Do Localities Benefit from Natural Resource Extraction?*

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Abstract

There is a strand of the economics literature that considers the regionalized economic effects of natural resource endowments. The so-called Natural Resource Curse suggests that natural resource endowments are associated with lower long-term growth rates in the areas in which the resources are located. Lower growth arises because these areas tend to specialize in the development and exploitation of the natural resources at the expense of other dynamic economic activities that offer higher long-term growth potential. Empirical evidence has, however, not reached consistent conclusions. In this paper, we take advantage of the rapid growth in oil and gas development and production in Texas over the course of a decade to consider the localized effects on inter-industry county-level employment at the NAICS-2, county-level mean and median income, and key public finance measures at both the county and school district levels. Considering the effects within a single, large and economically diverse state enables us to control for important state-level variables that influence local public finances. We find little evidence of short term effects necessary to generate the circumstance of a resource curse over the longer term.

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1 INTRODUCTION

With the advances in oil and gas drilling and recovery techniques that have occurred in the last decade, the State of Texas recently experienced another oil and gas boom. Whereas annual crude oil production had been in long term decline in Texas for decades prior to 2010, annual Texas crude oil production nearly tripled between 2009 and 2015, increasing from just below 400 million barrels in 2009 to 1.155 million barrels in 2015. Indeed, according to the U.S. Energy Information Administration, Texas accounted for nearly 40 percent of U.S. crude oil production in February, 2015, or about twice the share it held in February, 2009. This recent explosion in oil and gas production that occurred in Texas is, of course, attributable to the application of horizontal drilling and hydraulic fracturing technologies that have enabled extraction of oil and gas from shale deposits.

Economic research in the 1990s consistently found evidence that resource dependent economies exhibit slower long-term growth than more diversified economies. This phenomenon came to be called the Natural Resource Curse. While various reasons have been proposed for this resource curse, both theoretical and empirical analyses conclude that natural resource driven economic booms draw resources from non-booming export activities, lead to higher prices of non-tradables, and contribute to greater regional specialization. While most of the research in this area has focused on cross-country comparisons, similar results have been found at both the state and county levels in the United States. Yet, there is little research at the sectoral level to identify the microeconomic dynamics that would be inherent in a process of increasing regional specialization. We address that question.

In this paper, using both OLS and censored instrumental variable approaches, we investigate the localized economic effects of oil and gas production and revenues among a defined set of non-urban counties in Texas, as explained below. This paper adds to the literature in several dimensions. Our analysis extends the previous research on the question of resource endowment and employment growth by considering inter-industry effects at the county level. That is, we not only look at county overall employment growth, but investigate employment changes in terms of their industrial composition and the likely inter-industry spillovers that a resource boom might engender. In terms of the data, this would imply an increase in the relative size of the mining sector. This is important since one explanation for the resource curse is regional specialization and the re-allocation of labor toward the booming industry. These latter effects will not be evident in broader measures of employment growth, and would be obscured if county-level labor supply is inelastic.

Previous shorter term analyses of resource booms at the county level, Weber et al (2012), Weber (2014), and Brown (2014) for example, focus on broader measures of employment to analyze the broader impact on economic growth from growth in natural gas production. This paper not only considers a cross-industry view of employment, but also examines possible effects from the rapid increase in petroleum production that occurred more or less concurrently in many counties. We also estimate effects on both median and per capita county income for comparative and interpretive purposes. Our paper further undertakes an analysis of property tax base and public school finance at the school district level, based on host county resource endowment as instrument.

Using only the State of Texas as the region for analysis, we are able to exploit the controlled comparison presented by the uneven distribution of oil and gas resources at the county level to identify the localized impacts of oil and gas production on our variables of interest, i.e., employment, personal income, and public school finance. This provides an important control in the case of public finance that is not present in cross-state analyses. By using a single state for analysis, we have a consistent means by which to consider changes in property tax bases, rates, and public school finance. Although we are unable to observe directly whether or not the increases in tax capacity result in higher levels of local public goods provision, we consider the question of changes in levels of per-student public education expenditures as a direct measure of investment in human capital and an indirect measure of changes in levels in local public goods.[1] We make no attempt to include the environmental costs of the production activity to the localities in which the activity occurs. The jury is still out on the question of the short and long-term environmental costs and consequences of hydraulic fracturing.

We find that, at best, direct and indirect employment effects are modest while increases in per capita county personal income can be important. However, given that we also find lesser effects on county median income, we find it likely that gains in personal income have been rather more concentrated at higher income levels. As expected, we find that the value of county property tax bases increases with

[1] Beginning with Oates (1968), public education expenditures have been widely used as a proxy for the level of provision of local public goods. More recently, Weber, Burnett, and Xiarchos (2016) find that the larger property tax base that resulted from shale oil development in Central Texas led to increased school expenditures.

increases in production levels. Although we find no evidence that school finances were affected by oil and gas revenues over the course of the analysis, school districts appear to benefit from the higher levels of oil and gas activity in the post-2005 period (shale boom) as school tax rates are lower and per pupil expenditures higher in counties with higher levels of oil and gas production. This paper is the first, to our knowledge, to conduct a controlled analysis (single state regime) to investigate the economic effects of oil and gas extraction in relatively small geographies (counties and school districts) and to consider the effects of natural resource extraction on public finances. It is our view that increased resource mobility within small geographies, as opposed to state or national level economies, should accelerate the collateral economic impacts of a sharp expansion in natural resource extraction and facilitate identification of the ingredients that lend themselves to a resource curse over the longer term, if they occur, within a relatively shorter time frame.

After a brief discussion of the economic context of these research questions, we proceed with the empirical analysis in terms of industry effects, county personal income, and property taxes and school expenditures. We finish with a robustness analysis and discussion of conclusions.

2 ECONOMIC CONTEXT

The question of how an endowment of natural resources affects economic growth rates has been extensively studied in the literature. In cross-country comparisons, Sala-i-Martin (1997) finds that primary sector production is negatively correlated with growth and Sachs and Warner (1997) find a negative association between countries' growth rates and their ratios of natural resource exports to GDP. These earlier studies relied on cross-country growth comparisons –assuming convergence in growth rates among regions in the same country– to identify what has come to be called the natural resource curse. Papyrakis and Gerlagh (2007) analyzed growth rates across states in the U.S. and found a significant negative relationship at the state-level between natural resource dependence and income growth. Working at an even finer geographic scale, James and Aadland (2011) draw similar conclusions at the county-level in the United States.

Observation of the apparent natural resource curse has of course spawned a large literature that seeks to explain it. It is commonly argued that natural-resource dependence creates market and institutional failures that induce slower economic growth (Auty, 1994, Bhattacharyya and Hodler, 2010, Gylfason, 2001, Matsuyama, 1992, and Sachs and Warner 1997). Sachs and Warner (2001) note that resource-abundant economies are often high-price economies and tend to miss out on export led growth, i.e., Dutch Disease. James (2015) concludes that resource sectors have generally tended to grow more slowly than other sectors and, therefore, industrial composition is important to take into account. Papyrakis and Gerlagh (2007) conclude that natural resource abundance decreases investment, schooling, openness and R&D expenditures while increasing corruption, which explain the lower state-level growth rates.

To the contrary, Weber (2012) looks at natural gas booms at the county-level in three U.S. states, Colorado, Texas, and Wyoming, for the period 1998/99-2007/08 and finds that income and employment exhibit positive, but modest, gains with respect to increases in production of shale gas. He considers the impact of the gas booms only on total county employment, wage and salary effects, and effects on median income. He recognizes that the length of his study period may not capture long-term effects. However, Weber (2014) studies a decade of shale gas production in Texas, Louisiana, Arkansas and Oklahoma counties to look for symptoms within that time frame that might be suggestive of a resource curse in the longer term. Specifically, he looks for increased dependence on the mining sector, higher earnings per job, and declines in the educational attainment of the adult population. He concludes there is little evidence to suggest that gas production creates conditions conducive to a resource curse.

Oil and gas have notoriously exhibited boom-bust cycles. In fact, natural gas prices had been on an upward trend over the decade of Weber's analysis, but collapsed mid-year 2008. Drilling, in particular, is stimulated by high oil and gas prices. The resulting shifts in the supply curves can lead to steep price declines and bring new field development to a halt with an abrupt drop in employment. Much of the local oil and gas industry employment is associated with drilling and other oil and gas field service activities that depend on active well and rig counts. Thus, the identification of the resource curse is probably best addressed over the course of several cycles, since the magnitude of the effects from the boom may or may not outweigh the magnitude of the effects from the bust. Nevertheless, conditions that precipitate a resource curse must have a presence in the shorter term over the course of a single cycle. Taking a very long-term approach, Michaels (2010) looks at counties with oil resources in the Southern United States over the period 1890 to 1990 and concludes that oil contributed to both population and income growth and, in fact, appears to have stimulated manufacturing activity.

It is reasonable to suppose that increased levels of oil and gas activity would provide evidence of the ingredients for a resource curse via localized impacts in terms of private sector employment and income over the short to medium-term. At the very least, changes in royalty and lease income will be associated with the changes in oil and gas production/revenues. Weber (2012) appeals to Corden and Neary (1982) to motivate a useful discussion on a theoretical level. Much depends on the elasticity of labor supply with the requisite skills. If labor is attracted to an extractive industry from other local activities by virtue of bidding up wages, given an inelastic local labor supply in a full employment context, incomes will increase. However, given an inelastic supply of labor, total employment effects would be small as employment declines across the other activities, reflecting the increase in specialization.

On the other hand, if the local labor market does not offer workers with the necessary skills, then labor must be imported. This should result in an observed increase in both local employment and income. In the language of Input-Output analysis, there would be a direct employment effect in mining activities and, possibly, an indirect effect in upstream and downstream activities, including those activities that depend on uses of income such as retail and hospitality. Such indirect effects would tend to offset increases in specialization. Nevertheless, in either case, prices on non-tradable goods, such as rents and some services, will also be bid up confounding the effect on real local income.

One might thus seek an explanation for the contrary Weber (2012) result by looking at the localized elasticity of labor supply. It may be the case that the elasticity of labor supply is much higher –either because unemployment rates are relatively higher or because outside labor is more available– in the counties in his study area than would more generally be the case. Certainly, this could explain the different findings at very low levels of spatial aggregation, such as the county-level, relative to more aggregated entities such as states and countries. Moreover, net employment and income benefits to low income rural counties would not necessarily be inconsistent with a resource curse at the state or national level if the implied reallocation of resources has both winners and losers at the state or national level.

Benefits would also be expected to carry over to the public sector. Increased public sector resources gotten by way of higher specific taxes tied to the resource exploitation can add to the public purse. This is particularly true in the case of a resource boom. However, much of the literature that looks at levels of local public goods following fiscal windfalls at the local or municipal level finds that the fiscal benefits fail to reach the local population. Caselli and Michaels (2013) report that oil revenues accruing to Brazilian municipalities appear to increase local spending levels but actual changes in real social expenditures and household income are much more modest and, in fact, may not even occur. At the county and school district levels, tax impacts are more likely to arise through changes in the property tax base. This might arise due to changes in *in situ* mineral valuations or investments in improvements that increase tax liabilities, or by rising property values that are perhaps a consequence of the expansion in broader economic activity.

With the crude oil geyser that erupted from the well at Spindletop in East Texas on January 10, 1901, the Texas oil boom was underway. Oil and gas production has remained an important part of the Texas economy since that time although its production began a secular decline by mid-century. While the economy of the State of Texas is quite diversified, and the relative importance of the oil economy had been declining up to 2010, there are sub-regions that have been highly dependent on oil and gas extraction for decades. With the application of enhanced oil recovery techniques and hydraulic fracturing for extracting oil and gas from shale, gas output began to climb steeply once again by 2005 and oil production by 2009. Since much of this new production has come from shale formations that were previously untapped, new regions of the state have experienced an oil and gas boom. On-shore oil and gas activity is located in four principal zones: the Permian Basin in West Texas, the Eagle Ford shale formation in South Texas, the Barnett shale formation in North Texas, and the Haynesville/Bossier shale formation in East Texas. While the Permian Basin has expanded production into shale, it has been the principal region for decades for conventional extraction. The Eagle Ford, Barnett, and Haynesville/Bossier formations have been developed in the last ten years.

3 EMPIRICAL ANALYSIS

In this study, we use annual data for the variables of interest for the years 2000-2012. As can be noted in Figure 1, there was a sharp uptick in gas production in Texas after 2005 and in oil production after 2009. Seven counties began oil and gas production in or immediately after 2005. Counties with oil and gas production before 2005 also increased their oil or gas production after the break points of 2005 and 2009. Figures 2 and 3 illustrate the changes in Texas county maps. Therefore, we identify the years 2005 (gas production) and 2009 (oil production) as turning points in production. Since oil and gas production overlap at the county level, and our interest is only in the localized effects of extractive activities, we combine oil and gas production by converting both outputs to the common measure of kWh.

We use a difference-in-differences (DID) methodology in which we compare the differences in our outcome variables between the oil and gas producing counties and the non-oil and gas producing counties, as defined below. Use of non-oil and gas producing counties as a comparison group enables us to control for state specific and broader regional influences on the markets. We analyze, in turn, industry effects in terms of establishments and employment, per capita and median county incomes, and tax and public school expenditures.

3.1 Data

Our primary data for the number of establishments and employment by industry are compiled from the Quarterly Census of Employment and Wages (QCEW) for Texas. There were changes to the QCEW industry configuration in 2007. We are assuming that industry definitions remain consistent at the two-digit level. Oil and gas production by county and year were available from the Unites States Energy Information Administration website.[2]

Texas general fund county property tax rates were taken from the County Information Program, Texas Association of Counties, from data supplied by the Texas Comptroller of Public Accounts. Our property and school district level taxable values (assessed property value or total tax base) and tax rates are gathered from the Texas Education Agency, and school district revenue and expenditure data

[2] Available at http://www.eia.gov/

are taken from the Texas Education Agency's Public Education Information Management System (PEIMS). School districts, however, do not correspond to county divisions. Since we are unable to observe exact locations of the producing wells, we cannot apportion them across the school districts within any given county. However, all school districts are contained within a single county and all area of all the counties are within a school district.

Therefore, we aggregate all districts in a county to report school district variables at the county-level. Thus, school tax rates are averaged to the county level by the weighted average of the individual Independent School District (ISD) tax rates using school district shares of total county-level tax receipts as weights. This aggregation will result in an under-estimation of property tax base impacts at the level of the school districts in which the wells are actually sited and an over-estimation for those districts without wells that are located in an oil and gas producing county. A concomitant to this issue is that the effect of using the average tax rate for the districts in a county will also tend to over or under-estimate actual rates for the specific school districts. School expenditures are averaged to the county level using the districts' average daily attendance as weights.

We observe total extracted oil (in millions of barrels) and (saved) gas (in billions of cubic feet) at the county level which, as noted, are converted into kWh. We are also able to observe total oil and gas revenues that accrue to county production, although the recipients of those revenues can reside anywhere. County level annual personal income, unemployment rates, and populations are compiled from the U.S. Department of Commerce Bureau of Economic Analysis and the Bureau of Labor Statistics.

We identify two non-overlapping subsets of Texas counties which we refer to as oil and gas counties and non-oil and gas counties. This simple division requires further filtering along two dimensions. There are 169 counties in Texas, out of 254, that have some oil and gas revenues over the period. Since our goal is to compare counties that either have or achieve a specialization in oil and gas production with counties that have no specialization in oil and gas production, we compare only counties in which oil and gas revenues in any period are at least ten percent of average total county income to those counties in which oil and gas revenues represented less than one percent of average total county income. Thus, counties in which oil and gas revenues are greater than ten percent of total county income are treated as oil and gas producing counties while non-oil and gas counties are defined as those whose oil and gas revenues are below the one percent threshold. It is worth noting that if we had separated the counties into two sets using a single, continuous –and admittedly arbitrary– measure of the importance of oil and gas production, two counties with only a very slight difference in their measures could fall into different groups. It is partly to avoid this issue, and to emphasize a sharper distinction, that we choose the discrete division and drop counties whose oil and gas revenues are between one and ten percent of average total county income.

The acuity of the analysis is further enhanced if we narrow the comparison between oil and gas and non-oil and gas counties to those counties that had some degree of similarity at the beginning of the study period. Since oil and gas development has taken place in the relatively rural counties, it would be inappropriate to compare outcomes between the relatively static rural counties and the urban counties that have enjoyed substantial population and employment growth over the period from factors unrelated to oil and gas production. Thus, our second restriction on the counties included in the analysis is based on population. Specifically, we exclude counties with populations less than 1,764 or greater than 689,163 in 2001 (the largest oil and gas county by population) or per capita personal income less than $15,136.46 or greater than $40,686.69 in 2001 (the highest value among the oil and gas counties). This restriction reduces the number of counties used in the analysis from 254 to 218. The excluded counties are the more populous counties found along the I-35 corridor (the Dallas-Fort Worth, Austin/San Antonio, and Houston MSA areas). Only one county, Loving County, with a 2001 population of 72, failed to meet the minimum values. The effect of these two filters is to winnow the 254 Texas counties down to 174 counties used in the analysis, of which 125 comprise the set of oil and gas counties and the remaining 49 constitute the set of non-oil and gas counties.

Table 1 presents two-digit NAICS industry-level data on numbers of establishments and employment levels for both county sets. The table includes average values for the three sub-periods for both subsets within the overall period of the eleven years of observations. Oil and gas counties have only a slightly lower number of establishments and employees than the average control county. At the industry level, some of the largest disparities are in the mining, retail, health, and scientific sectors when comparing the two sets of counties. As can be noted in Table 2, containing summary statistics of the regression variables, non-oil and gas counties, on average, are substantially more populous than treatment counties. Average income and wages are the same in both, for practical purposes.

However, there are contrasting differences in the per capita and per student values of the property tax bases and school revenue by sources between the oil and gas counties and the non-oil and gas counties. But due to the formula for school finance in Texas, as explained below, higher local school tax revenues are offset by lower state transfers to districts. Differences in total per student expenditures are less a function of local property tax bases than the result of recognized cost differentials that are included in computing the required minimum average student expenditures and, perhaps, given the differences in average daily attendance, the presence of economies of scale in producing educational services.

3.2 Industry Effects

We first investigate the impact of oil and gas development on levels of establishments and employment in each county. We look at the growth in both the numbers of establishments and employed persons between 2001 and 2011 in the subsets of all oil and gas and non-oil and gas counties in Texas, as described above. We regress the establishment and employment growth on, *inter alia*, growth in oil and gas production each year. The model to be estimated is as follows:

$$\begin{aligned} \ln y_{c,t} &= \beta_1 \ln P_{c,t-1} + \beta_2 A_{2005-2008} + \beta_3 \ln P_{c,t-1} \times A_{2005-2008} \\ &\quad + \beta_4 A_{2009-2012} + \beta_5 \ln P_{c,t-1} \times A_{2009-2012} \\ &\quad + x'_{c,t-1}\gamma + z'_{c,t-1}\lambda + c_c + \varepsilon_{c,t} \end{aligned} \tag{1}$$

Our dependent variable (y) is either the county-level total number of establishments, all industries, or the county-level total employment, all industries, for a given year. Our independent variables can be categorized into four groups: county-level oil or gas production (P), county characteristics that vary with time such as unemployment rate and population (x), industry characteristics such as average county-level wages (z), and county (c) effects. For the purposes of the estimation, we use the value of zero for oil and gas production of all non-oil and gas counties, or the value of 1 in the case where we transform using logarithms. The dummy variables $A_{2005-2008}$ and $A_{2009-2012}$ capture the 2005 to 2008 and 2009 to 2012 periods. Our main interest is in coefficients β_3 and β_5 which capture the differences in growth rates between 2005–2008 and 2009–2012 compared to our omitted group, counties with no oil or gas resources. Note that since the values of the logarithm of production for the non-oil and gas counties is zero, the products in the interaction terms are non-zero only for oil and gas counties in the periods during which the dummy variables are non-zero. The term $\varepsilon_{c,t}$ is the error. Given the data are left-hand censored and our dependent variable must be non-negative, we estimate these empirical models using the Tobit regression technique. While no county effects can be included in the Tobit estimation, we add county effects when using OLS. Since none of the variables for which logarithms are computed ever takes the value of zero (keeping in mind that a value of 1 is assigned to production for non-oil and gas counties), this transformation creates no statistical problems.

To allay any concerns about endogeneity between geographical divisions and resource availability, we instrument the estimation by using the geography of the major oil and gas basins in Texas. Any county overlaying any part of a basin is treated as a basin county, and those that do not overlay any portion of the basin are then non-basin counties. There can be no question of endogeneity since county boundaries were defined well before the discovery of oil in Texas. So, we can confidently use this instrument to proxy for resource availability. We then interact this binary variable with oil and gas prices as a means of capturing the influence that price might have as an incentive for a basin county to more intensively develop their extraction activities.

Table 3 contains the OLS and Tobit regression estimation results for both of the outcome variables. As can be seen, while non-MSA counties gained both establishments and employment in both the 2005–2008 and 2009–2012 periods, the estimated coefficients for β_3 are not significantly different from zero for oil and gas counties while the estimates for β_5 are either negative (establishments) or essentially zero (employment). There is no evidence from this regression that oil and gas production in either the period between 2005 and 2008 or the 2009–2012 period added to employment growth. While a finding of no statistical evidence of an employment impact is contrary to our initial expectations, it is not inconsistent with much of the literature in this realm. This would of course be true if labor is inelastically supplied in these rural counties.

Accordingly, in order to consider the possibility of effects within and across industries that may tend to offset one another, we disaggregate county employment in Texas using both establishment and employment data by industry for the 12 years within the 20 industrial categories of the NAICS-2 in the QCEW as reported by the Texas Workforce Commission. This regression view should shed light on the extent to which the uptick in oil and gas production altered the industrial composition of the county-level establishments and employment, rather than county totals. As noted, we are aware of the changes to the NAICS industrial categories that occurred during the course of the decade but proceed under the view that substantive changes at the NAICS-2 level of aggregation are insignificant.

We consider the following empirical model:

$$\begin{aligned} \ln y_{c,j,t} &= \varphi_1 \ln P_{c,j,t-1} + \varphi_2 A_{2005-2008} + \varphi_3 \ln P_{c,j,t-1} \times A_{2005-2009} \\ &+ \varphi_4 A_{2009-2012} + \varphi_5 \ln P_{c,j,t-1} \times A_{2009-2012} \\ &+ x'_{c,j,t-1}\nu + z'_{c,j,t-1}\vartheta + c_c + \eta_{c,j,t} \end{aligned} \tag{2}$$

Our dependent variable (y) is either the yearly number of total county establishments or employees in industry j by NAICS-2 per county. Independent variables are similar to the ones described in equation 1. The term $\eta_{c,j,t}$ is the error.

Tables 4-7 contain Tobit regression results for these two outcome variables. There is no evidence in these results that oil and gas activity has had any effect on the sectoral composition of either the numbers of establishments or employment. It is hardly surprising that population, and to a slightly lesser extent, wage rates are positively correlated across the board with employment. Regressions using county fixed effects instead of the instrumental variable approach were also run and gave results that do not differ qualitatively from the IV models.

Theses results appear to be contrary to the substantial increases in activity, the economic booms, that were clearly evident in these areas. We should note, however, that the nature of the QCEW employment data can be misleading at the county level. The QCEW data are establishment-based, and since it is likely that much of the new oil and gas development has been undertaken by large, often multinational, firms with headquarters in large MSA[3] areas, much of the actual employment in

[3]U.S. Census and The U.S. Office of Management and Budget report statistics for metropolitan areas (MSA) according

place in the non-urban counties is credited to remote establishments. This might provide some insight, however, into why long-term positive impacts on local economies are elusive. That is, outside firms and employment arrive to exploit the opportunity and do not establish local structures and ownership in industrial activities. Thus, when the period of frenetic activity is over, largely when prices eventually decline and development slows or stops, these mobile agents leave with little evidence of having been there.[4]

3.3 County Personal Income

Next, we turn our attention to effects on county personal income. We use two specifications for oil and gas production. We consider the physical output of oil and gas production at the county level in one specification and oil and gas revenues at the county level in the other specification. Clearly, revenues are the product of physical production and prices, and may be more indicative of possibilities for localized income impacts. For either specification, the dependent variable in this model is either the log of county real per capita income or the log of county real median income between 2000 and 2012. Note increases (decreases) in per capita income that are not matched by increases (decreases) in median income suggest increases at upper (lower) end of the county income distribution. Thus, the regression captures the growth in per capita personal income or median income as a function of the yearly increments in county oil and gas production and revenues between 2001 and 2012.

$$\begin{aligned} \ln I_{c,t} \quad = \quad & \phi_1 \ln P_{c,t-1} + \phi_2 A_{2005} + \phi_3 \ln P_{c,t-1} \times A_{2005} \\ & + \phi_4 A_{2009} + \phi_5 \ln P_{c,t-1} \times A_{2009} \\ & + x'_{c,t-1} \upsilon + z'_{c,t-1} \zeta + c_c + \epsilon_{c,t} \end{aligned} \tag{3}$$

We estimate two models for each specification for oil and gas production; one that uses county

to the following county definitions. A *Central County* is defined as a county in which 50% of its population lives in urban areas of at least 10,000 in population, or where a population of 5,000 are located in a single urban area of at least 10,000 in population where that urban area is split between more than one county. An *Outlying County* can be included in the MSA (sometimes referred as a core-based statistical area) if these counties have strong social and economic ties to the central counties as measured by commuting and employment. Please see Census Geographic Glossary (U.S. Census Bureau) for more details.

[4] A windshield survey of the West Texas region toward the north from Midland-Odessa up to Seminole is highly suggestive on this point. There are countless RV and trailer parks that appear more like large gravel parking areas that are filled with fifth-wheels, suggesting the presence of an itinerant workforce.

fixed effects and one that employs an instrumental variable (with county fixed effects) as described above. Results for the OLS with county fixed effect models are presented in Table 8. Neither oil nor gas production nor oil and gas revenue appear to have affected county incomes. However, in the post-2005 periods, we observe positive impacts on both average and median county incomes. The IV regression results presented in Table 9 suggest a quite different story. The measures of physical production appear to reduce per capita income while increasing median income. On the other hand, the revenue measure exhibits increases in both per capita and median incomes, with a relatively larger increase in per capita incomes. This, of course, implies a greater impact within the upper half of household incomes. The IV approach does not find any impacts on incomes in either the 2005–2008 period or the 2009–2012 period.

3.4 Property Taxes and School Expenditures

We conclude our analysis by examining the impact of oil and gas production on county and school property taxes, i.e., total assessed value of property or property tax base, county general fund property tax rates and school tax rates, and school expenditures. Taxes on oil and gas interests are levied at both state and local levels. The State of Texas collects a severance tax of 7.5 percent of the market price of gas produced and saved and 4.6 percent of the market value of oil produced. Thus, tax revenues are determined by both market price and quantity of oil and gas produced. The state offers several severance tax incentives with the intention of encouraging higher cost secondary and tertiary extraction. For example, oil produced by a qualifying Enhanced Oil Recovery project is subject to a 2.3 percent tax on the market value of oil produced for a period of 10 years. State severance tax revenues (oil, gas, and condensate) have increased dramatically with the increases in production of oil and gas. As late as 2010, severance tax receipts represented 4.7 percent of total state tax revenues. By 2014, that share had risen to 10.9 percent, even as tax revenues from all sources had increased over 40 percent. In current dollar terms, severance tax payments in 2010 were \$1.856 billion and \$6.014 billion by 2014.

At the local level, each Texas county is served by an appraisal district that establishes the property value, based on fair market value, for all real property and tangible personal property in the county. Mineral interests are treated as real property. The fair market value of a completed or working well is the present discounted value (using a discounted cash flow approach) of the total lease recoverable reserves to be produced in the future. The real property tax liability is apportioned to individual interests, both working and royalty interests, according to their share of revenues for the total lease.[5] The price used for future production is the monthly average price from the preceding calendar year adjusted by the Comptroller's Market Condition Factor. Revenues for appraisal purposes are net of severance tax payments.

Counties and school boards should set tax rates with an eye to their budgetary requirements, given the assessed value of the relevant non-exempt property tax base determined by the appraisal district. County and school revenue realizations are then the product of tax rates and total non-exempt assessed value. However, the system of school finance in Texas has offsetting elements between state and local funding sources that have important implications for local taxing incentives. At the local level, virtually all revenues are generated by means of property taxation. The local share of the basic school funding is the base pre-determined school tax rate multiplied by the district's total property tax base. If those revenues are insufficient to meet the basic district funding level (as determined by the State), the State covers the difference. Thus, increases/decreases in the district's property tax base that generate higher/lower local school tax revenues are offset by reductions/increases in the State's share of basic funding. However, local districts have the option of increasing the local tax rate by up to 17 cents/$100 valuation over their base rate for funding for educational "enhancement" above the basic level.

There is also a statutory provision intended to ensure "equalized wealth levels" across school districts. Districts are deemed to be property-wealthy districts if their property tax base per student exceeds a given threshold. Property-wealthy districts' local tax revenues are then subject to recapture by the State in the amount generated by the district's pre-determined tax rate applied to the excessive property tax base for that year.[6]

[5] Strictly speaking, valuation for working interests is based on net revenues (projected gross revenues less projections for lease opeating expenses) while valuation for royalty interests is based on gross revenues (but net of severance tax). From the tax districts' perspective, property tax revenues will be determined by total net DCF, given the tax rate establilshed by the tax jurisdiction. See http://www.isouthwestdata.com/client/downloads/wisecad/APPRAISAL/Mineral%20Appraisal%20Handout.pdf for a complete discussion of the appraisal methodology for mineral interests.

[6] This is the so-called Robin Hood provision. The pre-determined tax rate is 2/3 of the district's 2005 tax rate. This provision can result in a significant transfer from the district to the State. For example, in the 2011-12 school year, with only 141 students, the Kenedy County Wide Consolidated School District (home to the Penascal Wind Development)

Our intention is to estimate total assessed value as a function of installed oil and gas output and property tax rates as functions of county total assessed value. There is, however, an empirical problem in the question relating to the effects of oil and gas production on tax rates. Assessed values of real property are to reflect market values and market values depend, at least partially, on tax rates. Thus, tax rates and property tax assessed values will be endogenously determined and the modeling methodology must allow for influences on these intertwined variables to be separately identified. In this circumstance, without identification, OLS will produce a lower bound of the parameter estimates.

To avoid this endogeneity problem and to identify the separate effects of growth in oil and gas production on county and school tax bases and rates, we conduct the empirical analysis in three steps. In Step 1, we estimate a model of the assessed value of the county and school property tax bases as a function of oil and gas production variables and county characteristics (equation 4). Then, in Step 2, we strip out the oil and gas production effects by computing values for county property tax bases as the predicted value from the estimated Step 1 model with the oil and gas production variables omitted. We consider this to be the estimated value of the assessed tax base that would have been observed in the absence of oil and gas production, a sort of counter-factual value ($\widehat{v}^{*}_{c,t-1}$).[7] Finally, in Step 3, we estimate county and school tax rates and school revenues in equations 5 and 6 using oil and gas production on the right-hand side and the stripped-out or counter-factual taxable values. In the school revenue calculation (equation 6), we have included average daily public school attendance (a) as a control group for county size as well.

We consider the following empirical models:

had a school property tax base of $7,234,228 per student against an allowable $476,500. $9,772,671 was recaptured by the State from this district. Property-wealthy districts are not necessarily wealthy districts in terms of median or per capita income.

[7] Similar empirical startegy has been applied by De Silva et al. (2016) when estimating the value of the assessed tax base that would have been observed in the absence of wind energy production.

$$\begin{aligned}
\ln(v)_{c,t} &= \varpi_1 \ln R_{c,t-1} + \varpi_2 A_{2005} + \varpi_3 \ln R_{c,t-1} \times A_{2005} \qquad (4) \\
&+\varpi_4 A_{2009} + \varpi_5 \ln R_{c,t-1} \times A_{2009} \\
&+x'_{c,t-1}\zeta + \alpha_c + \omega_{c,t} \\
\ln(tax\ rate_{c,t}^{i=p,s}) &= \psi \ln(\widehat{v}^*_{c,t-1}) + \omega_1 \ln R_{c,t-1} + \omega_2 A_{2005} + \omega_3 \ln R_{c,t-1} \times A_{2005} \qquad (5) \\
&+\omega_4 A_{2009} + \omega_5 \ln R_{c,t-1} \times A_{2009} \\
&+\alpha_c + \mu_{c,t} \\
\ln(r_{school})_{c,t} &= \vartheta \ln(\widehat{v}^*_{c,t-1}) + \kappa_1 \ln R_{c,t-1} + \kappa_2 A_{2005} + \kappa_3 \ln R_{c,t-1} \times A_{2005} \qquad (6) \\
&+\kappa_4 A_{2009} + \kappa_5 \ln R_{c,t-1} \times A_{2009} \\
&+\varrho \ln(a)_{c,t} + \alpha_c + e_{c,t} \\
\text{where } \widehat{v}^*_{c,t-1} &= \widehat{v}_{c,t-1} - (\varpi_1 \ln R_{c,t-1} + \varpi_3 \ln R_{c,t-1} \times A_{2005} \\
&+\varpi_5 \ln R_{c,t-1} \times A_{2009})
\end{aligned}$$

As illustrated in Table 10, oil and gas revenues in both the 2005–2008 and 2009–2012 periods had a positive influence on county property values and a negative effect on county tax rates, accompanied by rising per pupil revenues from local sources in comparison to counties with no oil or gas resources. However, oil and gas revenues 2005–2008 and 2009–2012 periods have no significant effect on school tax rates. In view of the Texas school funding formula, latitude to reduce school tax rates is limited. It is also not surprising there is little or no effect or observed differences between per student expenditures given the provisions designed to equalize real resources per pupil across districts. As local school tax revenues increase with the value of the property tax base, the district will either receive a lower transfer from the State or will be subject to recapture of the increase. As local school property tax collections increase, the State is the principal beneficiary. Note, there was some benefit in terms of reductions in county tax rates which, given the increase in taxable base, would allow county governments to maintain expenditures at lower tax rates, although the net effect on county revenues can not be observed through this interaction.

The IV regression results presented in Table 11 indicate that oil and gas revenues in both the

2005–2008 and 2009–2012 have no effect on property values but are consistent in terms of reductions in county tax rates and provide some indication of increases in per student revenues from local sources, post 2005. However, as in Table 10, given the Texas school funding formula, this does not automatically translate into an increase in overall revenues or increased per student expenditures.

3.5 Robustness Analysis

Moulton (1990) raised the problem of within-group correlation in DD estimations. If this is the case, the standard errors in our model may be underestimated. To overcome this, we employed clustered standard errors at the county level when appropriate. However, Bertrand, Duflo, and Mullainathan (2004) show that clustered standard errors can be biased downward in panel data if serial correlation is present. One approach that they recommend is to collapse the time dimension of the data down to three periods. In our application, we focus only periods before 2005, 2005 to 2008 and 2009 to 2012. We then aggregate the data by county and re-estimate all models. The industry results are insignificant as in the main tables. Income and tax results are qualitatively similar to our main results.

Another important assumption in DID models is the assumption of a parallel trend for outcome variables between the control and treatment samples, prior to the treatment. We have tested trends in all variables prior to 2005. The results indicate that the effect of the time trend interacted with the oil and gas production is not significant on the main dependent variables between the control and treatment counties prior to 2005. Note that we also estimate these regressions by the number of firms and employees by industry. The results indicate that there are no significant different trends prior to 2005 between the two samples of counties. We can provide these estimations on request.

4 CONCLUSIONS

Across each of the preceding areas of empirical analysis, we find little or no evidence of circumstances emerging over the period of this analysis that would be a necessary element, a precursor, in the longer term evolution culminating in a resource curse. One would expect the process that results in regional over-specialization would necessarily be reflected in the shorter-term through a reallocation of employment toward the booming activity. Given the small geographies under consideration, and relatively low costs to labor mobility, such reallocations should be able to take place within the time frame of this analysis. Despite the large spikes in oil and gas activity observed in Texas during the period of our analysis, such reallocations are not present. There is little, if any, reshuffling of employment among industries in the post-2005 and post-2009 periods and no marked tendency toward increased specialization. By the same token, if labor supply is elastic, there should be an increase in the overall labor force due to employment increases in the resource industry and economically linked sectors. As in the inter-industry analysis, we find little evidence of this latter effect.

These results on employment are consistent with earlier research at the county level (e.g., Weber, 2014) but need to viewed with a caveat. That is, since the QCEW data are establishment based, employment associated with out-of-county based establishments will not appear in these data, even for employees who are local residents, if paychecks are issued elsewhere. However, one would expect to observe indirect effects on the locally-owned, and thus reported, establishments. Since these indirect employment effects appear to be negligible, we conclude the effects of the booms are not as significant to the pre-boom or incumbent local activities as one might otherwise expect. It is perhaps useful to consider the results in the context of this QCEW reporting methodolgy. Since only local establishments are reported in each geography, the QCEW present a view of the locally owned or operated activities. One might think of it as a baseline economy. Thus, booms and busts in these extractive activities and support industries are essentially an imported employment phenomenon. These localities cannot maintain the requisite repository of specialized factors for a boom period over the entire cycle. These are specialized and mobile factors that enter and depart as the cycle demands. Perhaps an alternative analysis that considers the effect of the oil and gas booms in the larger headquarter cities would provide a complementary view. A large multinational corporation can more easily maintain and provide such a capacity by taking advantage of imperfect correlation between booming areas.

The income analysis may be more telling since county-level measures of personal income should capture local income regardless of source. It is of some interest that, while oil production has no apparent effect on either per capita or median income, oil revenues contribute to an increase in per capita county income relative to median county income. This suggests that the income benefit is realized by households in the upper half of the size distribution of income. This conclusion seems plausible since, while it is likely that wages and salaries in the oil industry are higher than the average wage/salary, higher production levels are not reflected in higher county incomes. Income effects are more closely associated with price fluctuations than with production levels.

There are benefits in terms of tax rates. That is, where property tax bases increase with oil and gas revenues, as would be expected, the concomitant benefit to the locality is lower county tax rates. This localized benefit, however, is not present in the case of school tax rates. While oil revenues contribute to higher per student locally generated school tax revenues, they do not translate into higher per student expenditures. It appears the State of Texas is the more likely beneficiary of the increased values of local school district property tax bases. The absence of the change in per student expenditures is probably a result of the Texas school funding formula, or it may be indicative of increased levels of non-student expenditures or other diversions. The conclusion in the case of school and educational expenditures is that natural resource extraction has had little or no impact at the county level and does not help to explain a Natural Resource Curse precipitated by lower investment in education.

Overall, we find little evidence of short to medium term effects in these smaller geographies that would be consistent with the theoretical underpinnings of a Natural Resource Curse. If anything, oil production has had a positive effect on local incomes and school finances. This raises questions for further research in this realm. That is, the existence of a resource curse at the national level appears to be a macroeconomic phenomenon that cannot be readily explained through micro-foundations. If there is little economic re-adjustment, or impact from resource extraction, in and across small geographies, what then can explain a resource curse at the national level? Are there other correlated institutional factors, geographical, political or cultural, that may not be identified by economic theory. Or, perhaps, the very question itself can be reversed. That is, do rigidities and frictions that inhibit broader economic development, such as low levels of human or entrepreneurial capital, push lesser developed countries toward an over-reliance or specialization in exploitation of their natural resource endowments?

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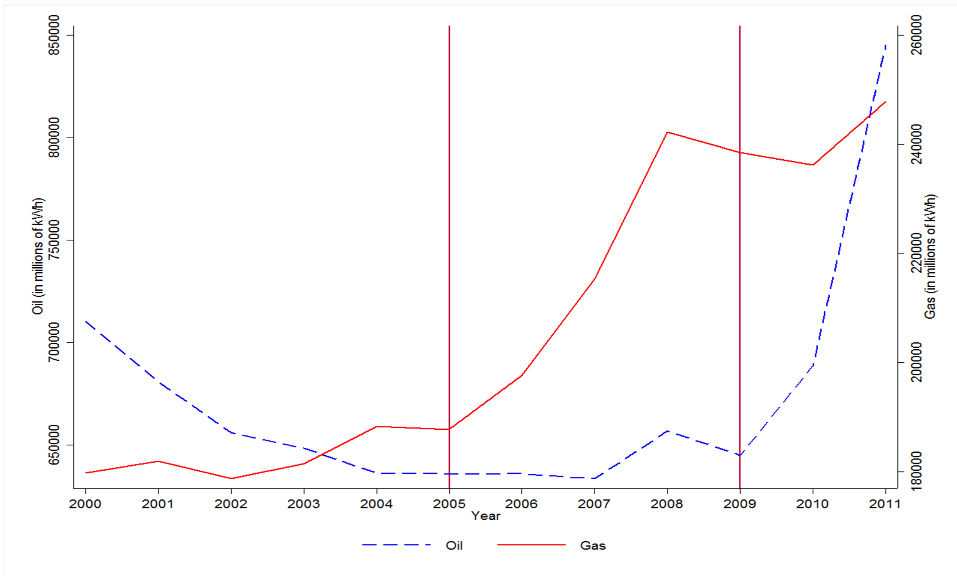
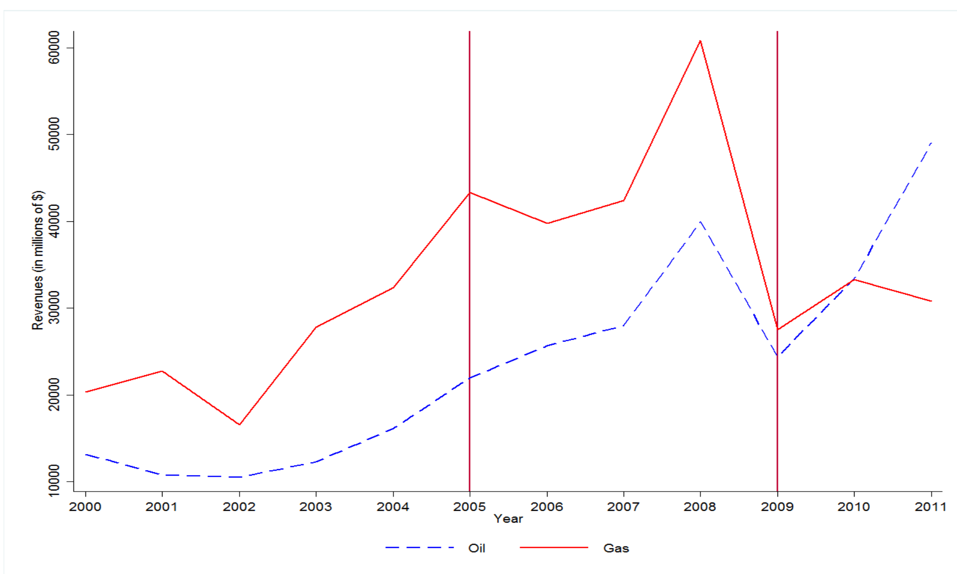
Figure 1: Texas Oil and Gas Production and Revenues by Year

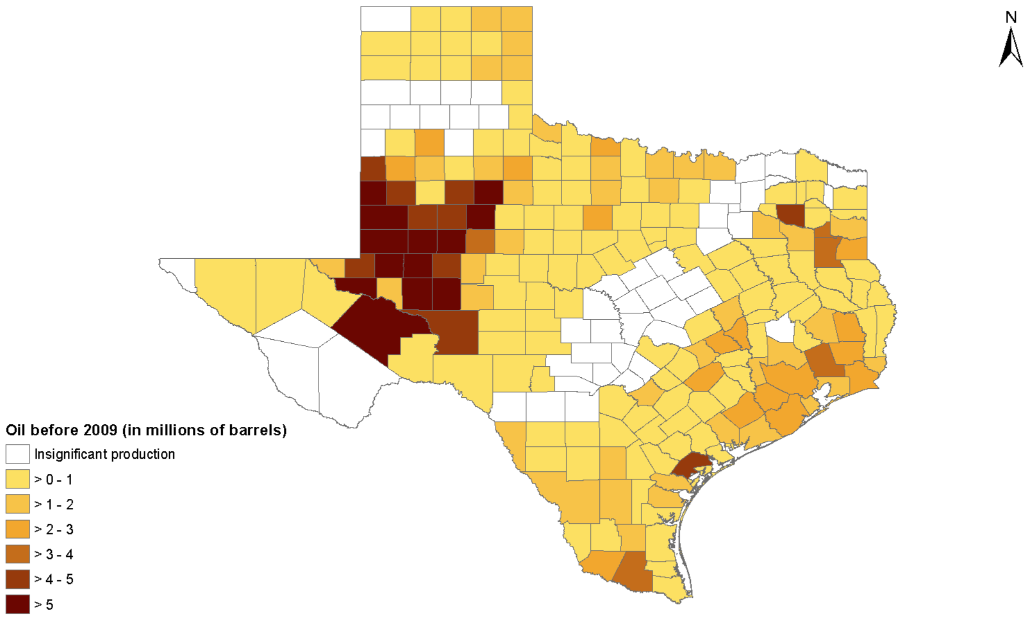


Panel A: Texas oil and gas production

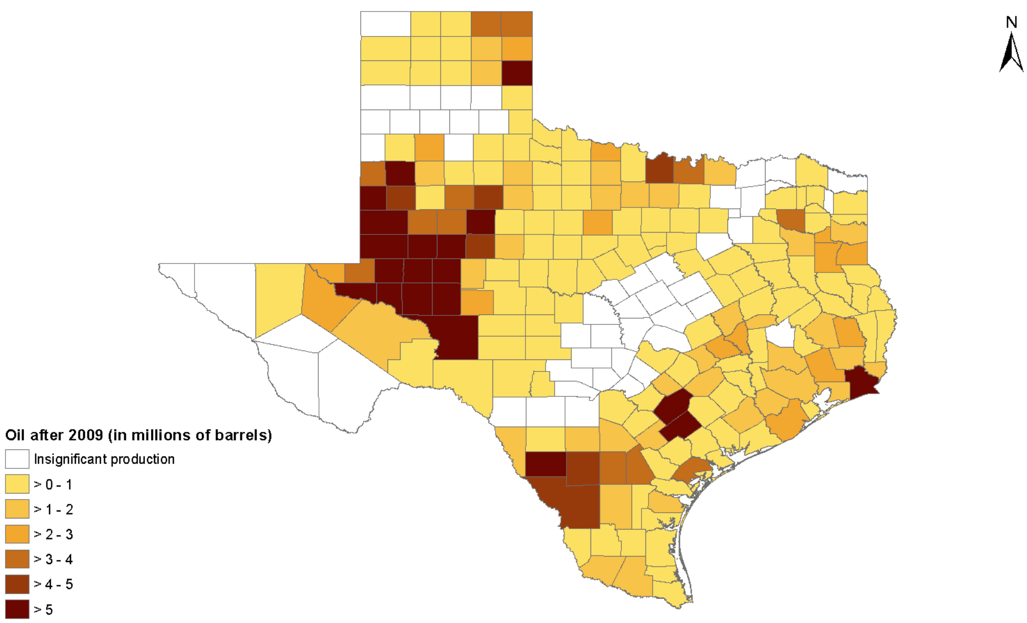


Panel B: Texas oil and gas revenues

Figure 2: Texas Oil Production

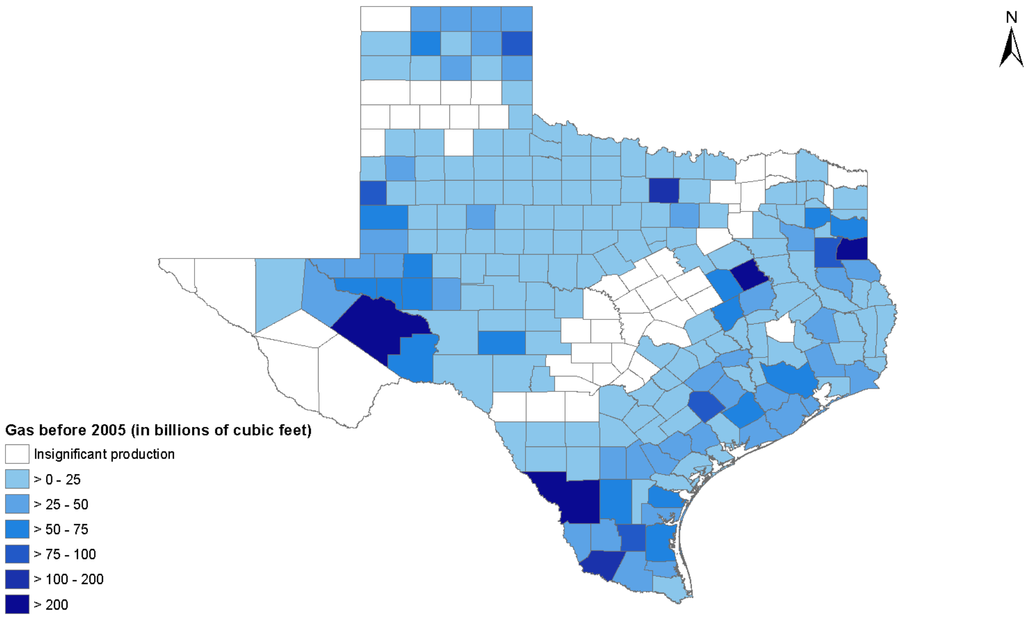


Panel A: Average oil production by county before 2009

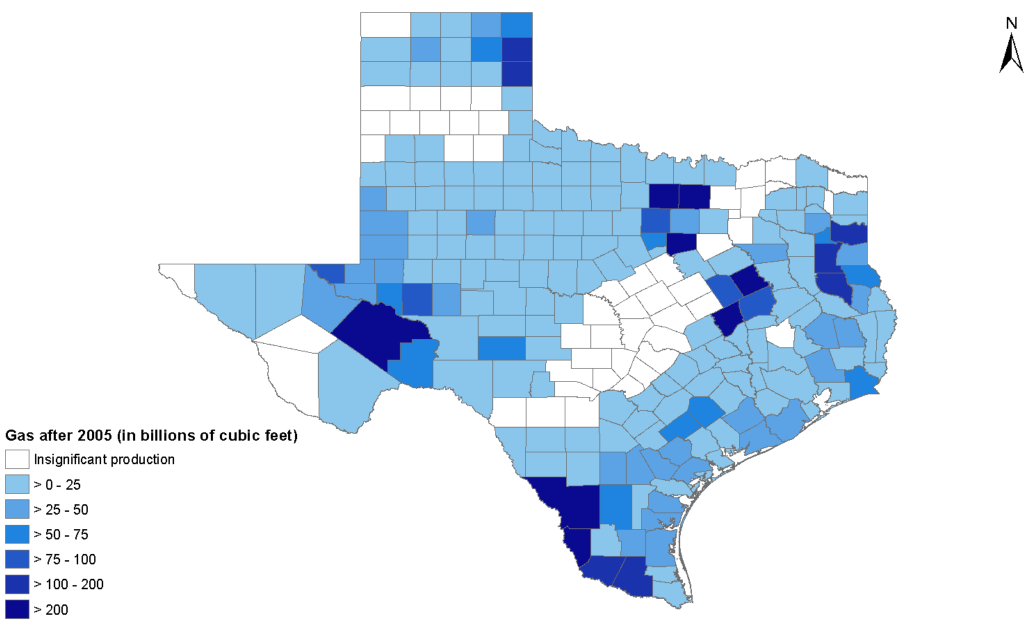


Panel B: Average oil production by county after 2009

Figure 3: Texas Gas Production



Panel A: Average gas production by county before 2005



Panel B: Average gas production by county after 2005

Table 1: County Share of Establishments and Employees by Industry

Industry	Counties with oil & gas						Counties without oil & gas					
	Number of establishments			Number of employees			Number of establishments			Number of employees		
	2001-05	2006-09	2010-11	2001-05	2006-09	2010-11	2001-05	2006-09	2010-11	2001-05	2006-09	2010-11
Agriculture	24.65	32.77	34.66	179.44	189.22	182.66	24.73	32.11	34.16	203.33	212.06	217.74
Mining	17.80	26.32	29.68	358.27	538.49	594.08	2.90	4.22	4.86	46.00	52.97	49.11
Utilities	5.49	5.78	6.17	104.39	85.73	94.07	6.90	7.86	7.86	188.09	176.27	159.56
Construction	13.32	37.83	39.62	193.25	448.68	468.98	35.29	107.65	116.06	402.75	1,091.12	1,071.60
Manufacturing	21.19	24.07	24.17	988.69	896.29	739.24	50.29	56.73	56.64	2,466.64	2,085.81	1,811.01
Wholesale	25.74	31.24	32.71	272.71	318.12	322.36	55.53	72.03	75.58	1,054.38	1,005.51	1,005.73
Retail	69.77	76.99	77.36	1,011.84	1,052.58	1,019.60	151.14	181.89	188.02	2,626.90	2,920.72	2,941.82
Transportation	21.10	29.62	31.33	285.80	365.90	380.92	32.18	44.34	46.16	647.62	788.10	760.85
Information	7.04	8.24	8.24	90.48	86.52	79.17	14.75	19.55	20.04	317.64	330.33	309.92
Finance	25.44	30.88	32.00	290.20	264.35	228.16	55.13	73.98	77.80	739.80	771.41	707.55
Real Estate	15.92	16.47	19.84	82.41	80.37	97.06	41.27	40.56	57.05	272.55	219.62	279.56
Scientific	27.76	38.37	42.87	164.01	208.91	214.37	69.63	106.84	121.76	476.66	669.39	712.35
Management	0.95	1.02	0.99	21.91	22.10	18.79	1.99	3.14	3.60	71.36	66.31	79.30
Waste Management	12.83	18.29	20.46	241.27	245.76	252.05	37.21	57.33	62.87	963.20	1,133.51	1,079.47
Education	2.50	5.52	6.55	272.37	781.05	955.67	7.81	14.90	18.59	1,216.46	2,425.98	2,949.56
Health	36.42	45.60	49.80	969.37	1,035.76	1,108.99	87.50	113.96	126.40	2,955.66	2,858.11	3,025.03
Arts & Entertainment	4.94	6.09	6.16	60.08	65.37	66.50	10.96	15.11	16.47	232.62	243.12	257.92
Accommodation	31.89	39.73	34.14	644.29	693.76	533.56	74.35	100.04	95.57	1,760.33	2,059.95	1,850.00
Other Service	31.87	44.54	47.94	180.34	218.76	223.38	78.15	108.11	121.51	548.00	612.80	635.47
Public Administration	7.90	22.75	28.05	251.88	395.35	459.89	10.37	27.85	34.72	674.59	1,052.54	1,247.17

Table 2: Regression Variables

Variables	All counties	Counties with oil & gas	Counties without oil & gas
Total number of counties	174	125	49
Oil & gas production	3,848.77	5,357.49	
(in millions of kWh)	(7,595.05)	(8,498.52)	
Oil and gas revenues	247.148	344.030	
(in millions of $)	(434.649)	(479.246)	
Taxable value	522.349	536.475	486.315
(in millions of $)	(891.393)	(923.758)	(802.630)
Taxable value per person	37,074.290	43,390.580	20,961.300
(in $)	(63,456.410)	(72,597.400)	(22,269.370)
Taxable value per student	218,642.100	249,856.200	139,014.300
(in $)	(340,059.300)	(381,323.300)	(176,161.200)
Property tax rate	0.529	0.536	0.510
	(0.161)	(0.163)	(0.152)
School revenue	25.267	20.308	37.917
(in millions of $)	(46.687)	(23.120)	(78.520)
School tax rate	0.999	0.992	1.017
	(0.083)	(0.074)	(0.101)
Total per student	11,332.930	11,597.48	10,658.040
expenditure	(2,538.431)	(27,16.406)	(1,853.803)
Per student expenditure	4,768.071	5,168.271	3,747.153
from local tax revenues	(2,464.922)	(2,605.202)	(1,679.560)
Per student expenditure	4,642.188	4,446.856	5,140.483
from state revenues	(1,787.265)	(1,630.091)	(2,056.613)
Average daily attendance	6,742.361	4,896.666	11,450.770
	(15,509.720)	(7,493.032)	(26,103.310)
Unemployment rate	5.824	5.677	6.198
	(1.867)	(1.696)	(2.204)
Population	36,035.580	25,446.320	63,049.020
	(72,550.490)	(32,334.550)	(12,2589.500)
Average wage ($)	19,757.020	20,178.710	18,681.280
	(5,261.310)	(5,605.882)	(4,068.886)
Average income ($)	24,508.530	24,259.030	25,145.010
	(4,947.773)	(4,946.554)	(4,898.144)
Median income ($)	31,793.590	31,152.850	33,428.130
	(6,630.930)	(5,529.467)	(8,633.225)
MSA central county	0.276	0.248	0.347
	(0.447)	(0.432)	(0.476)
MSA outlying county	0.178	0.184	0.163
	(0.383)	(0.388)	(0.370)

Standard deviations are in parentheses.

Table 3: Regression Results for Number of Establishments and Employees by Counties

Variables	Log number of firms$_{c,t}$				Log number of employees$_{c,t}$			
	Tobit	OLS	IV-Tobit	IV	Tobit	OLS	IV-Tobit	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(oil & gas production)$_{c,t-1}$	-0.002	0.006	0.080	-0.359	-0.001	0.005	0.024	-0.227
	(0.002)	(0.006)	(0.073)	(0.235)	(0.002)	(0.010)	(0.036)	(0.207)
$A_{2005-2008}$	0.279***	0.255***	2.235	0.172*	0.154***	0.140***	0.685	0.007
	(0.014)	(0.011)	(1.793)	(0.100)	(0.025)	(0.025)	(0.889)	(0.086)
Log(oil & gas production)$_{c,t-1}$	-0.001**	-0.000	-0.079	0.003	0.000	0.001	-0.021	0.006*
$\times A_{2005-2008}$	(0.000)	(0.000)	(0.072)	(0.004)	(0.001)	(0.001)	(0.036)	(0.003)
$A_{2009-2012}$	0.345***	0.289***	2.200	0.201	0.117***	0.112***	0.632	-0.026
	(0.022)	(0.020)	(1.683)	(0.124)	(0.037)	(0.041)	(0.835)	(0.114)
Log(oil & gas production)$_{c,t-1}$	-0.001	0.000	-0.080	0.004	-0.000	0.000	-0.022	0.006
$\times A_{2009-2012}$	(0.001)	(0.001)	(0.071)	(0.005)	(0.001)	(0.001)	(0.035)	(0.004)
Unemployment rate$_{c,t-1}$	-0.001	0.004**	0.051	-0.004	0.011	0.004	0.028	-0.002
	(0.009)	(0.002)	(0.047)	(0.008)	(0.010)	(0.004)	(0.023)	(0.008)
Log of population$_{c,t-1}$	0.811***	1.072***	0.914***	1.771***	1.021***	0.837***	1.055***	1.394***
	(0.026)	(0.105)	(0.092)	(0.654)	(0.035)	(0.166)	(0.045)	(0.488)
Log of wages$_{c,t-1}$	0.397***	-0.078*	-0.078	-0.067	0.682***	0.353***	0.519**	0.334***
	(0.104)	(0.046)	(0.417)	(0.086)	(0.121)	(0.117)	(0.207)	(0.126)
MSA counties	-0.009		-0.009		-0.045		-0.045*	
	(0.056)		(0.053)		(0.078)		(0.026)	
County effects		Yes		Yes		Yes		Yes
Observations	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914
R^2		0.990		0.958		0.987		0.979
Log likelihood	-470.800	1,575.000		188.200	-807.000	899.800		404.4
χ^2			2,502.000				16,120.000	
Wald test of exogeneity: Pr			0.004				0.349	
F-statistics for weak identification				0.179				0.179

Robust standard errors clustered by counties are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Stock-Yogo weak ID test critical values: 5% maximal IV relative bias 12.20 10% maximal IV relative bias 7.77

Table 4: IV–Tobit Regression Results by Industry Establishments

Variables	Log number of industry establishments$_{c,j,,t}$									
	Agriculture	Mining	Utilities	Construction	Manufacturing	Wholesale	Retail	Transport	Information	Finance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log(oil & gas production)$_{c,t-1}$	0.121	0.015	-0.046	0.734	-0.013	0.019	0.028	0.077	-0.010	0.011
	(0.109)	(0.092)	(0.058)	(0.504)	(0.048)	(0.039)	(0.030)	(0.066)	(0.045)	(0.026)
$A_{2005-2008}$	3.479	-1.302	-1.406	19.086	-0.253	0.697	0.729	1.994	-0.106	0.241
	(2.691)	(2.211)	(1.417)	(12.546)	(1.192)	(0.973)	(0.747)	(1.590)	(1.120)	(0.653)
Log(oil & gas production)$_{c,t-1}$	-0.132	0.059	0.050	-0.730	0.008	-0.027	-0.026	-0.074	0.004	-0.006
$\times A_{2005-2008}$	(0.108)	(0.088)	(0.057)	(0.504)	(0.048)	(0.039)	(0.030)	(0.064)	(0.045)	(0.026)
$A_{2009-2012}$	3.545	-1.107	-1.590	17.244	-0.200	0.697	0.691	1.919	-0.238	0.266
	(2.583)	(1.839)	(1.333)	(12.071)	(1.134)	(0.934)	(0.714)	(1.486)	(1.075)	(0.632)
Log(oil & gas production)$_{c,t-1}$	-0.136	0.050	0.060	-0.719	0.002	-0.029	-0.027	-0.072	0.007	-0.007
$\times A_{2009-2012}$	(0.108)	(0.079)	(0.057)	(0.506)	(0.048)	(0.039)	(0.030)	(0.063)	(0.045)	(0.026)
Unemployment rate$_{c,t-1}$	0.044	0.074	-0.020	0.515	-0.003	0.005	0.024	0.044	-0.004	0.014
	(0.070)	(0.053)	(0.036)	(0.320)	(0.029)	(0.025)	(0.019)	(0.040)	(0.028)	(0.017)
Log of population$_{c,t-1}$	0.225**	0.450***	0.557***	1.221***	1.011***	0.807***	0.948***	0.811***	0.757***	0.853***
	(0.097)	(0.153)	(0.051)	(0.364)	(0.043)	(0.029)	(0.026)	(0.069)	(0.043)	(0.018)
Log of wages$_{c,t-1}$	-0.130	1.107**	0.782***	0.876	0.629***	0.636***	0.028	0.269	0.238***	0.865***
	(0.457)	(0.551)	(0.096)	(0.596)	(0.063)	(0.039)	(0.072)	(0.304)	(0.057)	(0.052)
MSA counties	0.203**	-0.058	-0.174***	-0.137	-0.007	-0.058	-0.086***	-0.093	-0.081**	-0.026
	(0.097)	(0.069)	(0.048)	(0.461)	(0.040)	(0.036)	(0.026)	(0.059)	(0.036)	(0.025)
Observations	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914
χ^2	78.080	1,566.000	1,781.000	40.230	7,107.000	5,809.000	11,113.000	1,770.000	4,676.000	12,572.000
Wald test of exogeneity: Pr	0.008	0.000	0.028	0.000	0.966	0.694	0.007	0.238	0.982	0.000

Robust standard errors clustered by counties are in parentheses. *** p$<$0.01, ** p$<$0.05, * p$<$0.1

Table 5: IV–Tobit Regression Results by Industry Establishments (cont)

Variables	Log number of industry establishments$_{c,j,,t}$									
	Real Estate	Scientific	Management	Waste Manag	Education	Health	Arts & Ent	Accommod.	Other Serv.	Public admin.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log(oil & gas production)$_{c,t-1}$	-0.130	0.017	-0.007	0.106	0.045	0.019	0.110	-0.559	0.079	0.114
	(0.109)	(0.033)	(0.110)	(0.089)	(0.070)	(0.027)	(0.095)	(0.370)	(0.064)	(0.083)
$A_{2005-2008}$	-4.041	0.662	-0.313	2.861	1.731	0.746	2.629	-13.654	2.273	3.424*
	(2.733)	(0.812)	(2.753)	(2.214)	(1.733)	(0.664)	(2.367)	(9.188)	(1.591)	(2.062)
Log(oil & gas production)$_{c,t-1}$	0.135	-0.020	0.001	-0.109	-0.050	-0.024	-0.109	0.552	-0.081	-0.104
$\times A_{2005-2008}$	(0.109)	(0.033)	(0.110)	(0.089)	(0.070)	(0.027)	(0.095)	(0.368)	(0.064)	(0.083)
$A_{2009-2012}$	-2.925	0.658	-0.284	2.600	2.001	0.760	2.540	-13.581	2.465	3.930**
	(2.613)	(0.779)	(2.609)	(2.122)	(1.652)	(0.649)	(2.281)	(8.833)	(1.519)	(1.976)
Log(oil & gas production)$_{c,t-1}$	0.115	-0.018	-0.017	-0.102	-0.056	-0.023	-0.112	0.559	-0.089	-0.109
$\times A_{2009-2012}$	(0.109)	(0.033)	(0.110)	(0.089)	(0.069)	(0.027)	(0.096)	(0.369)	(0.064)	(0.083)
Unemployment rate$_{c,t-1}$	-0.035	0.012	0.056	0.089	0.041	0.026	0.037	-0.342	0.039	0.030
	(0.069)	(0.021)	(0.068)	(0.056)	(0.044)	(0.016)	(0.061)	(0.222)	(0.041)	(0.050)
Log of population$_{c,t-1}$	0.942***	0.966***	0.902***	1.162***	0.880***	0.961***	0.965***	0.570**	0.957***	0.410***
	(0.091)	(0.022)	(0.127)	(0.069)	(0.067)	(0.014)	(0.068)	(0.242)	(0.052)	(0.048)
Log of wages$_{c,t-1}$	0.319***	0.460***	0.432*	0.233***	0.047	0.499***	-0.002	-0.788	0.110	0.473**
	(0.096)	(0.047)	(0.221)	(0.065)	(0.143)	(0.141)	(0.165)	(0.986)	(0.085)	(0.212)
MSA counties	0.003	-0.101***	0.199**	0.091	-0.002	-0.083***	0.189**	0.095	-0.108*	-0.019
	(0.099)	(0.034)	(0.081)	(0.078)	(0.064)	(0.030)	(0.083)	(0.342)	(0.057)	(0.078)
Observations	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914
χ^2	1,188.000	8,709.000	1,042.000	2,028.000	1,743.000	10,070.000	1,186.000	66.350	2,427.000	607.200
Wald test of exogeneity: Pr	0.037	0.326	0.420	0.060	0.773	0.396	0.023	0.000	0.008	0.002

Robust standard errors clustered by counties are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6: IV–Tobit Regression Results by Industry Employment

Variables	Log number of industry employment$_{c,j,,t}$									
	Agriculture	Mining	Utilities	Construction	Manufacturing	Wholesale	Retail	Transport	Information	Finance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log(oil & gas production)$_{c,t-1}$	0.082	0.004	-0.116	1.106	-0.035	0.014	0.018	0.062	-0.084	-0.044
	(0.107)	(0.164)	(0.125)	(0.751)	(0.111)	(0.062)	(0.031)	(0.073)	(0.101)	(0.050)
$A_{2005-2008}$	2.522	-2.836	-3.435	28.217	-1.062	0.454	0.434	1.550	-2.146	-1.588
	(2.649)	(3.927)	(3.080)	(18.691)	(2.752)	(1.546)	(0.770)	(1.767)	(2.510)	(1.239)
Log(oil & gas production)$_{c,t-1}$	-0.102	0.118	0.114	-1.089	0.026	-0.023	-0.015	-0.060	0.075	0.056
$\times A_{2005-2008}$	(0.106)	(0.157)	(0.124)	(0.751)	(0.111)	(0.062)	(0.031)	(0.071)	(0.101)	(0.050)
$A_{2009-2012}$	2.545	-2.621	-3.808	25.264	-1.156	0.399	0.379	1.267	-2.492	-1.673
	(2.544)	(3.266)	(2.898)	(17.982)	(2.617)	(1.483)	(0.737)	(1.652)	(2.408)	(1.200)
Log(oil & gas production)$_{c,t-1}$	-0.107	0.100	0.135	-1.076	0.017	-0.026	-0.014	-0.053	0.086	0.057
$\times A_{2009-2012}$	(0.106)	(0.140)	(0.123)	(0.754)	(0.110)	(0.062)	(0.031)	(0.070)	(0.101)	(0.050)
Unemployment rate$_{c,t-1}$	0.020	0.117	-0.085	0.796*	-0.034	0.006	0.018	0.051	-0.078	-0.031
	(0.069)	(0.094)	(0.078)	(0.477)	(0.068)	(0.039)	(0.019)	(0.044)	(0.062)	(0.032)
Log of population$_{c,t-1}$	0.226**	0.734***	1.056***	1.636***	1.546***	1.109***	1.165***	1.189***	1.216***	1.021***
	(0.096)	(0.271)	(0.110)	(0.542)	(0.099)	(0.045)	(0.026)	(0.077)	(0.095)	(0.034)
Log of wages$_{c,t-1}$	0.632	2.433**	2.029***	1.956**	2.004***	1.009***	0.408***	1.081***	0.615***	1.467***
	(0.450)	(0.979)	(0.209)	(0.888)	(0.147)	(0.062)	(0.074)	(0.339)	(0.127)	(0.097)
MSA counties	0.139	-0.187	-0.245**	-0.225	-0.115	-0.168***	-0.059**	-0.061	0.046	-0.235***
	(0.096)	(0.122)	(0.103)	(0.686)	(0.093)	(0.057)	(0.027)	(0.065)	(0.080)	(0.048)
Observations	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914
χ^2	125.200	1,716.000	1,739.000	36.300	4,088.000	4,431.000	17,436.000	3,682.000	2,984.000	5,501.000
Wald test of exogeneity: Pr	0.003	0.000	0.184	0.000	0.981	0.746	0.268	0.597	0.566	0.000

Robust standard errors clustered by counties are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7: IV–Tobit Regression Results by Industry Employment (cont)

Variables	Log number of industry employment$_{c,j,,t}$									
	Real Estate	Scientific	Management	Waste Manag	Education	Health	Arts & Ent	Accommod.	Other Serv.	Public admin.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log(oil & gas production)$_{c,t-1}$	-0.175	0.018	-0.130	0.138	0.099	-0.017	0.109	-1.036	0.020	0.030
	(0.154)	(0.044)	(0.305)	(0.134)	(0.216)	(0.046)	(0.135)	(0.686)	(0.045)	(0.072)
$A_{2005-2008}$	-5.712	0.708	-3.810	3.204	3.600	-0.456	2.244	-25.492	0.733	1.255
	(3.838)	(1.086)	(7.615)	(3.338)	(5.366)	(1.140)	(3.354)	(17.060)	(1.134)	(1.790)
Log(oil & gas production)$_{c,t-1}$	0.185	-0.025	0.111	-0.132	-0.104	0.018	-0.108	1.022	-0.022	-0.020
$\times A_{2005-2008}$	(0.154)	(0.044)	(0.305)	(0.134)	(0.216)	(0.046)	(0.134)	(0.684)	(0.045)	(0.072)
$A_{2009-2012}$	-4.314	0.529	-3.859	2.758	4.371	-0.517	2.024	-25.399	0.913	1.808
	(3.669)	(1.042)	(7.219)	(3.199)	(5.116)	(1.114)	(3.232)	(16.401)	(1.082)	(1.715)
Log(oil & gas production)$_{c,t-1}$	0.161	-0.019	0.069	-0.131	-0.123	0.019	-0.110	1.033	-0.032	-0.027
$\times A_{2009-2012}$	(0.153)	(0.044)	(0.305)	(0.134)	(0.214)	(0.047)	(0.135)	(0.686)	(0.045)	(0.072)
Unemployment rate$_{c,t-1}$	-0.040	0.022	0.043	0.146*	0.025	0.022	0.022	-0.628	0.034	-0.003
	(0.097)	(0.028)	(0.187)	(0.084)	(0.135)	(0.028)	(0.086)	(0.413)	(0.029)	(0.043)
Log of population$_{c,t-1}$	1.236***	1.209***	1.971***	1.732***	2.104***	1.201***	1.647***	0.643	1.157***	0.911***
	(0.127)	(0.030)	(0.349)	(0.104)	(0.207)	(0.024)	(0.096)	(0.450)	(0.037)	(0.041)
Log of wages$_{c,t-1}$	0.596***	0.803***	1.092*	0.555***	1.051**	0.464*	-0.143	-1.428	0.424***	0.851***
	(0.134)	(0.063)	(0.611)	(0.098)	(0.444)	(0.242)	(0.234)	(1.831)	(0.061)	(0.184)
MSA counties	-0.052	-0.068	0.752***	0.195*	0.043	-0.238***	0.345***	0.181	-0.043	-0.171**
	(0.139)	(0.045)	(0.222)	(0.118)	(0.197)	(0.052)	(0.117)	(0.635)	(0.040)	(0.068)
Observations	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914
χ^2	1,086.000	8,322.000	837.400	2,087.000	1,179.000	5,045.000	1,807.000	39.510	8,214.000	2,319.000
Wald test of exogeneity: Pr	0.038	0.580	0.159	0.505	0.780	0.942	0.127	0.000	0.136	0.624

Robust standard errors clustered by counties are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 8: Regression Results for Income

Variables	$\text{Income}_{c,t}$							
	Per capita		Median household		Per capita		Median household	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Log(oil \& gas production)}_{c,t-1}$	-0.004	-0.004	-0.004**	-0.004**				
	(0.004)	(0.004)	(0.002)	(0.002)				
$\text{Log(oil \& gas revenues)}_{c,t-1}$					-0.002	-0.002	-0.001	-0.001
					(0.002)	(0.002)	(0.001)	(0.001)
$A_{2005-2008}$	0.086***	0.079***	0.031***	0.030***	0.079***	0.072***	0.028***	0.027***
	(0.011)	(0.012)	(0.005)	(0.005)	(0.015)	(0.015)	(0.006)	(0.007)
$\text{Log(oil \& gas production)}_{c,t-1}$	0.001***	0.001***	0.001***	0.001***				
$\times A_{2005-2008}$	(0.000)	(0.000)	(0.000)	(0.000)				
$\text{Log(oil \& gas revenues)}_{c,t-1}$					0.003***	0.003***	0.001***	0.001***
$\times A_{2005-2008}$					(0.001)	(0.001)	(0.000)	(0.000)
$A_{2009-2012}$	0.158***	0.170***	0.050***	0.052***	0.162***	0.175***	0.048***	0.050***
	(0.013)	(0.014)	(0.006)	(0.007)	(0.017)	(0.017)	(0.008)	(0.009)
$\text{Log(oil \& gas production)}_{c,t-1}$	0.001**	0.001**	0.001***	0.001***				
$A_{2009-2012}$	(0.000)	(0.000)	(0.000)	(0.000)				
$\text{Log(oil \& gas revenues)}_{c,t-1}$					0.001	0.001	0.002***	0.002***
$A_{2009-2012}$					(0.001)	(0.001)	(0.001)	(0.001)
$\text{Unemployment rate}_{c,t-1}$		-0.007***		-0.001		-0.007***		-0.001
		(0.002)		(0.002)		(0.003)		(0.002)
$\text{Log of population}_{c,t-1}$	0.105	0.102	0.129***	0.129***	0.090	0.086	0.119**	0.118**
	(0.075)	(0.076)	(0.049)	(0.049)	(0.075)	(0.076)	(0.051)	(0.051)
County effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914
R^2	0.863	0.863	0.949	0.949	0.868	0.869	0.951	0.951

Robust standard errors clustered by county are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 9: IV Regression Results for Income

Variables	$\text{Income}_{c,t}$							
	Per capita		Median household		Per capita		Median household	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Log(oil \& gas production)}_{c,t-1}$	-0.744***	-0.676***	0.315***	0.287***				
	(0.268)	(0.216)	(0.118)	(0.097)				
$\text{Log(oil \& gas revenues)}_{c,t-1}$					0.283***	0.250***	0.167***	0.182***
					(0.091)	(0.076)	(0.056)	(0.057)
$A_{2005-2008}$	-0.108	-0.119	0.068	0.068	-0.078	-0.043	-0.019	0.002
	(0.168)	(0.153)	(0.073)	(0.067)	(0.159)	(0.146)	(0.090)	(0.102)
$\text{Log(oil \& gas production)}_{c,t-1}$	0.009	0.008	-0.001	-0.001				
$\times A_{2005-2008}$	(0.006)	(0.006)	(0.003)	(0.003)				
$\text{Log(oil \& gas revenues)}_{c,t-1}$					0.000	0.001	-0.003	-0.004
$\times A_{2005-2008}$					(0.012)	(0.010)	(0.007)	(0.007)
$A_{2009-2012}$	-0.086	-0.036	0.088	0.074	0.016	-0.022	-0.024	-0.066
	(0.208)	(0.189)	(0.089)	(0.080)	(0.232)	(0.206)	(0.135)	(0.146)
$\text{Log(oil \& gas production)}_{c,t-1}$	0.010	0.010	-0.000	-0.000				
$A_{2009-2012}$	(0.008)	(0.007)	(0.003)	(0.003)				
$\text{Log(oil \& gas revenues)}_{c,t-1}$					-0.003	-0.002	-0.001	-0.002
$A_{2009-2012}$					(0.015)	(0.014)	(0.009)	(0.010)
$\text{Unemployment rate}_{c,t-1}$		-0.019		0.004		0.025**		0.021***
		(0.015)		(0.006)		(0.011)		(0.008)
$\text{Log of population}_{c,t-1}$	1.543*	1.409*	-0.415	-0.362	-0.057	-0.018	0.012	0.012
	(0.879)	(0.739)	(0.384)	(0.324)	(0.544)	(0.477)	(0.317)	(0.339)
County effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,914	1,914	1,914	1,914	1,914	1,914	1,914	1,914
F-statistics for weak identification	2.934	3.132	2.934	3.132	2.184	2.336	2.184	2.336

Robust standard errors clustered by county are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Stock-Yogo weak ID test critical values: 5% maximal IV relative bias 12.20 10% maximal IV relative bias 7.77

Table 10: Regression Results for Property and School Tax Rates

Variables	Log(taxable value)$_{c,t}$	Log(county tax rate)$_{c,t}$	Log(school tax rate)$_{c,t}$	Log(per student local revenues)$_{c,t}$	Log(per student expenditure)$_{c,t}$ From all sources	Log(per student expenditure)$_{c,t}$ From local tax
	(1)	(2)	(3)	(4)	(5)	(6)
Log(oil & gas production)$_{c,t-1}$	0.001	-0.004	-0.001	0.000	0.002	-0.000
	(0.008)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)
$A_{2005-2008}$	0.073***	0.061***	-0.180***	0.093***	0.068**	0.026*
	(0.025)	(0.021)	(0.011)	(0.010)	(0.026)	(0.014)
Log(oil & gas production)$_{c,t-1}$	0.008***	-0.008***	-0.001	0.002***	0.002	0.003***
$\times A_{2005-2008}$	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
$A_{2009-2012}$	0.115***	0.097**	-0.211***	0.147***	0.105**	0.068*
	(0.034)	(0.037)	(0.017)	(0.021)	(0.045)	(0.038)
Log(oil & gas production)$_{c,t-1}$	0.007***	-0.006***	-0.001	0.002*	0.004**	0.005***
$\times A_{2009-2012}$	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Log(population)$_{c,t-1}$	0.454**	0.055	0.003			
	(0.192)	(0.173)	(0.096)			
Log(income)$_{c,t-1}$	0.287***					
	(0.094)					
Log(total number of	0.289***					
establishments)$_{t-1}$	(0.040)					
$\widehat{v}^*_{c,t-1}$		-0.247*	-0.156*	0.289***	0.434**	0.170
		(0.140)	(0.082)	(0.079)	(0.204)	(0.192)
Log(average daily				-0.148	-0.215	-0.365
attendance)$_{c,t}$				(0.101)	(0.244)	(0.248)
County effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,914	1,740	1,392	1,218	1,218	1,218
R^2	0.985	0.892	0.770	0.908	0.700	0.957

Robust standard errors clustered by county are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 11: IV Regression Results for Property and School Tax Rates

Variables	Log(taxable value)$_{c,t}$	Log(county tax rate)$_{c,t}$	Log(school tax rate)$_{c,t}$	Log(per student local revenues)$_{c,t}$	Log(per student expenditure)$_{c,t}$ From all sources	Log(per student expenditure)$_{c,t}$ From local tax
	(1)	(2)	(3)	(4)	(5)	(6)
Log(oil & gas production)$_{c,t-1}$	0.069	0.014	-0.031***	-0.063***	0.191***	-0.263***
	(0.105)	(0.033)	(0.010)	(0.020)	(0.052)	(0.052)
$A_{2005-2008}$	0.116	0.115**	-0.163***	0.057	0.086	-0.019
	(0.079)	(0.051)	(0.026)	(0.035)	(0.087)	(0.114)
Log(oil & gas production)$_{c,t-1}$	0.003	-0.012***	-0.001	0.006***	-0.005	0.014**
$\times A_{2005-2008}$	(0.006)	(0.003)	(0.002)	(0.002)	(0.006)	(0.007)
$A_{2009-2012}$	0.176*	0.085	-0.204***	0.169***	0.158	0.044
	(0.102)	(0.065)	(0.037)	(0.059)	(0.157)	(0.205)
Log(oil & gas production)$_{c,t-1}$	0.001	-0.006	0.001	0.003	-0.008	0.018
$\times A_{2009-2012}$	(0.008)	(0.004)	(0.002)	(0.004)	(0.009)	(0.012)
Log(population)$_{c,t-1}$	0.432*	0.075	0.048			
	(0.236)	(0.182)	(0.116)			
Log(income)$_{c,t-1}$	0.302***					
	(0.097)					
Log(total number of	0.230***					
establishments)$_{t-1}$	(0.084)					
$\widehat{v}^*_{c,t-1}$		-0.328*	-0.241***	0.254**	0.744**	-0.169
		(0.168)	(0.086)	(0.110)	(0.327)	(0.392)
Log(average daily				-0.176	-0.143	-0.464
attendance)$_{c,t}$				(0.149)	(0.391)	(0.481)
County effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,914	1,740	1,392	1,218	1,218	1,218
F-statistics for weak identification	1.151	2.135	4.095	3.935	3.935	3.935

Robust standard errors clustered by county are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Stock-Yogo weak ID test critical values: 5% maximal IV relative bias 12.20 10% maximal IV relative bias 7.77