Oil Booms and Sectoral Spillovers in the United States

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Abstract

This paper examines the long and short-run effects of oil booms on agriculture and manufacturing outcomes in the United States using three different natural experiments. First, I evaluate the long-run impact of oil abundance on modern-day farm and manufacturing earnings and employment. Second, I analyze the short-run response of these outcomes to the oil price boom and bust cycle of the 1970s and 80s. Third, I estimate the impact of fracking booms in counties lying over productive shale plays. Overall, I find mixed evidence for how oil booms impact manufacturing activity. For agricultural outcomes, effects are somewhat consistently negative, providing evidence of "Dutch Disease" mechanisms for agriculture, though the results for fracking booms are inconclusive.

Keywords: Natural Resource Discoveries; Dutch Disease; Agriculture; Manufacturing

JEL Classification: Q32; Q33; Q10; R11

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1 Introduction

The question of how natural resource abundance affects overall growth and other economic sectors has spawned an enormous and active literature. The seminal papers Sachs and Warner (1995) and Sachs and Warner (2001) found a negative relationship between countries' natural resource dependence and GDP growth. Much of the subsequent literature examined possible mechanisms by which natural resources might harm growth and otherwise confirmed the negative relationship.[1] However, a number of more recent studies have found mixed or positive effects of natural resource abundance, calling the resource curse consensus into question,[2] and the literature remains very active.

In addition to country-level studies, several studies have analyzed the effects of local natural resource abundance within the United States,[3] a literature that has recently become significantly more active following the fracking boom.[4] These studies tend to find positive overall economic effects, though effects on agriculture and manufacturing output are generally ambiguous.

One of the most common explanations for a possible resource curse is the theory of "Dutch Disease" (so named after the slump in manufacturing following the 1970s gas boom in the Netherlands), a framework established in Corden and Neary (1982) in which booming resource exports harm other exported sectors like manufacturing and agriculture through two channels. First, the higher-productivity resource sector draws labor away from other sectors (called the "resource movement effect"). Second, the higher income from the oil boom raises demand for local services, likewise drawing labor away from exporting sectors (called the "spending effect"). However, these two effects do not fully describe the possible spillovers into non-oil sectors. For example, governments might use increased tax revenue to subsidize or invest

[1]For example Torvik (2002), Gylfason et al. (1999), Ross (2001), and Robinson et al. (2006).
[2]See Brunnschweiler and Bulte (2008), Alexeev and Conrad (2009), Smith (2015), and James (2015).
[3]For example Michaels (2010), Allcott and Keniston (2017), Jacobsen and Parker (2016), Matheis (2016).
[4]For example Feyrer et al. (2017) and Maniloff and Mastromonaco (2017).

directly in agriculture and manufacturing to offset the negative effects. Therefore the question of how oil booms impact local other sectors overall is empirical.

This paper uses three distinct natural experiments to analyze both short and long-run effects of oil booms on agriculture and manufacturing activity. First, similarly to Michaels (2010)[5], I evaluate how natural oil abundance is associated with modern-day outcomes. Because the United States has been thoroughly prospected and no major oil discovery has been made since the 1970s, it is reasonable to assume that having made a major discovery at any point in the past is a proxy for natural oil abundance, making the US an ideal setting to study the long-run economic effects of natural resource abundance.

Second, I study how agriculture and manufacturing outcomes in oil-abundant counties respond in the short-term to the severe oil price shocks of the 1970s and 80s, using the same abundance definition as in the long-run analysis. These shocks generally arose from geopolitical and global economic factors exogenous to any US county's economy. Further, the roughly symmetrical nature of the boom and bust over this period allows analysis of whether outcomes respond symmetrically to boom and bust cycles, and also lend further confidence that estimated effects are in fact due to oil shocks rather than other unrelated trends. This analysis is similar to that used in Jacobsen and Parker (2016) and Smith (2019), the former of which only analyzes the American West and the latter of which is a cross-country study.

Third, I estimate the impact of the fracking boom on agriculture and manufacturing outcomes in shale-rich counties. The fracking boom was an exogenous technology shock brought about by advances in horizontal drilling. Actual fracking activity could be endogenously determined, as some areas have banned or restricted the practice. Therefore treatment is defined by whether a county lies over a productive shale play. This definition is again based on exogenous natural abundance rather than actual local drilling activity.

I find that oil abundance had minor negative effects on both farm and manufacturing em-

[5] Michaels (2010) only examines the US South, while the present study considers the entire country.

ployment in the long-run (negative but non-significant effects are found for farm and manufacturing earnings). I likewise find that both farm and manufacturing employment are strongly related to the oil price, but in opposite directions. Manufacturing employment and earnings rise during the booms of the 1970s and fall during the bust of the 1980s, suggesting positive spillovers from the oil sector. Farm employment displays the opposite pattern.

I do not find evidence that the fracking boom impacted manufacturing in shale-rich areas, and the effect on agricultural activity is ambiguous: farm employment effects increase early in the fracking period and stay roughly flat thereafter, while farm earnings actually decrease in the early fracking period and stay roughly flat afterward. I thus do not make strong conclusions about how fracking has impacted farming activity.

This paper is organized as follows: Section 2 discusses the data and empirical specifications used in this study. Section 4 presents and discusses results, and Section 5 concludes.

2 Data and Methodology

In this section I discuss data sources and outline the identification strategy for each of the three natural experiments used to analyze the effect of resource discoveries on agricultural and manufacturing output.

2.1 Resource Data

Data on fossil fuel abundance comes from two sources. First, historical oil discoveries are drawn from the Oil and Gas Journal Data Book (2000), which lists all US oil fields containing at least 100 million barrels along with the year of discovery. This data set is linked to the Energy Information Administration's (EIA) Oil and Gas Field Code Master List, which provides the county where the field is located. Any county containing a field of at least 100 million barrels is assigned to the treatment group in the long-run and boom-bust analyses.

The second source pertains to the fracking boom. The EIA provides data (including shapefiles) for shale plays in the US. As in James and Smith (2017), for the fracking boom analysis we define treatment counties as those with with a geographic center lying over a "booming play." Booming plays are defined as those that contributed at least 1 percentage point of the overall increase in US shale oil or gas production between 2000-2012. The ten plays that meet this definition cumulatively make up over 90% of the growth in both shale oil and gas. Figure 4 displays the locations of all major shale plays in the US, with booming plays indicated by dashed lines. 205 counties in my main fracking analysis sample have a geographic center lying over one of these plays and are classified as treated.

2.2 Other Data Sources

My primary outcome variables are agricultural and manufacturing earnings and employment provided by the Bureau of Economic Analysis (BEA). These datasets tally total personal income earned and employment counts by several industries for all counties and years from 1969-2017.

Control variables used in the long-run analysis of Equation 1 include 1890 values of number of farms per square mile and a time-invariant measure of soil quality. The 1890 number of farms comes from a dataset used in Michaels (2010) (originally drawn from US Census data) and generously provided by the author. County-level soil quality data come from Schaetzl et al. (2012), and measures "natural native soil productivity" based on several soil characteristics.

2.3 Empirical Specification: Long-run Effects

The long-run, modern-day effects of resource abundance are estimated with the following equation:

$$Y_{i,2000} = \alpha + \beta * D_i + X_i + \delta_s + \epsilon_i, \tag{1}$$

Where $Y_{i,2000}$ is an outcome pertaining to agriculture or manufacturing activity in the year 2000 in county i,[6] D_i is an indicator equal to one if the county experienced a major oil field discovery, X_i is a set of control variables, and δ_s denotes state fixed effects. β then estimates the average conditional difference in 2000 outcomes between treatment and control counties and is the coefficient of interest. Control variables include a measure that proxies for the importance of agriculture or manufacturing (depending on which is the outcome variable) as of 1890. For the agriculture regression, this is the 1890 number of farms per capita. For manufacturing, it is the 1890 share of employment in manufacturing. These variables are included so modern-day farm earnings are compared to a pre-oil discovery baseline, so this specification may be thought of as a long-run two-period difference-in-differences model. Also included are soil quality decile bins that are meant to control for the effect of soil quality in a flexible, non-linear way. Standard errors are robust to heteroskedasticity.

2.4 Empirical Specification: Boom and Bust

Following a long period of low and stable oil prices, the OPEC oil embargo of 1973 more than quadrupled oil prices in the span of a few months. Prices remained elevated after the embargo ended due to fears of future embargos. Prices spiked again following the Iranian Revolution of 1978. In the following decade, however, real prices declined all the way to nearly pre-embargo levels. This was due to several factors, including improving energy efficiency and deepwater drilling technology significantly increasing global oil supply. The real oil price over time is shown in Figure 2, with vertical lines separating boom and bust periods.

[6] 2000 is chosen because it follows a long period of stable oil prices and shortly precedes the price surge that lasted for most of the following decade.

Effects of the boom-bust cycle on agriculture and manufacturing in oil-abundant counties are estimated with the following equation:

$$Y_{it} = \alpha + \sum_{s=1970}^{1990} \beta_s(\lambda_s D_i) + \mu_i + \gamma_t + \epsilon_{i,t} \tag{2}$$

where Y_{it} is an agriculture or manufacturing outcome for county i in year t. μ_i and γ_t are county and year fixed effects, respectively. λ_s is a year indicator equal to one if s=t and zero otherwise, and D_i is an indicator equal to one if county i ever experienced a major oil field discovery, as in Equation 1. β_s is then the conditional difference between oil-abundant and non-abundant counties in year s, relative to the difference in the omitted year 1969, which is interpreted as the estimated treatment effect in year s. Standard errors for all regressions are clustered at the county level.

2.5 Empirical Specification: Fracking Boom

Following advances in horizontal drilling technology, shale oil and gas production increased immensely during the 2000s (See Figure 3). Effects of the fracking boom on agriculture and manufacturing are estimated with the following equation:

$$Y_{it} = \alpha + \sum_{s=2001}^{2015} \beta_s(\lambda_s D_i) + \mu_i + \gamma_t + \epsilon_{i,t} \tag{3}$$

This specification is similar to Equation 2 above, but covers the period 2000-2015 to correspond to the fracking boom and with the treatment dummy D_i indicating whether the county lies over a "booming" shale play. Here β_s is the conditional difference between fracking and non-fracking counties in year s, relative to the difference in the omitted year 2000. Standard errors are again clustered at the county level.

3 Results

3.1 Long-run Effects

The results from Equation 1 are displayed in Table 1. There is no evidence that major oil discoveries impacted farm or manufacturing earnings in the long-run. However, oil discoveries are associated with decreases in employment shares of 1.3 and 1.1 percentage points for farming and manufacturing, respectively. Both effects are statistically significant at only a 10% level. Qualitatively these effects are not especially large; the sample average for year 2000 farm employment share is 8.7% with a standard deviation of 8.4 percentage points. Sample average manufacturing employment in 2000 averages 13.8% with a standard deviation of 9.1 percentage points. Still, there is some evidence of negative spillovers to these sectors from oil abundance in the long run.

3.2 Boom and Bust

The results from Equation 2 are displayed in Figures 5-10. The dotted lines indicate periods of oil price boom and busts (See Figure 2). Farm earnings decrease sharply following the oil boom, though recover fully before the boom period ends. This is somewhat suggestive of negative spillovers from oil, but the effects are highly erratic throughout the sample period. Farm employment shares, however, show a clear negative relationship with oil booms, with steadily decreasing effects throughout the boom period, which then start recovering three years into the bust period. By 1990 there is virtually no effect on employment shares. It is possible that these effects on employment shares could arise because oil booms increase overall employment without actually harming the farming sector. But Figure 7 reveals this is not the case. In this regression the dependent variable is the natural log of total farm employment. Again farm employment is depressed during the oil boom, bottoming out at a 5% decrease in employment relative to the counterfactual, and then recovering during the bust period.

Manufacturing outcomes display the opposite pattern, generally rising during the boom period and declining during the bust period (with some delay before the decline begins). This is consistent with past literature examining effects of oil booms on manufacturing. These effects are quite large, with both earnings and total employment effects topping out at between 20-30%. It should be noted that manufacturing activity did begin to increase in the pre-boom period, though there is no pre-trend the 2-3 years immediately preceding the boom.

Overall the effects found for the US are similar to those found in a cross-country setting during the same boom and bust period in Smith (2019), which likewise found pro-cyclical effects for manufacturing and the opposite for agriculture.

3.3 Fracking Boom

The results from Equation 3 are displayed in Figures 11-16. Taken as a whole, the effects on agricultural activity are somewhat ambiguous. Farm earnings do experience negative effects overall starting in the late 2000s, but then recover somewhat and the estimates are only intermittently statistically significant. Farm employment shares see a strong negative trend starting in 2010, but this is due to increases in employment in non-farming sectors. Overall farming employment increases during the sample period (though mainly before the boom in overall employment, which begins in roughly 2008) and only slightly decreases later in the sample. The overall pattern for farm employment is not suggestive of a strong impact from fracking.

There is even less evidence that the fracking boom influenced manufacturing. All three manufacturing outcomes display generally flat effects during the fracking boom (though manufacturing employment share does increase in the early 2000s, well before the start of the boom). The lack of effects is consistent with the findings in Maniloff and Mastromonaco (2017), which attributes the overall employment boom to mining, construction, transportation, and retail trade (this paper does not evaluate effects on agriculture).

4 Conclusion

The importance of understanding the many direct and indirect impacts of resource booms has spawned a large and ongoing literature. Spillover effects of resource booms into manufacturing have been fairly well studied, but a comprehensive account of such spillovers in the United States has been lacking, and spillovers into agriculture are not well understood. This study aims to fill these gaps, using three different natural experiments to estimate the impacts of oil booms on manufacturing and agriculture. In sum, I find mixed effects on manufacturing, with negative long-run effects, but pro-cyclical short-run effects during the oil boom and bust periods of the 1970s and 80s. Except for the recent fracking boom, I find negative impacts of oil booms on agriculture in both the short and long-run.

That negative "Dutch Disease" mechanisms appear to be present for agriculture but not manufacturing is an interesting finding. Smith (2019), which finds a similar pattern at the country-level, argues that governments may have used resource revenues to conduct industrial policy in favor of manufacturing but not agriculture, since manufacturing is considered more important for long-run development. Future research could dig deeper into the patterns revealed here, and examine whether local governments flush with severanct tax revenue tended to subsidize manufacturing, while higher wages and returns to capital in other sectors left agriculture out to dry.

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Figure 1: Oil Discovery Counties

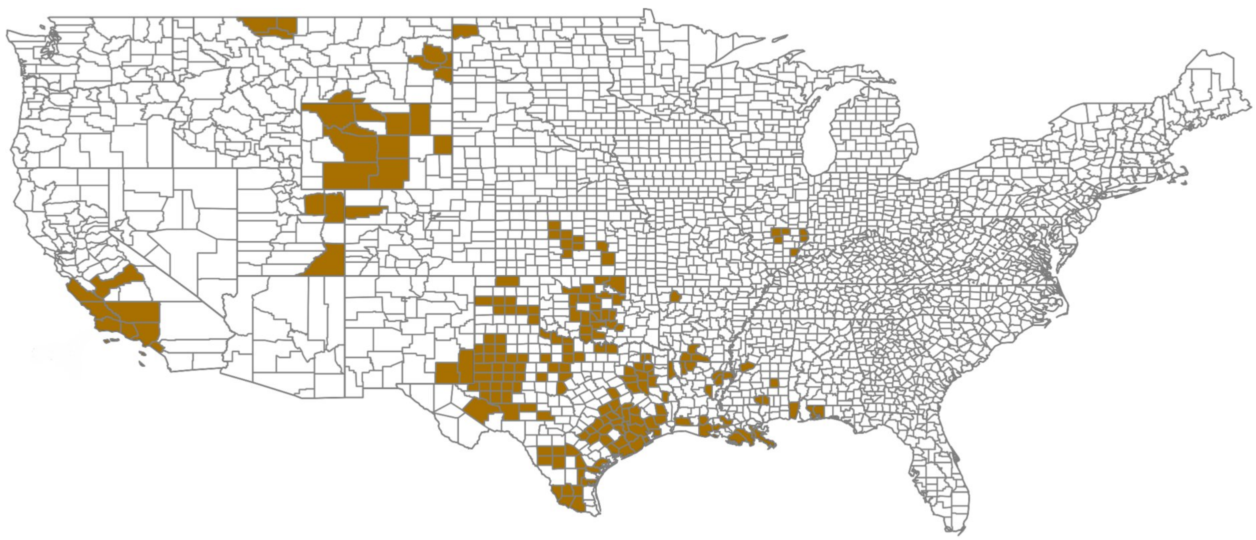


Figure 2: Real Oil Price Over Time

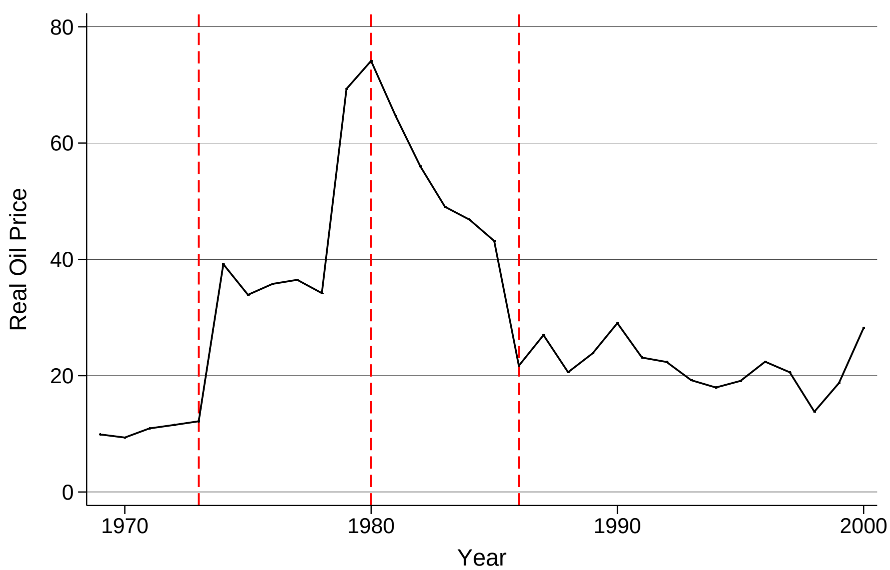
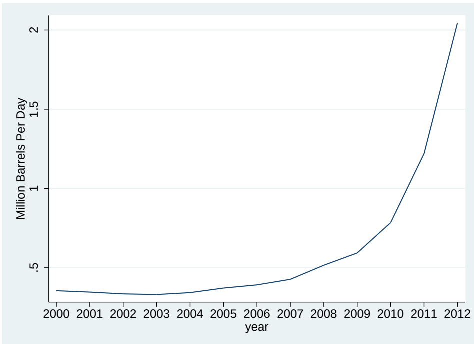
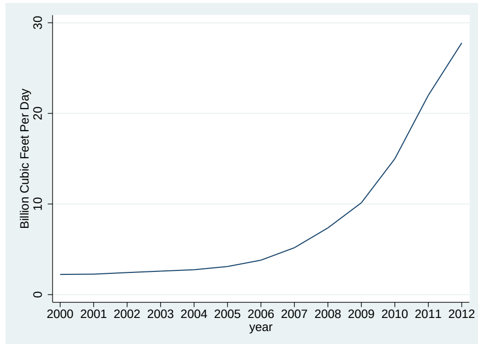


Figure 3: U.S.Shale Gas and Tight Oil Production, 2000-2012



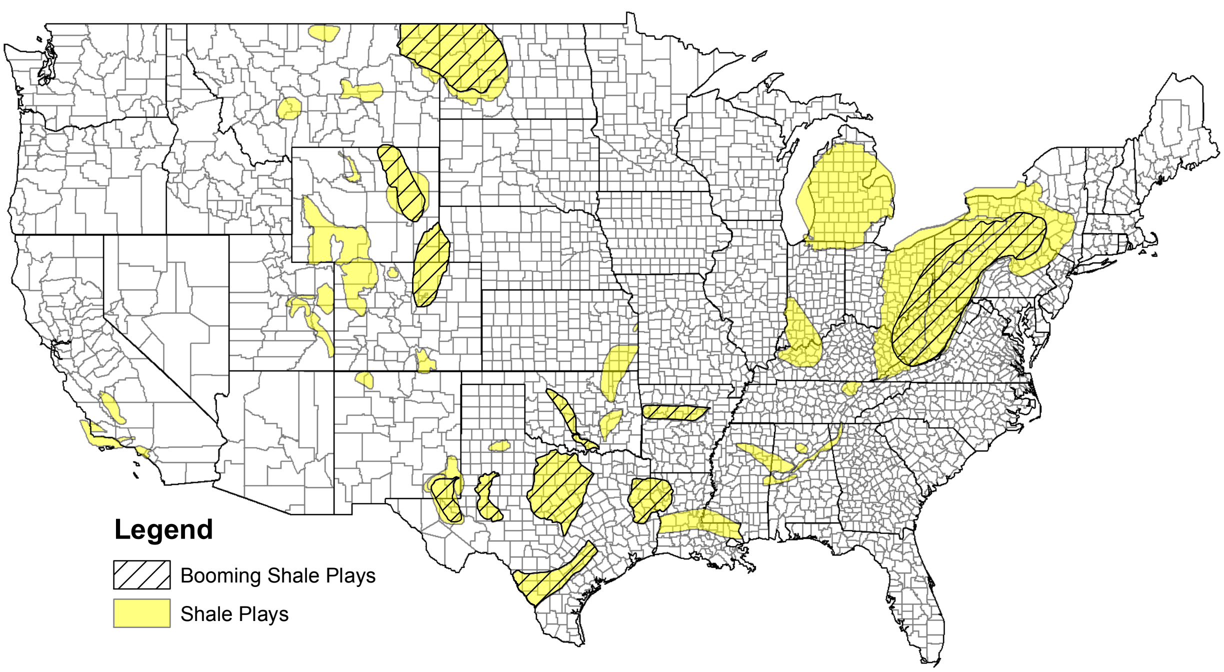
(a) Tight Oil Production



(b) Shale Gas Production

Note: Data collected from the Energy Information Administration, Shale in the United States

Figure 4: US Shale Plays



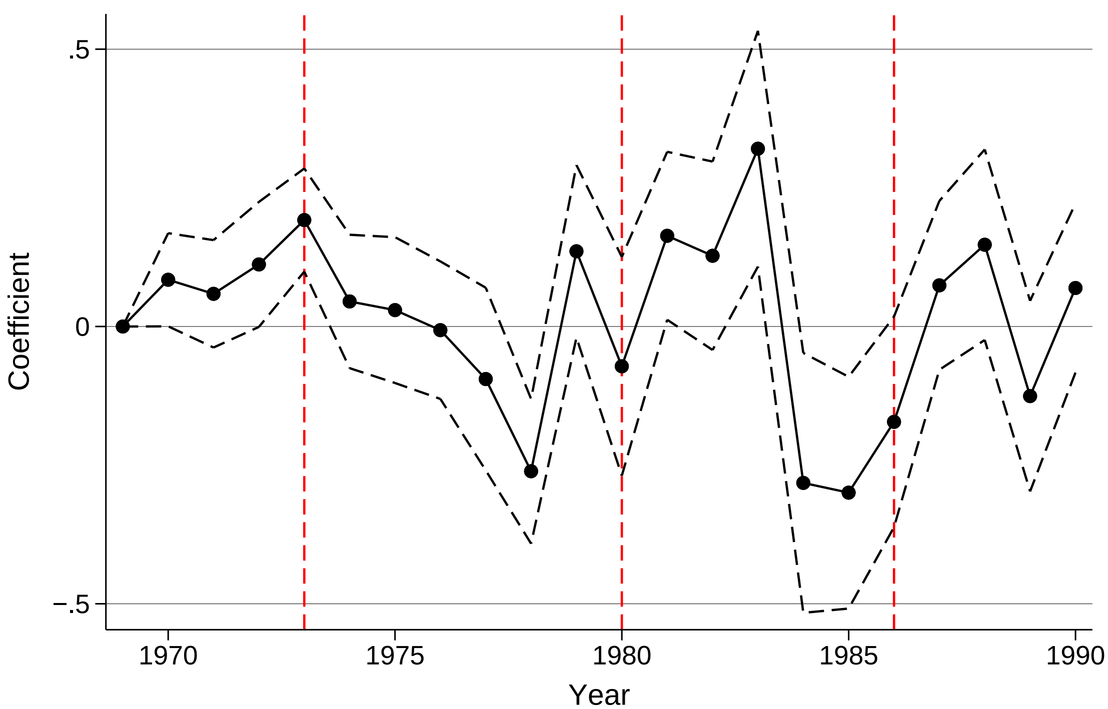
Source: Energy Information Administration

Table 1: Long-run Effects of Oil Abundance on Farm and Manufacturing Outcomes

	(1) Ln(Farm Earnings)	(2) Farm. emp. share	(3) Ln(Mfg. Earnings)	(4) Mfg. emp. share
Oil Rich	-0.078	-0.013*	-0.125	-0.011*
	(0.168)	(0.008)	(0.109)	(0.006)
1890 farms/cap	11.324***	0.538***		
	(0.978)	(0.050)		
1890 Mfg. emp. share			5.133***	0.007
			(0.508)	(0.042)
N	2422	2674	2393	2409
r2	0.39	0.42	0.27	0.29

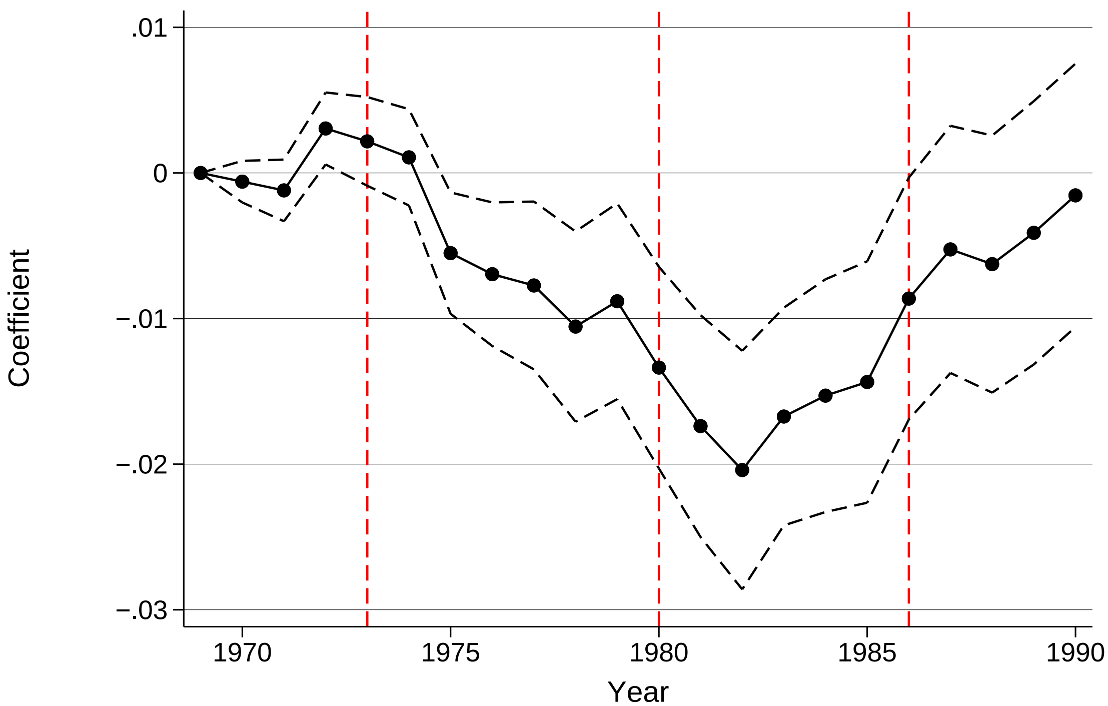
The dependent variable is indicated in the column header. All regressions include a set of decile indicators for soil quality and state fixed effects. *, **, *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Figure 5: Farm Earnings Effects of Oil Boom and Bust



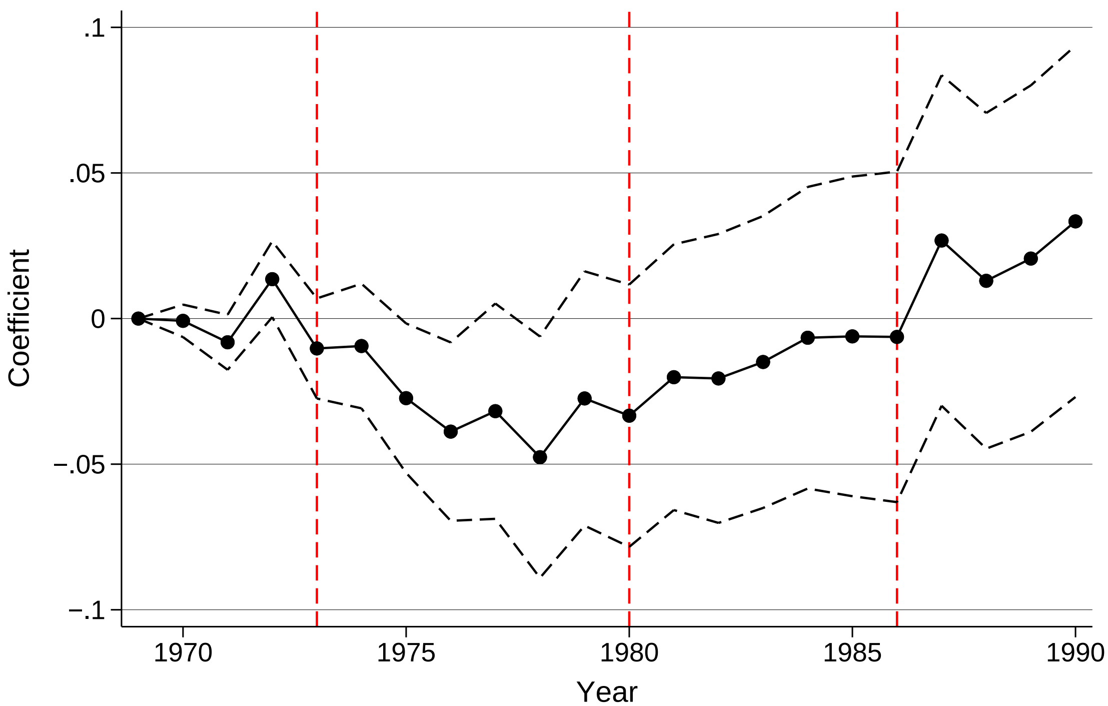
The figure plots year-specific treatment effect estimates of being an oil-abundant county from Equation 2, along with 95% confidence intervals. 1969 is the omitted reference year. Vertical lines denote the starts and ends of the boom and bust periods corresponding to Figure 2.

Figure 6: Farm Employment Share Effects of Oil Boom and Bust



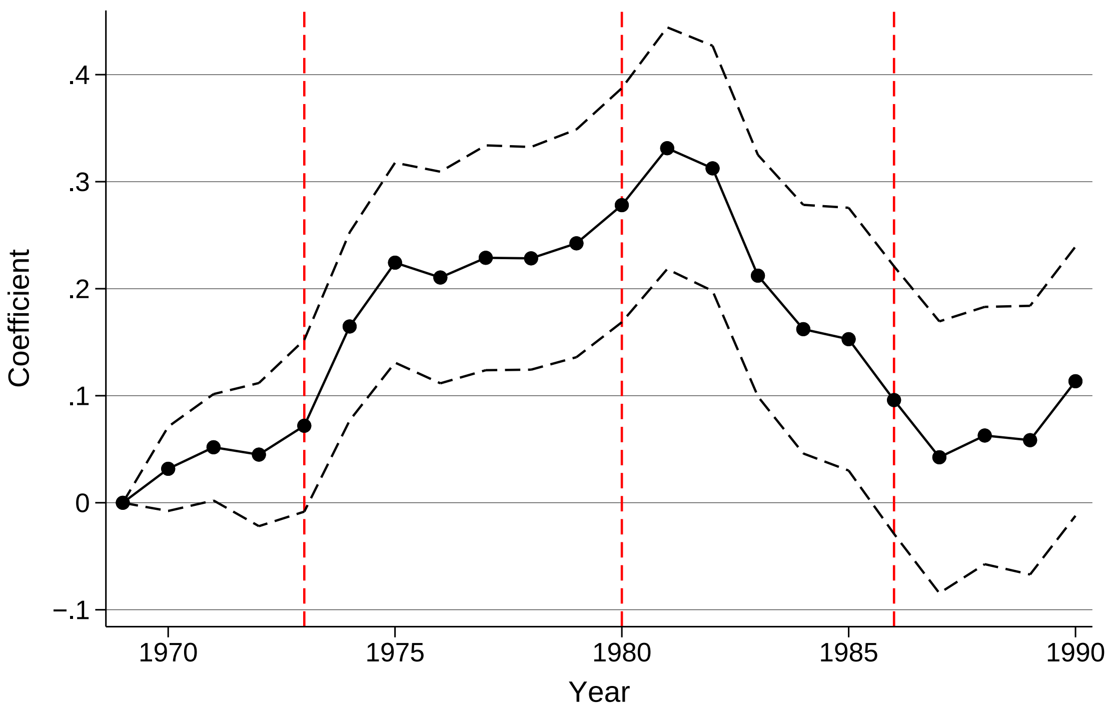
The figure plots year-specific treatment effect estimates of being an oil-abundant county from Equation 2, along with 95% confidence intervals. 1969 is the omitted reference year. Vertical lines denote the starts and ends of the boom and bust periods corresponding to Figure 2.

Figure 7: Ln(Farm Employment) Effects of Oil Boom and Bust



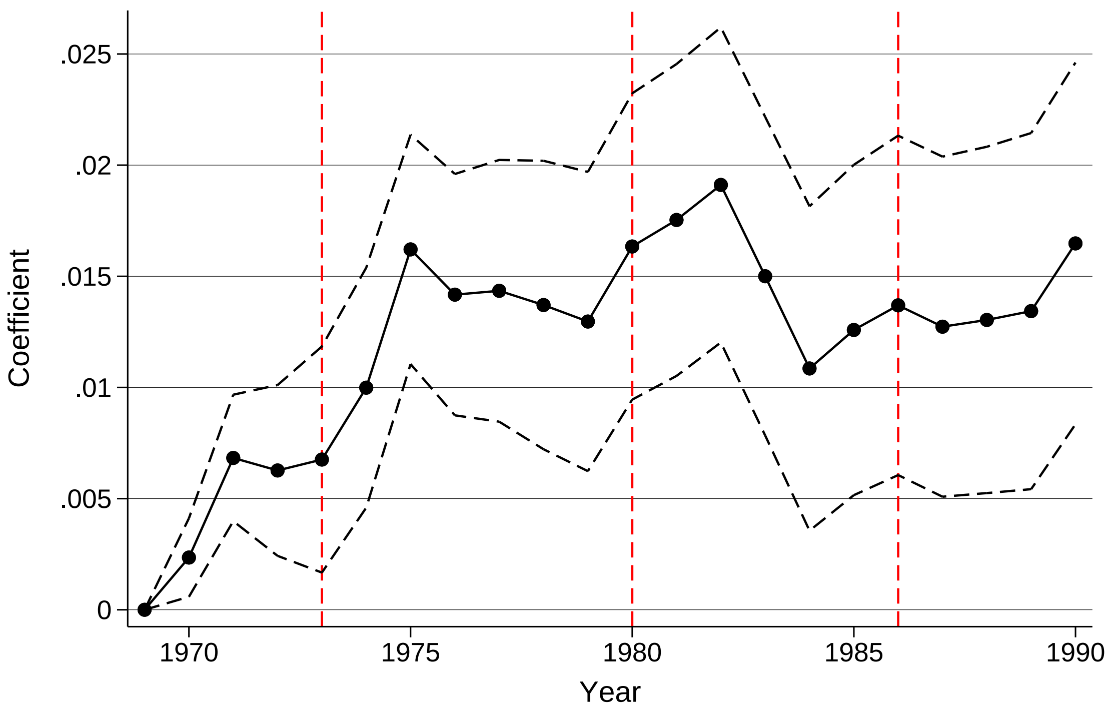
The figure plots year-specific treatment effect estimates of being an oil-abundant county from Equation 2, along with 95% confidence intervals. 1969 is the omitted reference year. Vertical lines denote the starts and ends of the boom and bust periods corresponding to Figure 2.

Figure 8: Manufacturing Earnings Effects of Oil Boom and Bust



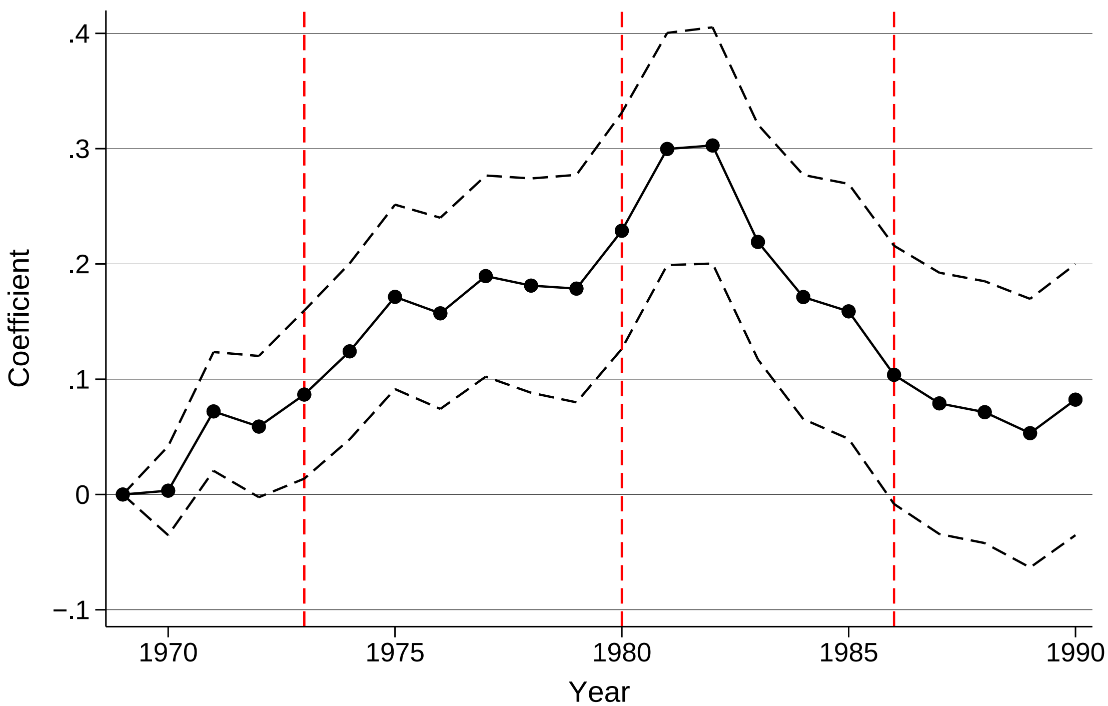
The figure plots year-specific treatment effect estimates of being an oil-abundant county from Equation 2, along with 95% confidence intervals. 1969 is the omitted reference year. Vertical lines denote the starts and ends of the boom and bust periods corresponding to Figure 2.

Figure 9: Manufacturing Employment Share Effects of Oil Boom and Bust



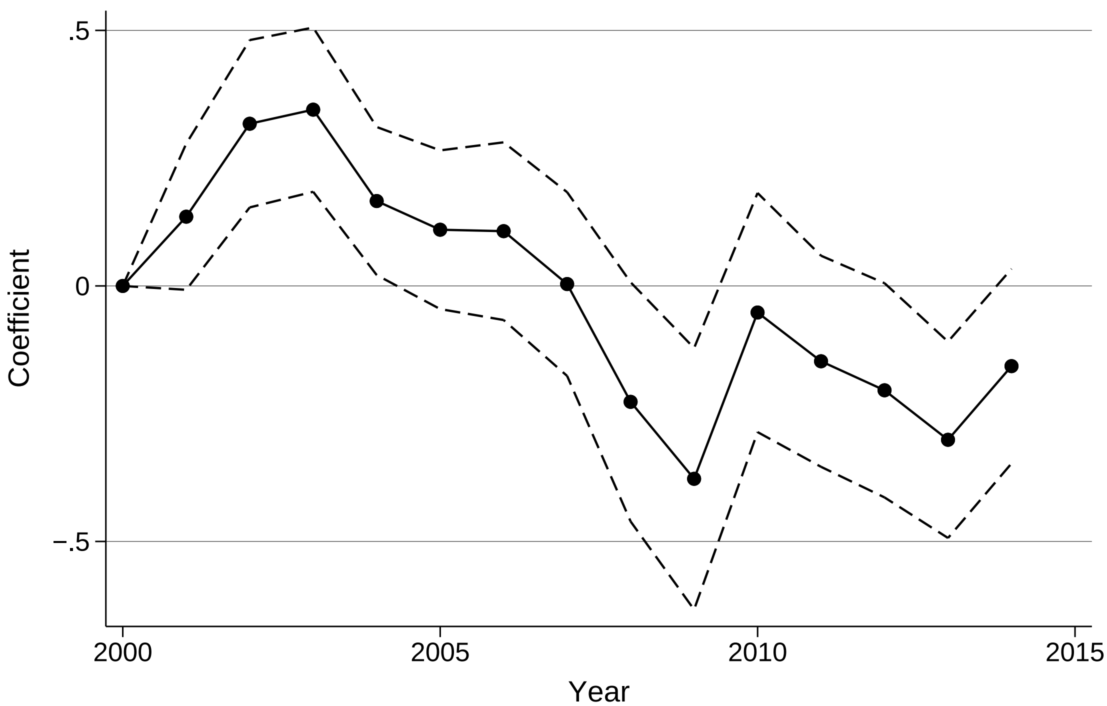
The figure plots year-specific treatment effect estimates of being an oil-abundant county from Equation 2, along with 95% confidence intervals. 1969 is the omitted reference year. Vertical lines denote the starts and ends of the boom and bust periods corresponding to Figure 2.

Figure 10: Ln(Manufacturing Employment) Effects of Oil Boom and Bust



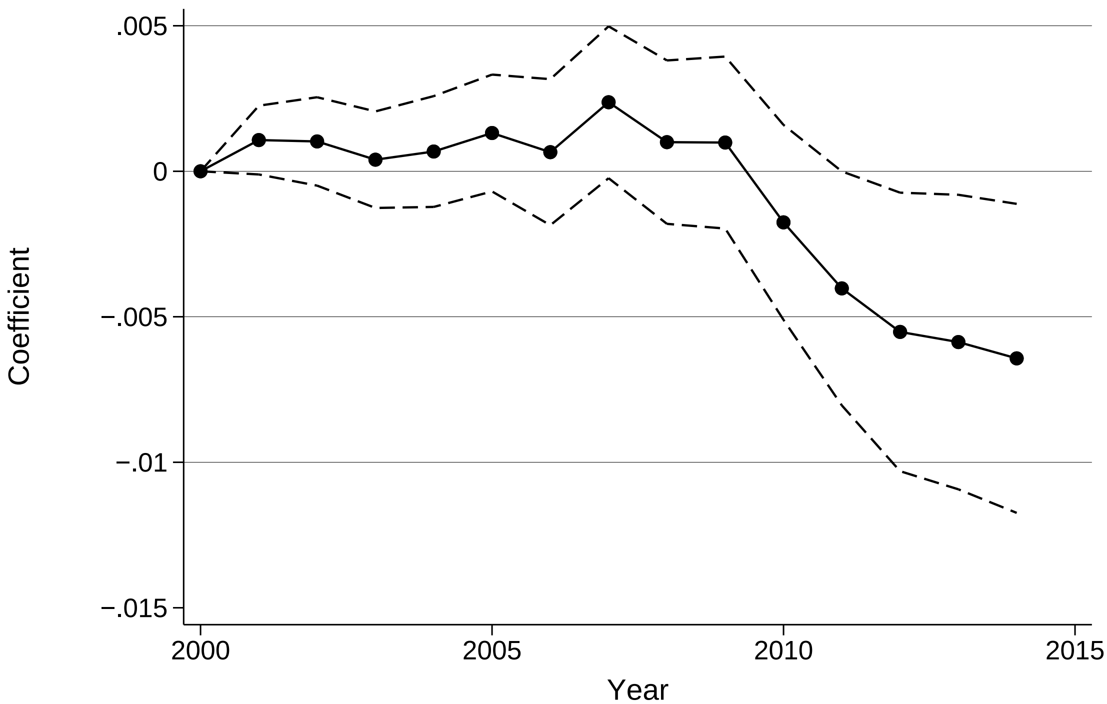
The figure plots year-specific treatment effect estimates of being an oil-abundant county from Equation 2, along with 95% confidence intervals. 1969 is the omitted reference year. Vertical lines denote the starts and ends of the boom and bust periods corresponding to Figure 2.

Figure 11: Farm Earnings Effects of Fracking Boom



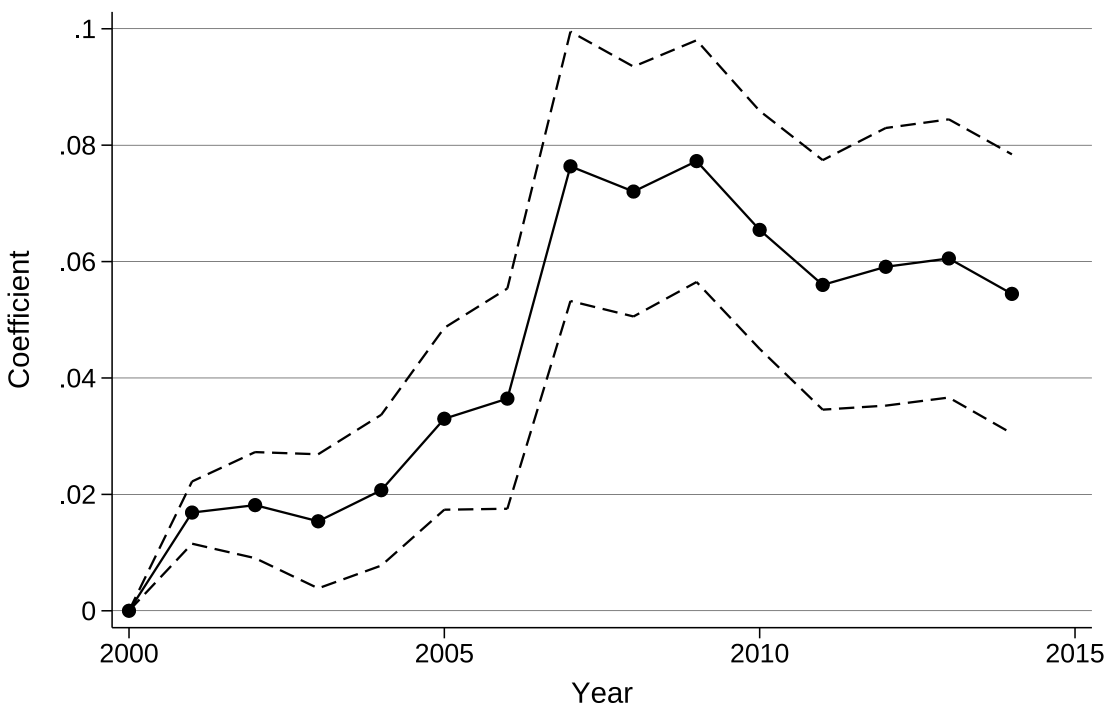
The figure plots year-specific treatment effect estimates of lying over a booming shale play, along with 95% confidence intervals. 2000 is the omitted reference year.

Figure 12: Farm Employment Share Effects of Fracking Boom



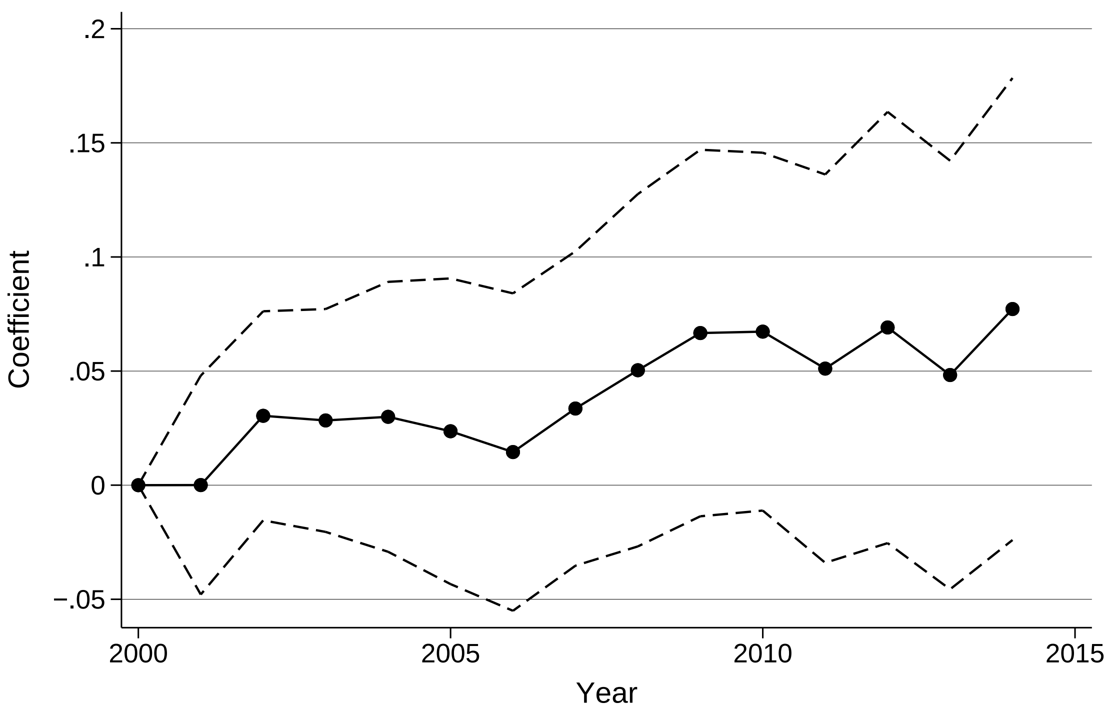
The figure plots year-specific treatment effect estimates of lying over a booming shale play, along with 95% confidence intervals. 2000 is the omitted reference year.

Figure 13: Ln(Farm Employment) Effects of Fracking Boom



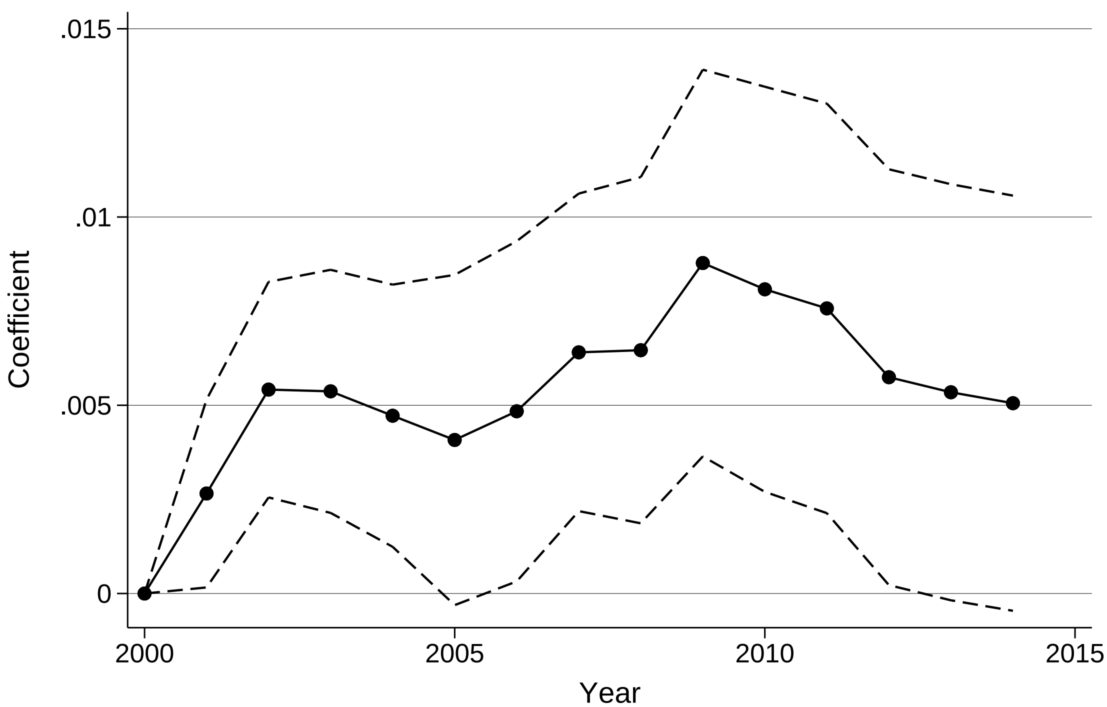
The figure plots year-specific treatment effect estimates of lying over a booming shale play, along with 95% confidence intervals. 2000 is the omitted reference year.

Figure 14: Manufacturing Earnings Effects of Fracking Boom



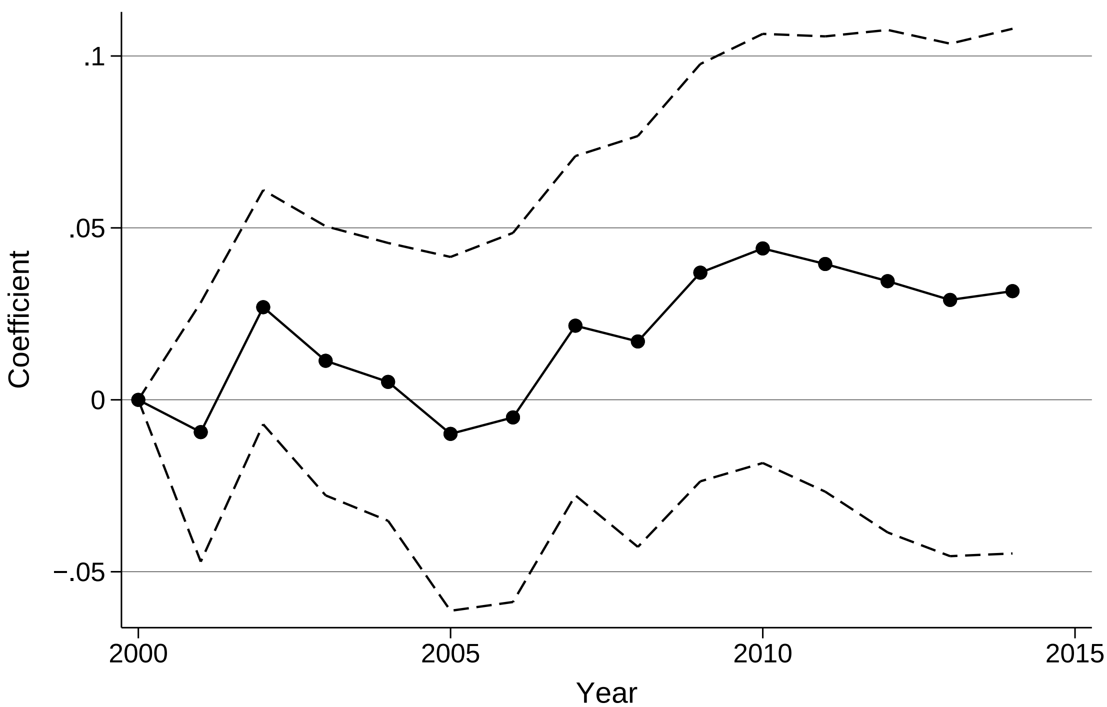
The figure plots year-specific treatment effect estimates of lying over a booming shale play, along with 95% confidence intervals. 2000 is the omitted reference year.

Figure 15: Manufacturing Employment Share Effects of Fracking Boom



The figure plots year-specific treatment effect estimates of lying over a booming shale play, along with 95% confidence intervals. 2000 is the omitted reference year.

Figure 16: Ln(Manufacturing Employment) Effects of Fracking Boom



The figure plots year-specific treatment effect estimates of lying over a booming shale play, along with 95% confidence intervals. 2000 is the omitted reference year.