work is an investment and can be viewed in a risk-return framework. The return on the investment to move is wages earned. The risk of moving can be viewed as distance, which is a function of money invested in the moving process, the opportunity cost of the time spent on the moving process, along with giving up the other things that generate utility such as separation from family, and city attractions. Figure 2 includes a curve displaying the relationship between relocation distance and expected return of relocating.

Figure 2: Expected Return on Investment to Relocate



The increase in employment and wages causes an increase in the demand for goods and services leading to an increase in the demand for labor by non-oil firms. Non-oil firms must increase their wages also to incentivize the movement of labor to the area.

Once the labor is in the area, the relative wages offered by non-oil jobs is competitive with the oil firms to the point where the laborer is indifferent between working for an oil firm or a non-oil firm. Assuming that oil jobs are viewed by the majority of the public as an inferior job, (because of it being manual work and not something that you can do your entire life), non-oil firms do not need to match the wages associated with their employment opportunities equally to those of oil firms. If the assumptions are true, non-oil firms can pay their workers at a discount price due to safer, less physically-straining work conditions.

Data and Methodology

For the analysis, this study identifies the North Dakota counties that lie above the Bakken formation. These counties are referred to as the Bakken (BAK) counties. BAK counties are the ones expected to benefit directly from the oil boom.

Quarterly employment and wage data for each county for the first quarter of 2001 to the fourth quarter of 2011 is gathered from Bureau of Labor and Statistics (BLS). Nominal (per-worker weekly) wages are converted to real wages using the Consumer Price Index (CPI) (CPI = 100, base year 2005).

The job mix and labor force data for each county is also calculated using data from the BLS. Job mix data reflects percentages of employment distributed across different job categories. The labor force of each county in 2001 is used as a proxy for population. Job mix and labor force data is used to control for county-level characteristics that might influence employment and wage growth over the time period.

Figure 3 and figure 4 show the employment ratio and real wage ratio for BAK and non-BAK counties for each quarter, beginning with the first quarter in 2001.

Figure 3: Employment Ratio by County Grouping

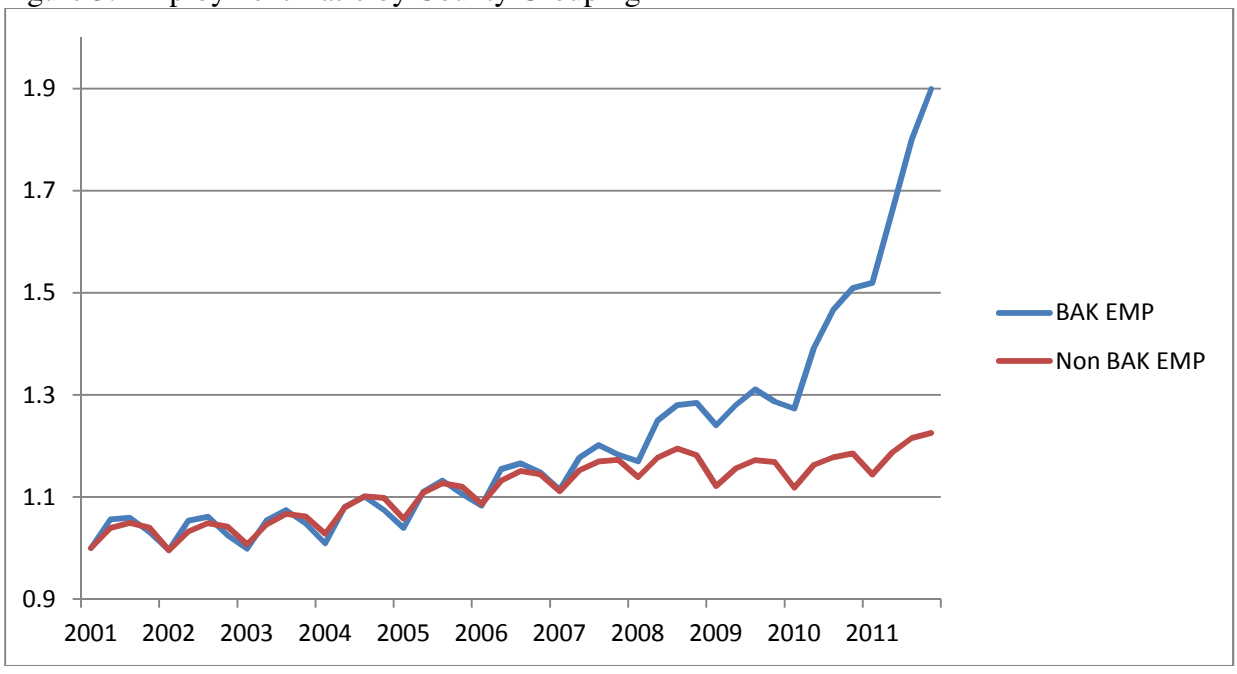
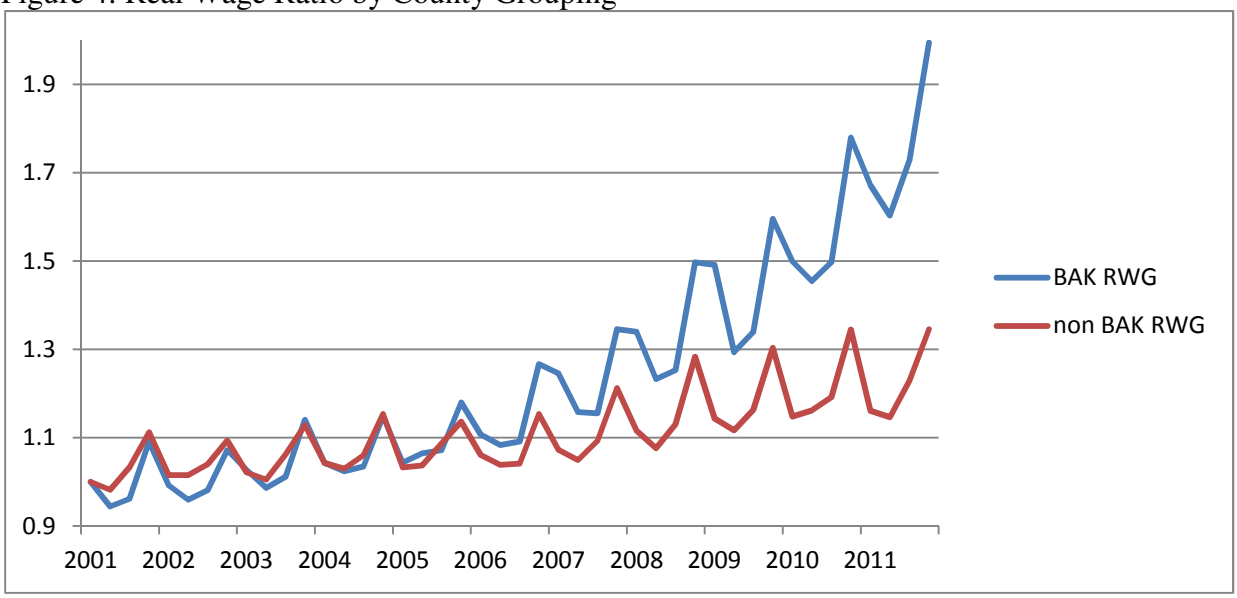


Figure 4: Real Wage Ratio by County Grouping



The figures suggest employment and real wages have grown more in Bakken counties than in non-Bakken counties. Also, the rate of change in Bakken counties has changed. The change in the growth rates of employment and wages appears to correlate roughly to 2008, the start of the oil boom.

Difference-in-Difference in North Dakota

A difference-in-difference approach is used to evaluate the impact of the oil boom on employment and wages in North Dakota. Difference-in-difference tests to see if some group observed changed more after an event compared to another group of observations. The traditional difference-in-difference methodology uses ordinary least squares (OLS) regression to estimate the coefficients and includes dummy variables indicating if the period in question is pre or post event, and if an observed group is part of the impacted group or the control group. In addition to the standard DD, a modified DD is used to examine changes to pre vs. post oil boom rates of growth among BAK and non-BAK counties.

Difference-in-Difference in Intercept

The DD model takes the following form to measure the changes in employment and wages in North Dakota counties:

$$\text{Log } EMP_{it} = \beta_1 X_i + \beta_2 BAK_i + \beta_3 POST_i + \beta_4 BAK_i * POST_i \quad (1)$$

$$\text{Log } RWG_{it} = \alpha_1 X_i + \alpha_2 BAK_i + \alpha_3 POST_i + \alpha_4 BAK_i * POST_i \quad (2)$$

where log of EMP_{it} is the log of employment in county i in quarter t. Log RWG_{it} is the log of weakly real wages in county i in quarter t. X_i is a set of covariates for each county including an intercept, quarterly dummy variables, a job mix for each county for quarter 1 of 2001 and labor force for each county in quarter 1 of 2001. Bak_i is a dummy variable indicating if the county is located above the Bakken formation. $Post_i$ is a dummy variable representing whether the oil boom has occurred yet. If time is greater than or equal to the first quarter of 2008, is a 1. Before 2008, $Post_i$ equals 0. The interaction variable BAK_i*$POST_i$ represents the impact of the oil boom on the Bakken counties. The coefficients of interest, β_4 and α_4, show the impact of the boom on employment and real wages in these counties.

Table 1 contains the results of the oil boom using equation 1 and 2. The coefficients of interest once again are the ones matched with BAK*POST. Counties with a higher percentage of jobs that fall into the natural job category tend to have experienced more growth in employment and wages from 2001 to 2011. This could be a function of the fact that BAK counties tended to have a higher percentage of these jobs before the oil boom and this variable is simply detecting this.

The variable of interest in equation 1 and 2, BAK*POST, indicates that employment in Bakken counties increased 8.68% more than it did in non-BAK counties. In addition, real wages grew 4.85% more in Bakken counties than non-Bakken counties. The combination of evidence indicating that employment and wages have risen in the area indicates that the demand for labor has increased more than the supply of labor over the post oil boom time frame.

Difference-in-Difference in the Slope

Referring back to Figures 2 and 3, it appears that employment and real wage levels are not only affected by the oil boom, but also the rate of growth has changed. A modified difference-in-difference is used to measure a change in the rate of growth in both employment and wages. The DD model is modified as follows to measure the change in the rate of growth:

$$\text{Log } EMP_{it} = \theta_1 X_i + \theta_1 t + \theta_2 t*BAK_i + \theta_3\, t*POST_i + \theta_4\, t*BAK_i*POST_i \quad (3)$$

$$\text{Log } RWG_{it} = \delta_1 X_i + \delta_1 t + \delta_2 t*BAK_i + \delta_3 t*POST_i + \delta_4 t*BAK_i*POST_i \quad (4)$$

The primary adaptation is the inclusion of t, is a time trend increasing by one each quarter. The coefficients of interest, θ_4 and δ_4 measure the change in the rates of growth of employment and wages, respectively, in BAK counties relative to non-BAK counties.

Table 2 displays the results from equations 3 and 4. Focusing on the variable of interest, t*BAK*POST, Bakken counties' employment grew at a rate

of .271% faster per quarter than non-Bakken counties after the oil boom start ed. Equation 4 shows no statistically significant changes in the quarterly growth rates in BAK counties relative to non-BAK counties. This indicating that after the initial increase in demand for labor, the supply has kept up with growth in demand.

In addition, counties with an higher percentage of jobs that fall into the natural jobs category experience increases in the rate of growth for both employment and wages. This also could be attributed to the higher percentage makeup of natural jobs in BAK counties as discussed earlier.

Conclusion

The evidence suggests that the oil boom in the Bakken region had a significant impact on both employment and wages in the area. The oil boom increased employment in the Bakken region by 8.68% and real wages by 4.85% compared to non-BAK counties.

The difference in difference in the slope showed that the rate of growth of employment is increasing at a faster rate than it did before the oil boom also. BAK counties are growing 0.271% faster per quarter post boom than non-BAK counties. The rate of growth in real wages is not found to be statistically different between BAK and non-BAK counties post boom. A possible explanation for this is the increase in population of BAK counties during this time, shifting the supply curve to the right enough to offset the growing demand for labor

The combination of the results shows that the oil boom did have an impact on both employment and wages. After the initial increase in demand, the supply of labor has been able to keep up with the demand. This serves as a possible explanation for why the modified DD did not show an impact in the rate of growth in real wages over time.

Policy concerns have been raised about how to maximize tax revenue to keep cost of living down. Any policy being discussed should take into consideration the impact it could have on employment and wages. This study measures the impact the oil boom has had on employment and wages over time. This research highlights that altering the incentives for firms to expand oil production in the Bakken will likely have an impact on employment and wages. Namely, future research could examine the elasticity of employment and wage growth relative to an increase in the effective tax rate on oil firms.

Table 1: Difference-in-Difference in the intercept

Regressor	log employment		log real wages	
Intercept	-1.374034	***	6.007828	***
	(0.097902)		(0.080565)	
% Business	-1.10901	***	-2.302446	***
	(0.194642)		(0.160174)	
% Construction	0.336756		1.8205	***
	(0.353291)		(0.290729)	
% Education	-0.045642		-0.746387	***
	(0.103252)		(0.084967)	
% Finance	-1.544962	***	-0.886137	***
	(0.306856)		(0.252517)	
% Information	-1.497175	***	0.977752	***
	(0.332338)		(0.273486)	
% leisure	-3.837134	***	-3.502397	***
	(0.225494)		(0.185563)	
% Manufacturing	-1.010012	***	-0.503429	***
	(0.067945)		(0.055913)	
% Natural	0.90521	***	0.400182	***
	(0.165414)		(0.136122)	
% Transportation	-0.456834	***	0.046979	
	(0.100531)		(0.082729)	
Log Labor Force = 2001	1.19803	***	0.09429	***
	(0.007228)		(0.005948)	
Quarter 2 = 1	0.013025		-0.040536	***
	(0.010392)		(0.008552)	
Quarter 3 = 1	0.016774		-0.011072	
	(0.010605)		(0.008727)	
Quarter 4 = 1	0.014492		0.08612	***
	(0.010444)		(0.008594)	
BAK = 1	0.008173		0.097325	***
	(0.008514)		(0.007007)	
Post = 1	-0.023446		0.066658	***
	(0.015316)		(0.012604)	
BAK*Post = 1	0.086778	***	0.048528	***
	(0.01929)		(0.015874)	
Adjusted R	0.991674		0.788846	
F value	7527.279		237.0613	
N	1012		1012	

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level

Table 2: Difference-in-Difference in the Slope

Regressor	log employment		log real wages	
Intercept	-1.477054	***	5.529028	***
	(0.110837)		(0.084675)	
% Business	-1.18746	***	-2.365613	***
	(0.189726)		(0.144943)	
% Construction	0.471526		1.846399	***
	(0.353075)		(0.269735)	
% Education	0.07611		-0.630626	***
	(0.103666)		(0.079197)	
% Finance	-1.340254	***	-0.790761	***
	(0.30201)		(0.230724)	
% Information	-1.297464	***	1.10219	***
	(0.328039)		(0.250609)	
% leisure	-3.842699	***	-3.393755	***
	(0.223426)		(0.170689)	
% Manufacturing	-0.923628	***	-0.440139	***
	(0.067447)		(0.051527)	
% Natural	0.954788	***	0.556996	***
	(0.166335)		(0.127074)	
% Transportation	-0.428664	***	0.114094	
	(0.101139)		(0.077267)	
Log labor force 2001	1.200769	***	0.138298	***
	(0.009355)		(0.007147)	
t*log labor force 2001	6.99E-05		-0.001745	***
	(0.000267)		(0.000204)	
Quarter 2 = 1	0.015001		-0.04003	***
	(0.01038)		(0.00793)	
Quarter 3 = 1	0.018486	*	-0.012828	
	(0.010586)		(0.008087)	
Quarter 4 = 1	0.014471		0.080313	***
	(0.010426)		(0.007965)	
T	0.000475		0.017086	***
	(0.002404)		(0.001837)	
t*BAK	-0.000342		0.001706	***
	(0.00044)		(0.000336)	
t*POST	-0.000275		0.004477	***
	(0.000862)		(0.000659)	
t*BAK*Post	0.002714	***	-0.000599	
	(0.000845)		(0.000646)	
Adjusted R	0.991715		0.81891	
F value	6724.266		254.9924	
N	1012		1012	

*** Significant at the 99% confidence level
** Significant at the 95% confidence level
* Significant at the 90% confidence level

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