The long term consequences of resource based specialization

Working Paper

The Long Term Consequences of Resource Based Specialization

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Abstract

Economists have long debated whether an abundance of natural resources adversely affects long term economic performance. Focusing on three economic channels discussed in the literature, I investigate whether resource abundance slows down industrialization or the accumulation of education, or whether it raises inequality. I examine these channels using geological variation in oil abundance in the Southern United States. In 1890 oil abundant counties were mostly agricultural and similar to other nearby counties, but after oil was discovered they began to specialize in its production. From 1940-1990 oil abundant counties developed a manufacturing sector that was smaller in terms of its share of employment, but not in terms of its absolute size. At the same time, these counties enjoyed a better educated workforce and higher per capita income, and attracted population at a faster rate. By 1990 these advantages had diminished, but oil abundant counties still had slightly higher per capita income without suffering from worse inequality. Taken together, my results suggest that while resource based specialization involves some long term costs, it can serve as an important lever for development.

Keywords: Specialization, Development, Human Capital, Resource Curse, Oil.
JEL classification: O1, N5, J2, R1

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1 Introduction

Does resource abundance cause specialization that is costly in the long run? This question has long puzzled economists, and two recent books show that it still does.[1] "Escaping the Curse of Natural Resources" (Humphreys, Sachs, and Stiglitz, eds., 2007) argues that development which relies on abundant natural resources is often costly, while "Natural Resources: Neither Curse Nor Destiny" (Lederman and Maloney, eds., 2007) argues that it can be beneficial.

The debate over the impact of resource based specialization is complicated by the multiplicity of causal channels that have been proposed. While some of these channels involve institutional processes, others emphasize economic effects common to both developed and developing countries. This paper examines a setting with relatively little institutional variation, which allows me to focus on three economic channels. First, resource based specialization may slow down industrialization and growth in agricultural economies (Lucas 1988 and Matsuyama 1992 explore this "Dutch Disease" channel). Second, it may slow the accumulation of education (Leamer et al. 1999; Gylfason 2001). And third, it may increase income inequality (Leamer et al. 1999; Engerman and Sokoloff 1997; Humphreys et al. 2007). Understanding the significance of these channels is important not only for policy makers in resource rich economies; it can also shed light on the role of geography in economic development.

One of the challenges in assessing these channels is that most of the evidence we have comes from cross country studies. Despite considerable research effort, this evidence is mixed. Some influential studies (e.g. Sachs and Warner 1995, 2001) find that the ratio of raw materials to total exports is negatively correlated with growth since the 1960s. But Lederman and Maloney (2007) and Brunnschweiler and Bulte (2006) argue that these results are not robust to using alternative measures of resource abundance. While the findings of these studies are often at odds with each other, their interpretation also raises several

[1] The debate over the "Resource Curse" goes back at least to Adam Smith (1776). In recent decades this debate has been sparked by Corden and Neary (1982), Auty (1993), and many others.

econometric issues. First, the extent of resource extraction is endogenous (e.g. David and Wright 1997). For example, countries may specialize in resource intensive industries because they have little else, instead of the other way around. Second, institutional quality may be spuriously correlated with endowments, causing omitted variables bias (e.g. Acemoglu et al. 2002). Oil rich economies in the Gulf Region, for example, shared many common institutions even before oil was discovered (Pamuk 2006). And finally, and the quality of data may vary considerably across countries and over time. These issues make it difficult to estimate the economic effects of resource based specialization.

This paper proposes to overcome these issues by examining the production of oil in parts of the Southern US from 1890-1990. The study of the South is particularly interesting, since it remained largely agricultural and relatively poor for a long time.[2] To address the problem of endogenous discovery and utilization of natural resources, I use a novel identification strategy that relies on geological variation in the location of subsurface oil.[3] I construct a new dataset that tells us the location of major geologically defined oilfields, the amount extracted from them by 1999, and the amount that was projected to have remained. There were no discoveries of major inland oilfields during the 1990s, so the data provide a plausible approximation of the natural endowment of oil.

In order to analyze the effects of oil abundance I match the geological data to census data. The high quality of these data limit the measurement issues I face compared to many studies that span several decades.[4] To use the variation in the data, I define a county as oil abundant if it lies above at least one oilfield (or part of an oilfield) that contained more than 100 million barrels of oil before any oil was extracted. I construct a plausible control group for the oil abundant counties using other nearby counties that are not oil abundant. The resulting sample includes 775 counties, 171 of which are oil abundant. In some specifications

[2] See Wright (1986) and Caselli and Coleman (2001).

[3] The location of natural gas is correlated with the location of oil, and an oilfield may produce substantial amounts of gas. Therefore, throughout this paper I use "oil" to refer to both oil and natural gas.

[4] Some recent studies examine the effect of short-run demand shocks on specialized regions within countries (Black, McKinnish, and Sanders 2005; Buckley 2003; and Angrist and Kugler 2005).

I exclude counties adjacent to oil abundant ones (from which workers might commute to work) or contrast oil abundant counties in Texas, Louisiana, and Oklahoma to oil scarce counties in nearby states; my results are robust to these changes in the sample.

But while this sample can teach us about the causal effect of resource abundance on the development of the US economy, how much can we learn about other settings? One concern is that people can migrate within countries more easily than between countries. But in fact, migration across country borders has also been important in some resource rich economies. At the same time, even labor movements within the US are not frictionless. For example, if an increase in local labor demand raises wages, housing prices can also increase. Such an increase can mitigate differences in workers' real wages across counties, while still making locally produced tradable goods more expensive. This mechanism is qualitatively similar to a real exchange rate appreciation. Another difference between counties and countries is in the government's ability to determine schooling policies. And yet in the US local administrators can still affect the quality of schools in their counties. These considerations imply that despite the differences from other settings, we can still learn much about resource based specialization by examining the counties in our sample.

An examination of the sample reveals that the oil abundant counties were similar to the control counties in terms of industrialization and manufacturing wages in 1890, before the discovery of major oilfields in the South. After oil was discovered, oil abundance raised employment in mining from about 1-2 percentage points to about 6-8 percentage points throughout the period 1940-1990.[5] In fact, in oil abundant counties, employment in mining was equal to about 50-110 percent of employment in manufacturing, reflecting the highly specialized nature of these counties. Moreover, the employment in mining understates the importance of the oil sector in the oil abundant economies, since many workers were employed in service and manufacturing industries closely related to oil extraction.

Having found that oil abundance leads to specialization in oil production, I examine

[5]Most of the mining workers in the region I analyze are employed in oil and gas extraction.

whether it had an effect through the channels mentioned above: sluggish industrialization, slow accumulation of education, or increased inequality. First, I find that in 1940 oil abundant counties were no less industrialized than the control counties. This was probably because oil production often relies on local refineries. As a result, oil initially crowded out agriculture, rather than manufacturing. But over the next 50 years the region moved away from agriculture towards manufacturing and services. I find that oil abundance slowed down the expansion of the manufacturing sector as a fraction of employment.[6] I also find some evidence that oil abundance offset the effect of right to work laws: these laws increased the employment share of manufacturing only in counties that were not oil abundant. Yet interestingly, oil abundance did not reduce the overall size of the manufacturing sector. As I discuss below, oil abundant counties became richer, so they attracted more population. Since trade is not frictionless even within the US, higher population may have increased local demand, mitigating the effect of "Dutch Disease" on the size of the manufacturing sector. This offsetting effect of labor mobility may be relevant for other resource rich economies with substantial factor mobility.

Second, I find that oil abundance initially increased the share of educated workers in the workforce, but later slowed down the accumulation of education. From 1890-1940 oil was a relatively skill intensive industry in an agricultural region, so it increased demand for education. By 1940 oil abundant counties had about 2.5 percentage points (or about 13 percent) more high school graduates than the control counties. But as discussed above, after 1940 oil slowed down the expansion of employment shares of other relatively skill intensive industries, such as manufacturing. This inertia in the growth of demand for education caused oil abundant counties to accumulate fewer educated workers after 1940. There is some evidence that this was due both to the educational choices of locals and to the education level of migrants. Interestingly, the slower accumulation of education in oil abundant counties occurred despite their higher per capita spending on education. And yet despite the relative

[6] This result is not mechanical, as it is almost unchanged when I calculate the fraction of manufacturing in non-mining employment.

slowdown in the accumulation of education in the oil abundant counties, their workforce was not much less educated than that of the control counties even in 1990.

Third, I examine whether oil abundance affected the level or the distribution of income. I show that most of the earnings from the region's oil industry accrued to people who lived in the oil abundant counties, though some revenues were transferred within state. I find that oil abundant counties enjoyed per capita income that was about 20-30 log points higher than the control counties around 1950. This was due not only to higher earnings in oil extraction: the presence of the oil sector also increased manufacturing wages. Over time the advantage of the oil abundant counties narrowed, but in 1989 their per capita income that was still about 5-6 percent higher.[7] This inverted U-shaped effect of resource abundance on per capita income over time is consistent with evidence from the Western US (Mitchener and McLean 1999) and the Middle East (Pamuk 2006). It may also help reconcile the evidence that the US developed successfully using natural resources before 1940 (Wright 1990) with the evidence on slow growth of resource rich economies in recent decades. Finally, it is worth noting that oil abundance shifted the entire income distribution to the right, and it had little effect on income inequality.

My main findings on the effects of oil abundance are statistically significant even after controlling for various geographic and demographic covariates and for state-year interactions. I find further support for these results using an orthogonal source of variation in oil abundance. A comparison of oil abundant counties with different levels of oil endowment gives results consistent with the evidence discussed above.

Taken together, this evidence suggests that the long term effects of specialization in oil production through purely economic channels were generally favorable. Specialization was not entirely without cost: it caused inertia in the industry structure that slowed the accumulation of education. But this study suggests that inertia might be common to long term specialization that arises from other fixed sources of comparative advantage, due to

[7] The relative slowdown of growth in oil abundant counties occured mostly from around 1940-1970, when oil prices were quite stable.

resource abundance or other factors.

Taking a broader perspective, my findings suggest that geographic fundamentals, such as resource abundance, can have an important impact on long term development trajectories. At the same time, if resource abundance causes bad economic performance in other settings, this is likely because it interacts with other factors, such as weak institutions.

The remainder of the paper is organized as follows. Section 2 discusses the data and the samples, Section 3 presents the empirical analysis, and Section 4 concludes.

2 Data and Samples

This section describes the data set that I construct to examine the long term effects of resource based specialization. I discuss the sources of data I use and the tradeoffs I face in constructing the sample, and I then explain the advantages of this dataset for the questions at hand.

I begin by using the Oil and Gas Journal Data Book (2000). This source lists the names of US oilfields that had at least 100 million barrels of oil before any oil was extracted from them. For each oilfield, we know the amount extracted by 1999 and the amount that was projected to have remained. Major oilfields were first discovered in the US South after 1890 (see Figure 1). The hazard rate of discovery of new fields increased until the 1930s, and it has since declined. In fact, only one major US oilfield was discovered during the 1990s, and it lies under the sea. The oilfield data therefore provide a plausible approximation of the exogenous oil endowment of the different counties.[8]

In order to determine whether a county is oil abundant, I use the Oil and Gas Field Code Master List, which tells us which county (or counties) lie above each oilfield. I define a county as oil abundant if it lies above one or more of the large oilfields discussed above. Of the 222 oil abundant counties in the US, about 150 are found in three adjacent states in the Southern US: Texas (107 counties), Oklahoma (24 counties), and Louisiana (19 counties). Unlike the

[8]Though it is still possible that the esitmated quantity in some known oilfields that were thought to contain less than 100 million barrels would exceed this threshold if technology improves further.

two other oil abundant states (Alaska and California) the 3 states I consider are divided into counties in a fairly regular way, offering a plausible set treatment and control counties. In order to focus the analysis on counties that are similar in all but their oil abundance, I use the Geographic Information System to restrict my sample to counties that are within 200 miles of the oil abundant counties of Texas, Oklahoma, and Louisiana. This leaves a sample of 775 counties, 171 of which are oil abundant (see map in Figure 2).[9]

Throughout much of the analysis below, I use three specifications based on this sample. Specification (1) uses all the counties in the sample. Specification (2) excludes counties that are adjacent to the oil abundant counties. One advantage of this specification is that workers in non-adjacent counties are less likely to commute to work in the oil abundant counties. A second advantage is that adjacent counties may have more small oilfields that are not identified in my data. It turns out that in 1940 the employment share of mining was similar in both the adjacent and non-adjacent counties. By 1990, however, these shares diverged, as mining accounted for 2.7 percent of the labor force in the adjacent counties and only 0.9 percent in the non-adjacent counties. A final advantage is that almost all the oil refining capacity in the sample counties is now found in the oil abundant counties and in the adjacent counties, suggesting that the non-adjacent counties were less affected by the refining industry.[10] The drawbacks of using only non-adjacent counties as controls is that this sample is smaller, and the control counties may differ more from the oil abundant ones for other reasons. But in the next section I examine these initial differences and conclude that the non-adjacent counties are in fact plausible controls.

One concern about the two specifications discussed above is that oil revenues may affect economic outcomes at the state level. For this reason, specification (3) contrasts the oil

[9] In addition to the 150 oil-abundant counties mentioned above, 21 other oil abundant counties in Alabama, Arkansas, Florida, Kansas, Mississippi, and New Mexico that are also included in the sample. In 1970 the oil abundant counties in the sample accounted for about 46 percent of US income from oil and gas extraction and about 73 percent of income from oil and gas extraction in the sample (Bureau of Economic Analysis, Regional Economic Accounts).

[10] Calculations based on Energy Information Administration data for 2006 suggest that about 57 percent of refining capacity in the sample is found in the oil abundant counties, compared to about 38 percent in the adjacent counties and about 5 percent in the other counties.

abundant counties in the three oil abundant states (Texas, Oklahoma, and Louisiana) with counties that are not oil abundant and lie in the other nearby states shown in Figure 2.[11] The shortcoming of this specification is, that it may attribute to oil abundance any state-specific policies that are unrelated to oil. I therefore examine additional specifications that control for state-year variation when I discuss the robustness of my estimates.[12]

Having discussed different the comparisons within the sample, I use the County Data Books (Haines 2004) to obtain county-level statistics on land area, population, industries, education, local taxation and expenditures, and income.[13] I complement these data with micro data from the 1980 census, which allows me to further examine the effect of oil abundance on education. Unfortunately, these micro data are more coarsely aggregated, so they identify only the county group in which each individual resides. There are 179 county groups in the sample, and 73 of them have at least one oil abundant county.[14]

In addition to the data on economic outcomes, I use also data from Rappaport and Sachs (2003) on the distance from the geographic centroid of each county to the nearest ocean and navigable river. Finally, I use data on states that enacted right-to-work laws and related pro-business policies, mostly during the 1940s and 1950s (Holmes 1998, Lumsden and Petersen 1975). Holmes shows that these laws facilitated the development of manufacturing, and I examine if they had a differential impact on counties oil abundant counties.

The dataset that I construct has several advantages for examining the long term consequences of regional specialization. First, it provides a new source of variation in resource abundance that is plausibly exogenous. This improves over cross-country comparisons, which typically use measures of the amount of natural resources extracted. Resource extraction is

[11] According to BEA data, in 1970 the oil abundant counties in the oil abundant states received 71 percent of the oil and gas revenues in the sample, while the oil scarce counties in the oil scarce states in the sample received only about 4 percent.

[12] The robustness checks section also considers the possibility of other spatially correlated shocks.

[13] The data on agricultural employment from 1960 onwards includes forestry and fisheries, which is small compared to agriculture. I use data from 1960 (which reports forestry and fisheries separately) to impute employment in forestry and fisheries in 1940 and 1950 and add it to the employment in agriculture for those years.

[14] Of the 775 sample counties, 21 were split between multiple county groups. I assigned each of these to the county group with the lowest number. Excluding these counties has little effect on the results.

determined by factors such as strategic pricing considerations (Libecap 1989) and the level of technology (David and Wright 1997); these, in turn, may be correlated with the outcomes of interest and make it difficult to draw causal inferences.

Second, for specialization to be important, the specialized good has to constitute a substantial fraction of demand over a long period of time. National Income and Product Accounts show that the share of oil and gas extraction in total employee compensation was about 0.7 percent in 1948 and about 0.6 percent in 1987[15], and as I discuss below it was a major source of income in the counties I analyze.

Third, I can trace some outcomes of interest back to 1890, and many more outcomes become available from 1940 onwards. The availability of consistent data over a long period of time allows me to examine the impact of natural resources on an economy that is initially very agricultural. This is attractive because problems associated with resource abundance have typically been attributed to less developed economies.

Fourth, the data offers a large set of control economies that are similar in terms of their economy and technology, except for their oil abundance. Finally, the institutional differences within the region are smaller than the differences between most countries, so any spurious correlation between resource abundance and institutions is much less of a concern than in the case of international comparisons. Armed with this data, I can now proceed to examine whether there is evidence of an economic "Resource Curse" in this setting.

3 Empirical Analysis of Specialization in Oil Production

3.1 Specialization in an Agricultural Economy

In 1890 the economy of the Southern US was predominantly agricultural (Wright 1986), and large oilfields had not yet been discovered (see Figure 1). Census data for 1890 is available for most of the sample counties, although some county boundaries had not yet been

[15] It did, however, fluctuate over time, especially with the rise of energy prices during the 1970s and its decline during the 1980s.

drawn then, especially in Oklahoma and West Texas, and there were also some subsequent boundary changes. Bearing these caveats in mind, we can nonetheless examine whether relevant economic outcomes were correlated with oil abundance before oil was discovered. Reassuringly, I find that oil abundance was uncorrelated with the percentage of manufacturing employees in the total population and with log average wage income of manufacturing workers in 1890.[16]

The decades after 1890 saw the discovery and development of many oilfields. These discoveries, along with the growing importance of the automobile, raised the importance of the oil sector, especially in the region I analyze. In the period of discoveries, many firms competed in this sector - sometimes using contractual agreements when they realized that they drew from common pools of oil. Eventually, much of the ownership was consolidated in the hands of several large and vertically integrated firms. Increased regional refining capacity, inflows of workers and capital, and an improved transportation infrastructure allowed these firms to ship oil to major industrial centers on the Eastern Seaboard.[17]

But despite these important changes, the region I analyze was mostly agricultural even in 1940 (Table 1).[18] In oil abundant counties the mining sector employed 6.2 percent of the labor force - more than the entire manufacturing sector. In contrast, the mining sector employed about 1.3 percent of the labor force in other nearby counties.[19] Table 1 also shows that oil abundant counties performed well around 1940 compared to the control counties. In the next sections I examine the performance of these oil abundant counties over the subsequent 50 years.

[16] A regression of the percentage of manufacturing employees in total population on an indicator for oil abundance for the 596 counties that reported this data for 1890 gives a coefficient of 0.2 with robust standard error of 1.2. A regression of log average manufacturing wage income on an indicator for oil abundance for 527 counties yields a coefficient of .005 with robust standard error of .051.

[17] These issues are discussed in Pratt (1980) and Libecap and Wiggins (1984).

[18] From 1960 onwards, County and City Book data reports employment in agriculture together with employment in forestry and fisheries, although the latter typically comprise a small share of the combined category. I used the 1960 data, which also reports agriculture separately, to impute the additional employment in forestry and fisheries in 1940 and 1950, assuming that their share did not change by county.

[19] Employment in mining includes the extraction of natural resources other than oil and gas. But as the columns for the control counties in Table 1 show, there was little mining except oil in this region.

3.2 Specialization and Industrialization

The first question I examine is whether oil abundance slows down industrialization. The literature has explored different versions of the "Dutch Disease" mechanism, where a resource abundant sector raises real factor prices and crowds out the production of other tradable goods (Sachs and Warner 2001, Humphreys et al. 2007). In his analysis of a two sector open economy, Mastuyama (1992) argues that in the long run this can slow down the growth of manufacturing; when learning by doing takes place only in manufacturing, an economy might be better off without its abundant resource. While the flow of technology within the US precludes us from analyzing the effects of learning by doing in this setting, we can still examine whether comparative advantage in oil production decreased the size of the manufacturing sector.

The transition to manufacturing and services from agriculture was one of the important economic changes that took place in the US South after 1940 (Wright 1986). In our sample of counties, this transition was rapid: the fraction of the labor force employed in agriculture fell from about 40 percent in 1940 to about 10-15 percent in 1970. This transition offers an opportunity to examine the effect of specialization on industrialization.

In order for specialization to affect industrialization, we should first examine whether it affected factor prices. As I discuss below, this was indeed the case: oil abundant counties enjoyed higher wages around the middle of the 20th century. Migration did not offset these higher wages, as there is some evidence of increased housing prices. This meant that local producers of non oil goods faced higher factor prices, and this may have made oil abundant counties less attractive for a wide range of manufacturing goods.[20]

But did this comparative advantage in oil production slow down industrialization? To examine this question, I examine the effect of oil abundance on the employment share of

[20] Important exceptions are upstream and downstream manufacturing industries closely related to oil: the production of oilfield machinery, refining, and petrochemicals (Pratt 1980).

manufacturing, mining, and agriculture using the following regression:[21]

$$Y_{ct} = \psi_t + \alpha_t d_c + \varepsilon_{ct}, \tag{1}$$

where Y_{ct} is the outcome in county c at year t, ϕ_c are year effects, α_t is a time-varying coefficient on the indicator for oil abundance, d_c, and ε_{ct} is a residual. Note that in order to identify α_{1940} this regression omits the intercept and county fixed effects; but adding these last terms has no effect on the estimates of the differential effect of oil abundance over time, $\alpha_t - \alpha_{1940}$.

The results in Table 2 and Figure 3 show that in 1940 the employment share of mining was about 5 percentage points higher in oil abundant counties compared to the various control groups. The employment share of agriculture was about 8-9 percentage points lower than in the control group, whereas there was no significant difference in the employment share of manufacturing. In other words, in a very agricultural economy oil crowded out agriculture.

As the results also show, there was relatively little change in the employment share of mining from 1940-1990. This was likely due in part to the stability of US oil prices before 1973, which was brought about by strategic interactions of firms and government (Libecap 1989). When oil prices increased during the 1970s, the employment share of mining temporarily increased, returning to its earlier levels after oil prices fell in the 1980s. The discovery of new oilfields, as depicted in Figure 2, and the depletion of some existing fields may also affected the employment share of mining over time. As the results show, however, the net effect of these changes appears to have been relatively small from 1940-1990.

But while the effect of oil abundance on the employment share of mining was stable, the same cannot be said of its effect on agriculture and manufacturing. Oil abundant counties, which shifted out of agriculture early, were gradually caught up by the other counties. By 1990 the employment share of agriculture was only about 1.5-2 percentage points lower in the oil abundant counties, and the employment share of manufacturing was 4-7 percentage

[21] The remaining employment share is almost entirely in services.

points lower. Note that these results are not mechanical: the are almost unchanged when I calculate the employment share of agriculture and manufaturing in the non-mining workforce (results available from author).[22]

The effect of oil abundance on the employment share of manufacturing need not only have been direct. Pro business policies enacted in some states, especially during the 1940s and 1950s, made them more attractive to manufacturing (Holmes 1998). In an earlier version of this paper (Michaels 2006) I show some evidence that right to work laws may have increased the employment share of manufacturing in the control counties, but not in the oil abundant counties. I interpret this result as suggesting that counties in right to work law states may have become more attractive to manufacturing, but oil abundance implied higher wages and prevented relocation of manufacturing to these counties.

But interestingly, even as oil abundance reduced the employment share of manufacturing, it did not significantly decrease its absolute size (Table 3). This is because, as I discuss below, oil abundant counties attracted more population. Increased population may have made local manufactured goods relatively more attractive if there were frictions in trade between counties. This offsetting effect of factor mobility on "Dutch Disease" has received little attention in the literature, which typically ignores factor mobility. In practice, however, it can be important if we are interested in the aggregate size of the manufacturing sector (e.g. Matsuyama 1992). The applicability of this channel of factor mobility to other settings varies. In some countries migration in response to oil discoveries was limited, while in other cases, such as the Gulf States and Saudi Arabia, substantial migration did take place. The evidence presented here suggests that oil abundance did not necessarily decrease the size of the manufacturing sector in countries and regions where labor mobility was possible.

In summary, I find that while oil abundance did not decrease employment in manufacturing, it did decrease the employment share of manufacturing. By changing the employment

[22] As I discuss below, population grew faster in the oil abundant counties, so over time land became relatively more scarce in those counties. But if this effect was quantitatively important, it would have likely implied that the employment share of agriculture would have declined more quickly in oil abundant counties.

shares of the different sectors, oil abundance might still have had an impact on the demand for educated workers. The next section examines this mechanism and other possible channels through which oil abundance may have affected the accumulation of education.

3.3 Specialization and Accumulation of Education

The possibility that resource abundance slows down the accumulation of education has been examined in several studies. For example, Leamer et al. (1998) argue that reliance on natural resources may have slowed down the accumulation of education in Latin America, and Gylfason (2001) finds that a high fraction of natural resources in GDP is correlated with low educational spending and attainment.

In order to examine the effect of oil abundance on education in the sample of counties I require a relevant and consistent measure of the stock of educated workers. Due to data limitations, I focus on the fraction of people with a high-school degree (or more) among people 25 years and older.[23] As the top row in Table 4 shows, oil abundant counties had a better educated workforce in 1940, with about 2-3 percentage points more high-school graduates than the control counties. This finding is consistent with the fact that oil extraction was more skill intensive than agriculture, the industry it crowded out in 1940.[24]

From 1940-1990 the fraction of high-school graduates increased rapidly in all counties, as shown in Figure 4 and Table 4. But in the oil abundant counties the rate of accumulation of education was significantly slower. To what extent can the quicker transition from agriculture to manufacturing and services in counties that were not oil abundant explain their more rapid accumulation of education? Xiang (2005) finds that the production of new goods is much

[23] Unfortunately, no comparable measure is available before the discovery of oil. Using the complete census micro data for 1880 (North Atlantic Population Project), I calculate the fraction of children aged 14-18 who attended high school in the 590 sample counties that existed then. Average school attendance in the oil abundant counties was about 5.6 percent, and in the other sample counties it was about 6.1; the difference was not statistically significant. Although I cannot construct a similar measure of attendence for 1940 (because micro data do not identify county of residence), this comparison suggests that oil abundant counties would probably not have had a better educated workforce in 1940 if oil had not been discovered.

[24] In 1940, the fraction of employees that attained at least a high-school degree was 15 percent in mining, compared to about 10 percent in agriculture and about 26 percent in manufacturing (Author's tabulations from the Integrated Public Use Microdata Series - IPUMS).

more skill intensive than the production of existing goods. If specialization causes inertia in the industry structure, in the sense that new industries and products make up a smaller share of the employment in the oil abundant counties, this may slow down the accumulation of education. We should note that this mechanism may operate in economies that specialize in a fixed set of products, even if natural resources are not the source of their comparative advantage.

To estimate the quantitative importance of this mechanism, I use census data on the educational attainment of employees in agriculture, mining, manufacturing, and services. The effect of the differential changes in industry composition account for about 1-1.5 percentage points in the fraction of high-school graduates. In other words, differences in aggregate changes in industry composition can explain about 20-30 percent of the slower rate of accumulation of education in oil abundant counties.[25] Since this calculation does not account for persistence in manufacturing and service industries related to oil, it seems likely that variation at lower levels of industry aggregation within manufacturing may explain even more of the differential changes in education.

These results suggest that inertia in the industry structure can slow down demand for education. But is the slower accumulation of education really due to the decisions of people raised in oil abundant counties? In other words, does local demand for skills matter where migration is possible? To shed light on this question, I examine the occupational and educational choices of natives and people who migrated into each county. I begin by regressing the fraction of high school dropouts among people aged 16-19 on an indicator for oil abundance using oil abundant and control counties as in specifications (1)-(3). The estimates suggest that dropout rates were about 0.8-1.7 higher in oil abundant counties in 1990.[26] Next, I use micro data from the 1980 census, which identify individuals' county group of residence. Of the people aged 19 or 20 who did lived in county groups with at least one oil abundant counties and did not migrate in the previous 5 years, about 4 percent were employed in the

[25] Detailed calculations available from author.

[26] County level data on dropout rates is not available for earlier years

oil extraction industry; the corresponding figure in the control county groups was only about 1 percent, and the difference was highly significant. This shows that local demand conditions affected the employment choices of natives, and therefore probably had an impact on their educational choices. The micro data also suggest that the fraction of high school graduates among people aged 25 and over was about 2.5 percentage points lower in county groups with oil abundant counties, though the estimate is only marginally significant. This estimate is a bit larger and more precise for people who migrated in the past 5 years. Although this cross sectional evidence should be taken with caution, it suggests that both natives and people who moved into the county likely contributed to the slower accumulation of education where oil was abundant.

To further examine the role of supply and demand for education, I use the micro data to estimate a Mincer wage regression for people aged 18-65. In other words, I regress log hourly wage on years of schooling, age, age squared, an indicator for oil abundance and its interaction with schooling. The coefficient on oil abundance is positive and significant (around 5 percent) and the interaction term is negative, though not significant. This suggests that although educated workers are no more common in the oil abundant county groups, the returns to skill are not higher than elsewhere. The regression provides further evidence that changes in demand for education, rather than supply of education, affected the educational attainment in oil abundant counties.

While I find evidence for endogenous supply of education in response to changes in industry structure, I find little support for other alternative explanations.[27] First, the oil industry's increased demand for skill from 1940-1990 was comparable to that of other industries. This means that it is not inertia within the oil sector that reduced the demand for skill over time, but rather the fact that it increasingly crowded out other skill intensive industries.

Second, the oil abundant counties have higher per capita income throughout the period,

[27] This mechanism is formalized in the model discussed in the next section.

so we may expect that they generate higher tax revenues per capita and spend more per capita. In fact, this is indeed the case: public spending per capita was higher in the oil-abundant counties, and the difference in expenditures roughly corresponds to the difference in per capita income, for both 1970 and 1980 (despite the change in oil prices).[28] Per capita spending on education was also correspondingly higher in oil-abundant counties. This implies that a supply based explanation for the slowdown in accumulation of education in oil abundant counties seems inadequate.

Finally, the lower rate of accumulation of education was not likely driven by changes in the composition of foreign migration, since the oil abundant counties seem to have lost their advantage around 1970, when migration to the US from Mexico was still relatively low (Card and Lewis 2005). By 1990 oil abundant counties had a similar or even slightly lower fraction of high school graduates in their workforce.

Taken together, the evidence in this section suggests that the demand for skill in oil abundant counties expanded more slowly, since their industry structure changed more slowly. In other words, the employment share of agriculture was decreasing at a slower rate in the oil abundant counties, and as a result the demand for skill was expanding more slowly. Yet even this slower accumulation did little more than to offset the increase in the share of educated workers in the workforce caused by oil abundance around 1940. But even if the cost of oil abundance in terms of the accumulation of education is limited, is it possible that the benefits of resource based specialization were also limited, or that they were shared by a relatively small number of individuals. The next section explores this possibility.

3.4 Specialization and Income

Some discussions of the "Resource Curse" assume that the benefits from resource extraction only accrue a small part of the population. The literature discusses various mechanisms

[28] Interestingly, the share of intergovernmental transfers in local government revenues was about 10 percent lower in oil abundant counties from 1962-1987. This suggests that oil abundant counties were not particularly good at lobbying for resources.

related to different resource endowments (e.g. Leamer et al. 1999; Humphreys et al. 2007; Engerman and Sokoloff 1997). As I discussed above, most of the oil revenues in the sample I analyze accrue to residents of the oil abundant counties, and this section examines the effect of oil abundance on the level and distribution of income.

As Table 5 shows, in 1949 the median family income was about 30 log points higher in the oil abundant counties, compared to the other counties in the sample. The results using data on per capita income, which are available since 1959, are very similar. Moreover, if income from the oil industry is more likely to accrue to people who reside outside the oil abundant counties than other types of income, then these results provide a lower bound for the effect of oil on income.

Table 5 also shows that by 1989 the gap in per capita income and median family income in favor of the oil abundant counties had narrowed to about 5-6 percentage points. Note that the gap narrowed from 1940-1970, when oil prices were quite stable, increased temporarily when oil prices rose in the 1970s and then narrowed again dring the 1980s. Since I have no income data before 1949, Figure 5 compares the estimated effect of oil abundance on income to its estimated effect on average manufacturing wages in 1890, 1920, and 1954. To allow for consistent comparisons over time, Figure 5 shows the results for a fixed subsample of 451 counties - all the sample counties for which data exist for all the relevant years. This Figure shows that average manufacturing wages rose from about 2 percent (not significant) in 1890 to over 9 percent in 1954. This is still lower than the difference in income per capita and median family income during the late 1940s and 1950s, suggesting that some of the difference in income is due to differences in industry composition between oil abundant counties and control counties.[29] Figure 5 also shows how the discovery of oil led to a divergence in income relative to the control counties, and how income subsequently converged.

Although I cannot rule out this convergence during the second half of the 20th century

[29] I have also examined the sample counties for which the average manufacturing wage can be calculated for 1954, 1963, 1972, and 1983. In this subsample manufacturing wages in oil abundant counties were about 10-20 percentage points higher than in the control counties and the difference was statistically significant.

is due to factors such as reduced costs of trade, the results in previous sections suggest that at least some of the convergence is due to the effect of specialization on the rate of sectoral change and the accumulation of education. A direct test supports the hypotheses that convergence was due in part to the effects of oil abundance: median family income in the oil abundant counties grew more slowly from 1949-1989 even after we account for initial differences in income.[30]

My finding that oil discoveries lead to a period of high growth that is followed by a period of lower growth is consistent with Mitchener and McLean (1999), who attribute some of the rapid growth of income per capita in the Western US and its subsequent convergence to its resource abundance. My results are also consistent with the calculations of Pamuk (2006) for oil abundant Middle Eastern countries from 1820-2000. These findings may also explain the general findings that resource rich economies may have grown more slowly after 1960 (Sachs and Warner 1995, 2001), since this was the period that followed the initial growth gains from oil.

Another interesting aspect of oil abundance is its effect on the distribution of income. The similar impact of oil abundance on both the levels and the changes of per capita income and median family income (Table 5) suggest that oil abundance had little effect on the distribution of income. This can be seen quite clearly in Figure 6, which shows that in 1979 and 1989 the distribution of household income in the oil abundant counties first order stochastically dominated that of the control counties.[31] The data on household income distribution also allow us to directly test the effect of oil abundance on income inequality. Regressions of the Gini coefficient for the 1979 household income distribution on an indicator for oil abundance using the specifications mentioned above yield estimates that are very close

[30] Regressing ln(median family income in 1989) on a dummy for oil abundance and controlling for ln (median family income in 1949) using the samples as in specifications (1)-(3) in Table 5 gives coefficients of about -.02 to -.05, which are statisitcally significant in specifications (2) and (3). This suggests that changes in income are not driven only by mean reversion.

[31] Results using the 1949 data, for which we only observe three different ranges of household income, are also consistent with the hypothesis that the income distribution in the oil abundant counties first order dominated that of the control counties.

to zero (results available from author).

Since the oil abundant counties enjoyed higher levels of income per capita for many decades, we might expect that they attracted population over time. Patterns of population change (Table 6) suggest that net migration to the oil abundant counties was larger during the earlier decades after 1940, when income differentials were large. It is difficult to separate the precise contributions of migration from other counties and fertility to the rise in population. There is some evidence, however, that higher per capita income and wages in the oil abundant counties did attract population. As the differences in per capita income decreased, the population growth in the oil abundant counties compared to the other sample counties also decreased.[32]

Taken together, the evidence presented here suggests that oil abundant counties were attractive places to live, with a higher level of per capita income and an income distribution that was no more unequal than other nearby counties.

3.5 Additional Specification Checks

The analysis in the previous sections assumes that economic outcomes in the oil abundant counties would have been similar to those in the control counties, were it not for the differences in oil endowments. Even though the evidence for 1890 (before the major oil discoveries) seems consistent with this hypothesis, it is important to address several concerns for my empirical strategy.

One concern we might have is that oil abundant counties lie relatively close to each other, and therefore experience some common shocks. The map in figure 2 suggests that there is indeed some spatial correlation in the location of oil abundant counties. To address this concern, I re-estimated the standard errors in the first specification of each of the tables discussed above, clustering them by 1980 county group. The advantage of this strategy is

[32]It is also difficult to assess the importance of increased housing prices in oil abundant counties. But available data suggest that on average, the median rental rate in oil-abundant counties was about 6 percent higher in 1990 (this estimate is statistically significant).

that county group boundaries take into account commuting patterns, providing a natural way to account for the fact that counties are not independent of each other. At the same time these county groups might not be equally suitable for different time periods. The results for different time interactions of the oil abundance indicator suggest that this clustering typically increases the standard errors by about 30-50 percent. But even with these larger standard errors the results of interest are precisely estimated.

But even if the time varying interactions of oil abundance are precisely estimated, we might still be concerned that they reflect the ongoing process of oil discovery (see Figure 1). To mitigate this potential concern, I reestimated the regressions discussed above excluding counties where major oilfields were discovered only after 1940, and there is little change in the results.[33] The results also suggest that the impact of oil abundance on most outcomes was already large by 1970, so it is not likely driven by subsequent depletion of oilfields. Oilfield depletion was also likely offset by improved extraction technologies, so even when oil prices declined (1990), the employment share of mining in oil abundant counties was still similar its 1940 levels.

Another concern that is related to the nonrenewable nature of oil is that its location may be correlated with other geographic factors that affect economic activity. For example, oil (like gas and coal) is formed from the preserved remains of prehistoric marine plants or animals, which settled on the sea floor. Despite movements of tectonic plates over many millions of years and changes in the sea level, oil still seems to be found closer to existing oceans. If proximity to water has important time varying effects, it may bias my estimates. To address this concern, the first column in Tables 7-10 adds to the corresponding specifications in Tables 2-5 time-varying interactions of distance to the ocean and to the nearest navigable river. These interactions appear to have little impact on the magnitude and precision of the estimates of interest.

Yet we might also be concerned that oil abundance might be spuriously correlated with

[33] In about 70 percent of the oil abundant counties in the sample, at least one major oilfield was discovered before 1940.

other factors that change over time. The second column in Tables 7-10 adds controls for the percentage of non-white population, which may be correlated with changes in education and income. This specification also controls for time interactions of 1940 variation in average farm size, since land inequality may affect endogenous investments in education (Galor, Moav, and Vollrath 2005). The results show that adding these controls has little effect on the magnitude or the precision of the coefficients of interest.[34]

Finally, we might be concerned that time varying policies at the state level might be correlated with the location of oil. The thirds specification in Tables 7-10 controls for state-year interactions. Even after adding these controls, the effects of oil abundance on industry composition, education, and income around the middle of the 20th century remain significant, though they somewhat smaller. The effect of oil abundance on changes over time is also smaller than before, though it remains statistically significant. Note that in this specification, the effect of oil abundance on the size of the mining sector is also smaller and diminishes over time, so the smaller effect on other outcomes seems plausible.

While all the regressions discussed thus far rely on the distinction between oil abundant and oil-scarce counties, I also explore the effect of differences in log oil endowment among the oil abundant counties on the economic outcomes of interest.[35] One advantage of this approach is that it uses a source of variation that is orthogonal to the one I use in previous regressions, since here I only consider the oil abundant counties. Using differences in endowment size is therefore a strong robustness check on the previous estimates. The main drawback of this approach is that I analyze only 171 counties, or about 22 percent of the entire sample.

The results using the subsample of oil abundant counties are generally consistent with my previous findings. Counties that are more oil abundant had a larger employment share of mining in 1940, a similar employment share of manufacturing, and a considerably smaller employment share of agriculture. Oil abundant counties were also better educated in 1940,

[34]Similarly, controlling for median age in each county, a variable which is available since 1950, has little effect on the results.

[35]If an oilfield lies under multiple counties, I assume that each of them has an equal share of the oil endowment.

and had higher income per family and per capita in 1949 and 1959.

The bottom panel of Table 11 shows that over time the difference in the employment share of mining between the most oil-rich counties and the other oil abundant counties has narrowed considerably. The next columns indicate that over time oil production differentially crowded out services, rather than manufacturing. The estimates also suggest a smaller and less precise effect of oil abundance on education, and a significant and negative effect on the change in income. The main difference from the results in the previous tables is that the findings here do not represent any reversal: in 1989 the oil-rich counties are not worse off than the counties with less oil in any of the outcomes I measure. This caveat notwithstanding, the pattern that emerges from Table 11 is quite consistent with the previous evidence: endowment-driven specialization in oil production initially improves economic outcomes, but over time this advantage eroded as the less specialized economies shifted more quickly to newer and more skill abundant industries.

4 Conclusions

This paper examines the effects of specialization in oil production in oil rich parts of the Southern US. I trace out the impact of this specialization over an entire century, when the region shifted from agriculture towards manufacturing and services. This setting allows me to test some of the economic channels that have been proposed in the "Resource Curse" literature.

I find that during the 50 years after oil was first discovered in the 1890s, its effects were large and beneficial. The development of the oil sector increased education and income per capita without causing ill effects on industrialization or inequality.

But consistent with the "Dutch Disease" hypothesis, I find that after 1940 oil abundance reduced the employment share of manufacturing by about a quarter; this effect was not mechanical, as oil abundance had a much smaller effect on the employment share of services. Although this effect was sizeable, oil abundant counties were able to offset it by attracting

more population, so on net the absolute size of their manufacturing sector was unaffected by oil. This result sheds light on the importance of factor mobility for the development of resource abundant economies.

But while the absolute size of manufacturing did not decline due to oil abundance, I still find that oil abundance slowed the change in industry composition over time. As a result, it also slowed the accumulation of education, and I find some evidence that this effect was due to the response of both natives and migrants. This costly aspect of specialization likely arose from the fact that the economy remained specialized in a fixed set of commodities over a long period of time. In other words, slower accumulation of education may be common to other economies that specialize for many decades in shipbuilding, tourism, or wine.

The effect of oil abundance on the trajectory of income per capita was similar to its effect on education. Although oil abundant counties enjoyed higher per capita income, their advantage narrowed over time, so oil had an inverse U-shaped effect on growth. And yet despite the slower growth rate of oil abundant counties in recent decades, they continued to enjoy higher levels of per capita income than other nearby counties at least through 1989. My findings also suggest that much of the income from oil was retained in oil abundant counties, and that oil did not increase income inequality.

In summary, this paper concludes that although specialization in oil need not increase inequality, it can introduce some costs in the long run. The inertia it introduces in the industry structure can slow the accumulation of education, and if migration is restricted it may also slow the development of other tradable sectors. But if resource abundance causes bad outcomes in other settings, it is likely due to other channels, such as interactions with weak institutions (Mehlum et al. 2006), or inability to adjust when the resource is depleted or demand runs out. These concerns notwithstanding, I conclude that resource based specialization can be used as an important lever for development.

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Table 1. Summary Statistics

	Oil-abundant	Non oil-abundant		
		All	Adjacent to oil-abundant	Not adjacent to oil-abundant
Land Area (Square miles, 1940)	988 (561)	962 (828)	974 (771)	954 (869)
Population (1940)	30,493 (49,112)	25,243 (41,842)	24,413 (40,850)	25,865 (42,618)
Population density (1940)	36.1 (50.3)	38.4 (117.8)	38.4 (156.0)	38.3 (78.2)
Percent employed in mining (1940)	6.2 (7.8)	1.3 (3.4)	1.4 (3.2)	1.1 (3.6)
Percent employed in agriculture (1940)	37.5 (18.6)	45.4 (16.5)	44.0 (15.8)	46.4 (17.0)
Perecnt employed in manufacturing (1940)	5.7 (5.7)	5.9 (5.8)	5.9 (6.6)	5.8 (5.2)
Percent of high-school graduates among 25+ year-olds (1940)	21.2 (8.4)	18.7 (7.4)	19.6 (7.3)	18.1 (7.4)
Median family income (1949 US Dollars)	2,403 (806)	1,874 (764)	2,017 (732)	1,770 (772)
Per capita income (1959 US Dollars)	1,415 (394)	1,214 (380)	1,274 (365)	1,169 (385)
Counties	171	604	258	346

NOTES. Oil abundant denotes that the county was located above at least part of an oil field (or multiple oil fields) that contained at least 100 million barrels of oil before any oil was extracted. The non oil-abundant counties are all the counties within 200 miles of the oil-abundant counties of Texas, Louisiana, and Oklahoma that are not oil-abundant. Standard deviations are in parentheses.

Table 2. Effect of Oil Abundance on Sector Employment Shares

	Mining			Manufacturing			Agriculture		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
	Panel of Counties (1940-1990)								
Oil-abundant x 1940	4.9	5.1	5.0	-0.2	-0.2	-0.8	-7.9	-8.9	-8.8
	(0.6)	(0.6)	(0.7)	(0.5)	(0.5)	(0.5)	(1.6)	(1.7)	(1.8)
Oil-abundant x 1950	6.9	7.5	7.5	-1.4	-1.5	-2.2	-10.8	-13.0	-13.5
	(0.7)	(0.7)	(0.7)	(0.6)	(0.7)	(0.7)	(1.4)	(1.6)	(1.6)
Oil-abundant x 1960	5.7	6.4	6.4	-2.9	-3.7	-5.0	-5.4	-6.1	-6.2
	(0.6)	(0.6)	(0.6)	(0.7)	(0.7)	(0.7)	(1.1)	(1.2)	(1.3)
Oil-abundant x 1970	5.2	5.7	5.8	-4.8	-6.4	-8.0	-2.4	-1.9	-1.9
	(0.5)	(0.5)	(0.6)	(0.8)	(0.9)	(0.9)	(0.9)	(0.9)	(1.0)
Oil-abundant x 1980	6.0	7.1	7.3	-3.7	-4.9	-6.4	-2.2	-2.0	-2.0
	(0.6)	(0.6)	(0.6)	(0.7)	(0.8)	(0.8)	(0.8)	(0.8)	(0.9)
Oil-abundant x 1990	4.4	5.1	5.2	-4.2	-5.6	-7.3	-1.9	-1.5	-1.5
	(0.4)	(0.4)	(0.5)	(0.6)	(0.7)	(0.7)	(0.6)	(0.7)	(0.7)
1940	1.3	1.1	1.1	5.9	5.8	6.2	45.4	46.4	46.5
	(0.1)	(0.2)	(0.2)	(0.2)	(0.3)	(0.3)	(0.7)	(0.9)	(0.9)
1950	1.5	1.0	1.0	9.3	9.4	9.7	38.6	40.8	41.2
	(0.1)	(0.1)	(0.1)	(0.3)	(0.4)	(0.4)	(0.7)	(0.9)	(0.9)
1960	1.8	1.0	1.1	13.0	13.9	14.5	23.1	23.8	24.2
	(0.1)	(0.1)	(0.1)	(0.4)	(0.5)	(0.5)	(0.5)	(0.7)	(0.7)
1970	1.5	1.0	1.0	17.6	19.3	20.0	14.5	14.0	14.3
	(0.1)	(0.1)	(0.1)	(0.5)	(0.7)	(0.7)	(0.4)	(0.5)	(0.6)
1980	2.6	1.5	1.5	16.8	18.0	18.9	11.1	10.8	11.1
	(0.1)	(0.1)	(0.1)	(0.4)	(0.6)	(0.6)	(0.4)	(0.5)	(0.5)
1990	1.7	0.9	1.0	15.3	16.8	17.8	9.7	9.3	9.5
	(0.1)	(0.1)	(0.1)	(0.4)	(0.5)	(0.6)	(0.3)	(0.4)	(0.4)
Observations	4,641	3,097	3,045	4,649	3,101	3,053	4,633	3,093	3,037

NOTES. The dependent variable is the percentage of the labor force employed in each sector. "Oil abundant" denotes that the county was located above at least part of an oil field (or multiple oil fields) that contained at least 100 million barrels of oil before any oil was extracted. Specification (1) uses the full sample of counties. Specification (2) excludes counties adjacent to the oil abundant counties. Specification (3) includes only oil abundant counties in Texas, Louisiana, and Oklahoma, and non oil abundant counties in the other nearby states. Panel regressions include time effects, as explained in the discussion of equation (1). Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table 3. Effect of Oil Abundance on Ln(Employment) by Sector

	Mining			Manufacturing			Agriculture		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
	Panel of Counties (1940-1990)								
Oil-abundant x 1940	1.99	2.22	2.26	0.22	0.15	0.03	-0.14	-0.19	-0.24
	(0.17)	(0.19)	(0.19)	(0.14)	(0.15)	(0.16)	(0.09)	(0.09)	(0.10)
Oil-abundant x 1950	2.38	2.86	2.85	0.18	0.10	-0.01	-0.18	-0.27	-0.35
	(0.14)	(0.16)	(0.16)	(0.15)	(0.16)	(0.17)	(0.08)	(0.08)	(0.09)
Oil-abundant x 1960	2.05	2.46	2.38	0.23	0.11	-0.02	-0.02	-0.07	-0.13
	(0.14)	(0.15)	(0.15)	(0.15)	(0.15)	(0.16)	(0.07)	(0.08)	(0.09)
Oil-abundant x 1970	1.85	2.23	2.19	0.14	0.06	-0.08	0.10	0.10	0.06
	(0.13)	(0.14)	(0.15)	(0.15)	(0.16)	(0.17)	(0.07)	(0.07)	(0.08)
Oil-abundant x 1980	2.03	2.53	2.57	0.23	0.16	0.04	0.13	0.12	0.10
	(0.12)	(0.13)	(0.13)	(0.15)	(0.16)	(0.17)	(0.07)	(0.07)	(0.08)
Oil-abundant x 1990	2.02	2.48	2.53	0.09	-0.02	-0.12	0.22	0.21	0.22
	(0.12)	(0.13)	(0.13)	(0.15)	(0.16)	(0.17)	(0.07)	(0.07)	(0.08)
1940	3.01	2.79	2.79	5.36	5.43	5.48	7.74	7.80	7.81
	(0.08)	(0.11)	(0.11)	(0.07)	(0.09)	(0.08)	(0.03)	(0.04)	(0.04)
1950	3.32	2.84	2.86	5.77	5.85	5.90	7.47	7.55	7.59
	(0.07)	(0.09)	(0.09)	(0.07)	(0.09)	(0.09)	(0.03)	(0.04)	(0.04)
1960	3.74	3.33	3.40	6.13	6.24	6.30	6.81	6.85	6.90
	(0.07)	(0.08)	(0.08)	(0.07)	(0.09)	(0.09)	(0.03)	(0.04)	(0.04)
1970	3.85	3.47	3.49	6.50	6.59	6.65	6.29	6.30	6.33
	(0.06)	(0.08)	(0.07)	(0.07)	(0.09)	(0.09)	(0.03)	(0.04)	(0.04)
1980	4.37	3.87	3.87	6.77	6.84	6.90	6.22	6.24	6.26
	(0.07)	(0.08)	(0.08)	(0.07)	(0.09)	(0.09)	(0.03)	(0.04)	(0.04)
1990	4.02	3.56	3.54	6.80	6.90	6.94	6.18	6.18	6.18
	(0.06)	(0.08)	(0.07)	(0.07)	(0.09)	(0.08)	(0.03)	(0.04)	(0.04)
Observations	4,381	2,892	2,837	4,624	3,092	3,044	4,632	3,092	3,036

NOTES. The dependent variable is the log employment in each sector. "Oil abundant" denotes that the county was located above at least part of an oil field (or multiple oil fields) that contained at least 100 million barrels of oil before any oil was extracted. Specification (1) uses the full sample of counties. Specification (2) excludes counties adjacent to the oil abundant counties. Specification (3) includes only oil abundant counties in Texas, Louisiana, and Oklahoma, and non oil abundant counties in the other nearby states. Panel regressions include time effects, as explained in the discussion of equation (1) in the text. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table 4. Effect of Oil Abundance on Stock of Educated Workers

	(1)	(2)	(3)
	Panel of Counties (1940-1990)		
Oil-abundant x 1940	2.5	3.2	2.3
	(0.7)	(0.8)	(0.8)
Oil-abundant x 1950	1.0	0.7	-1.1
	(0.9)	(1.0)	(1.0)
Oil-abundant x 1960	1.8	2.1	0.5
	(0.9)	(1.0)	(1.0)
Oil-abundant x 1970	-0.4	-1.2	-3.5
	(0.9)	(1.0)	(1.1)
Oil-abundant x 1980	-1.6	-2.7	-4.7
	(0.9)	(1.0)	(1.0)
Oil-abundant x 1990	-1.3	-2.0	-3.0
	(0.8)	(0.9)	(0.9)
1940	18.7	18.1	18.7
	(0.3)	(0.4)	(0.4)
1950	24.7	25.1	26.3
	(0.4)	(0.6)	(0.6)
1960	32.2	31.9	33.0
	(0.4)	(0.6)	(0.6)
1970	41.6	42.4	43.7
	(0.5)	(0.6)	(0.7)
1980	56.0	57.1	58.0
	(0.4)	(0.6)	(0.6)
1990	66.5	67.2	67.4
	(0.4)	(0.6)	(0.6)
Observations	4,648	3,101	3,053

NOTES. The dependent variable is the fraction of high-school graduates among people aged 25 and over. "Oil abundant" denotes that the county was located above at least part of an oil field (or multiple oil fields) that contained at least 100 million barrels of oil before any oil was extracted. Specification (1) uses the full sample of counties. Specification (2) excludes counties adjacent to the oil abundant counties. Specification (3) includes only oil abundant counties in Texas, Louisiana, and Oklahoma, and non oil abundant counties in the other nearby states. Panel regressions include time effects, as explained in the discussion of equation (1) in the text. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table 5. Effect of Oil Abundance on Income

	Ln(Median Family Income)			Ln(Per Capita Income)		
	(1)	(2)	(3)	(1)	(2)	(3)
	Panel (1949-1989)			Panel (1959-1989)		
Oil-abundant x 1949	0.273	0.342	0.353			
	(0.033)	(0.037)	(0.038)			
Oil-abundant x 1959	0.194	0.232	0.218	0.166	0.207	0.213
	(0.027)	(0.030)	(0.032)	(0.025)	(0.028)	(0.030)
Oil-abundant x 1969	0.095	0.111	0.102	0.067	0.083	0.082
	(0.020)	(0.022)	(0.023)	(0.018)	(0.021)	(0.021)
Oil-abundant x 1979	0.129	0.155	0.161	0.103	0.133	0.143
	(0.016)	(0.018)	(0.019)	(0.016)	(0.017)	(0.018)
Oil-abundant x 1989	0.063	0.064	0.063	0.043	0.049	0.052
	(0.018)	(0.019)	(0.020)	(0.017)	(0.019)	(0.020)
Observations	3,856	2,578	2,538	3,099	2,068	2,036

NOTES. "Oil abundant" denotes that the county was located above at least part of an oil field (or multiple oil fields) that contained at least 100 million barrels of oil before any oil was extracted. Specification (1) uses the full sample of counties. Specification (2) excludes counties adjacent to the oil abundant counties. Specification (3) includes only oil abundant counties in Texas, Louisiana, and Oklahoma, and non oil abundant counties in the other nearby states. Panel regressions include time effects, as explained in the discussion of equation (1) in the text. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table 6. Effect of Oil Abundance on Ln(Population)

	(1)	(2)	(3)
	Panel of Counties (1940-1990)		
Oil-abundant x 1940	0.13	0.09	0.06
	(0.08)	(0.09)	(0.09)
Oil-abundant x 1950	0.24	0.21	0.16
	(0.09)	(0.09)	(0.10)
Oil-abundant x 1960	0.34	0.33	0.27
	(0.10)	(0.10)	(0.11)
Oil-abundant x 1970	0.32	0.30	0.26
	(0.10)	(0.11)	(0.11)
Oil-abundant x 1980	0.36	0.33	0.33
	(0.11)	(0.11)	(0.12)
Oil-abundant x 1990	0.37	0.34	0.36
	(0.11)	(0.12)	(0.12)
1940	9.70	9.74	
	(0.04)	(0.05)	
1950	9.65	9.68	
	(0.04)	(0.05)	
1960	9.60	9.61	
	(0.04)	(0.05)	
1970	9.61	9.63	
	(0.05)	(0.06)	
1980	9.73	9.75	
	(0.05)	(0.06)	
1990	9.74	9.77	
	(0.05)	(0.06)	
Observations	4,649	3,101	3,053

NOTES. "Oil abundant" denotes that the county was located above at least part of an oil field (or multiple oil fields) that contained at least 100 million barrels of oil before any oil was extracted. Specification (1) uses the full sample of counties. Specification (2) excludes counties adjacent to the oil abundant counties. Specification (3) includes only oil abundant counties in Texas, Louisiana, and Oklahoma, and non oil abundant counties in the other nearby states. Panel regressions include time effects, as explained in the discussion of equation (1) in the text. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table 7. Effect of Oil Abundance on Sector Employment Shares, With Controls

	Mining			Manufacturing			Agriculture		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
	Panel of Counties (1940-1990)								
Oil-abundant x 1940	5.1	4.9	4.9	-0.8	-0.4	0.5	-9.3	-8.3	-5.8
	(0.6)	(0.6)	(0.6)	(0.5)	(0.5)	(0.5)	(1.6)	(1.6)	(1.6)
Oil-abundant x 1950	7.1	6.8	6.5	-2.5	-2.0	-0.7	-10.5	-9.7	-7.4
	(0.7)	(0.6)	(0.7)	(0.6)	(0.6)	(0.6)	(1.5)	(1.5)	(1.5)
Oil-abundant x 1960	5.8	5.5	5.1	-3.9	-3.4	-1.0	-4.4	-3.7	-4.1
	(0.6)	(0.6)	(0.6)	(0.7)	(0.7)	(0.7)	(1.1)	(1.1)	(1.2)
Oil-abundant x 1970	5.2	4.9	4.7	-5.9	-5.4	-1.6	-1.1	-0.5	-2.7
	(0.6)	(0.5)	(0.5)	(0.7)	(0.7)	(0.7)	(0.9)	(0.9)	(0.9)
Oil-abundant x 1980	5.9	5.7	5.0	-4.3	-3.9	-1.0	-0.8	-0.4	-2.3
	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)	(0.7)	(0.8)	(0.8)
Oil-abundant x 1990	4.4	4.2	3.7	-4.7	-4.4	-1.0	-0.6	-0.5	-2.5
	(0.4)	(0.4)	(0.4)	(0.6)	(0.6)	(0.5)	(0.6)	(0.6)	(0.7)
1940	0.1	0.9		9.2	7.5		51.7	47.5	
	(0.3)	(0.4)		(0.5)	(0.8)		(1.3)	(1.6)	
1950	0.7	1.5		14.7	13.2		38.7	34.5	
	(0.3)	(0.4)		(0.6)	(0.8)		(1.2)	(1.5)	
1960	1.2	2.0		19.2	17.7		19.1	14.9	
	(0.2)	(0.4)		(0.6)	(0.8)		(0.9)	(1.2)	
1970	1.1	1.9		25.6	24.4		8.1	4.2	
	(0.2)	(0.4)		(0.8)	(0.9)		(0.6)	(1.1)	
1980	2.4	3.1		22.6	21.4		4.7	0.8	
	(0.3)	(0.4)		(0.6)	(0.8)		(0.5)	(1.0)	
1990	1.3	2.1		20.4	19.1		4.0	0.1	
	(0.2)	(0.3)		(0.6)	(0.8)		(0.4)	(1.0)	
Observations	4,641	4,636	4,636	4,649	4,644	4,644	4,633	4,628	4,628

NOTES. The dependent variable is the percentage of the labor force employed in each sector. Oil abundant denotes that the county was located above at least part of an oil field (or multiple oil fields) that contained at least 100 million barrels of oil before any oil was extracted. All specifications use the full sample of counties. Specification (1) controls for interactions of distance to the nearest navigable river and ocean with year dummies. Specification (2) adds to (1) controls for fraction of non-white population in county and for year interactions of average farm size in 1940. Specification (3) adds to (2) controls for state-year interactions. Panel regressions include time effects, as explained in the discussion of equation (1) in the text. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table 8. Effect of Oil Abundance on Ln(Employment) by Sector, With Controls

	Mining			Manufacturing			Agriculture		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
	Panel of Counties (1940-1990)								
Oil-abundant x 1940	2.02	1.92	1.89	0.06	0.23	0.57	-0.22	-0.14	0.10
	(0.18)	(0.18)	(0.18)	(0.14)	(0.13)	(0.15)	(0.08)	(0.07)	(0.10)
Oil-abundant x 1950	2.35	2.25	1.99	-0.01	0.17	0.42	-0.21	-0.14	0.01
	(0.15)	(0.15)	(0.15)	(0.15)	(0.14)	(0.14)	(0.08)	(0.07)	(0.06)
Oil-abundant x 1960	1.98	1.88	1.78	0.08	0.20	0.52	-0.02	0.04	0.13
	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.08)	(0.07)	(0.07)
Oil-abundant x 1970	1.75	1.66	1.58	-0.01	0.10	0.41	0.14	0.20	0.17
	(0.14)	(0.14)	(0.14)	(0.14)	(0.13)	(0.14)	(0.07)	(0.07)	(0.08)
Oil-abundant x 1980	1.81	1.75	1.53	0.08	0.18	0.42	0.19	0.24	0.18
	(0.12)	(0.13)	(0.12)	(0.14)	(0.14)	(0.14)	(0.07)	(0.07)	(0.07)
Oil-abundant x 1990	1.78	1.76	1.53	-0.08	0.06	0.31	0.23	0.26	0.15
	(0.12)	(0.13)	(0.13)	(0.14)	(0.14)	(0.14)	(0.07)	(0.07)	(0.07)
1940	3.02	3.56		6.40	6.01		8.32	8.08	
	(0.14)	(0.19)		(0.10)	(0.16)		(0.06)	(0.08)	
1950	3.49	4.02		6.88	6.52		7.84	7.60	
	(0.13)	(0.17)		(0.10)	(0.16)		(0.06)	(0.08)	
1960	4.00	4.49		7.14	6.82		6.99	6.75	
	(0.12)	(0.16)		(0.10)	(0.16)		(0.06)	(0.08)	
1970	4.22	4.68		7.57	7.28		6.25	6.03	
	(0.11)	(0.15)		(0.10)	(0.15)		(0.06)	(0.08)	
1980	5.08	5.55		7.79	7.52		6.11	5.89	
	(0.11)	(0.14)		(0.10)	(0.15)		(0.06)	(0.07)	
1990	4.76	5.26		7.85	7.52		6.14	5.92	
	(0.10)	(0.15)		(0.10)	(0.15)		(0.06)	(0.08)	
Observations	4,381	4,380	4,380	4,624	4,619	4,619	4,632	4,627	4,627

NOTES. The dependent variable is the log employment in each sector. Oil abundant denotes that the county was located above at least part of an oil field (or multiple oil fields) that contained at least 100 million barrels of oil before any oil was extracted. All specifications use the full sample of counties. Specification (1) controls for interactions of distance to the nearest navigable river and ocean with year dummies. Specification (2) adds to (1) controls for fraction of non-white population in county and for year interactions of average farm size in 1940. Specification (3) adds to (2) controls for state-year interactions. Panel regressions include time effects, as explained in the discussion of equation (1) in the text. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table 9. Effect of Oil Abundance on Stock of Educated Workers, With Controls

	(1)	(2)	(3)
	Panel of Counties (1940-1990)		
Oil-abundant x 1940	4.3	3.3	2.7
	(0.6)	(0.6)	(0.6)
Oil-abundant x 1950	3.9	3.0	2.8
	(0.7)	(0.7)	(0.7)
Oil-abundant x 1960	4.3	3.4	2.6
	(0.7)	(0.7)	(0.7)
Oil-abundant x 1970	2.6	1.8	2.2
	(0.8)	(0.8)	(0.8)
Oil-abundant x 1980	1.1	0.6	1.0
	(0.8)	(0.8)	(0.8)
Oil-abundant x 1990	0.8	0.7	0.1
	(0.8)	(0.7)	(0.7)
1940	11.7	16.3	
	(0.4)	(0.7)	
1950	13.9	18.4	
	(0.6)	(0.8)	
1960	22.0	26.4	
	(0.6)	(0.8)	
1970	30.4	34.5	
	(0.7)	(0.9)	
1980	45.8	49.9	
	(0.7)	(0.9)	
1990	58.4	62.7	
	(0.6)	(0.8)	
Observations	4,648	4,643	4,643

NOTES. The dependent variable is the fraction of high-school graduates among people aged 25 and over. "Oil abundant" denotes that the county was located above at least part of an oil field (or multiple oil fields) that contained at least 100 million barrels of oil before any oil was extracted. All specifications use the full sample of counties. Specification (1) controls for interactions of distance to the nearest navigable river and ocean with year dummies. Specification (2) adds to (1) controls for fraction of non-white population in county and for year interactions of average farm size in 1940. Specification (3) adds to (2) controls for state-year interactions. Panel regressions include time effects, as explained in the discussion of equation (1) in the text. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table 10. Effect of Oil Abundance on Income, With Controls

	Ln(Median Family Income)			Ln(Per Capita Income)		
	(1)	(2)	(3)	(1)	(2)	(3)
	Panel (1949-1989)			Panel (1959-1989)		
Oil-abundant x 1949	0.347	0.280	0.280			
	(0.028)	(0.026)	(0.026)			
Oil-abundant x 1959	0.252	0.193	0.152	0.232	0.180	0.183
	(0.025)	(0.023)	(0.024)	(0.022)	(0.021)	(0.021)
Oil-abundant x 1969	0.129	0.086	0.079	0.115	0.072	0.042
	(0.019)	(0.019)	(0.020)	(0.017)	(0.016)	(0.017)
Oil-abundant x 1979	0.142	0.111	0.094	0.128	0.095	0.060
	(0.016)	(0.016)	(0.017)	(0.016)	(0.015)	(0.016)
Oil-abundant x 1989	0.084	0.071	0.064	0.066	0.052	0.034
	(0.018)	(0.017)	(0.018)	(0.017)	(0.015)	(0.016)
Observations	3,856	3,851	3,851	3,099	3,095	3,095

NOTES. "Oil abundant" denotes that the county was located above at least part of an oil field (or multiple oil fields) that contained at least 100 million barrels of oil before any oil was extracted. All specifications use the full sample of counties. Specification (1) controls for interactions of distance to the nearest navigable river and ocean with year dummies. Specification (2) adds to (1) controls for fraction of non-white population in county and for year interactions of average farm size in 1940. Specification (3) adds to (2) controls for state-year interactions. Panel regressions include county fixed effects and time effects. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table 11. Effect of Variations in Oil Endowment Within Oil Abundant Counties

	Percent employment			Educated Workers	Ln(Median Family Income)	Ln(Per Capita Income)
	Mining	Manufacturing	Agriculture			
			Panel (base year and end year only)			
Ln(oil endowment) x (Base year)	3.68	0.72	-7.29	2.75	0.17	0.14
	(0.61)	(0.30)	(1.14)	(0.55)	(0.02)	(0.02)
Ln(oil endowment) x (End year)	1.93	0.12	-1.33	2.13	0.07	0.06
	(0.43)	(0.40)	(0.35)	(0.73)	(0.02)	(0.02)
Observations	342	342	342	342	337	342

NOTES. The sample is restricted to oil-abundant counties, as explained in previous tables. "Oil endowment" measures the total number of barrels in oil fields that had at least 100 million barrels and lie beneath each county. When multiple counties lie above a single oil field, I assume that the quantity of oil in that field is shared equally between the counties. For brevity, the sample in each of the panel regressions includes only the base year and the end year. Columns (1)-(3) estimate the effect on industry composition of employment; column (4) measures the effect on the fraction of people aged 25 and over that have at least completed high school; and columns (5) and (6) examine the effect on income. In columns (1)-(4) the base year is 1940 and the end year is 1990. In column (5) the base year is 1949 and the end year is 1989. In column (6) the base year is 1959 and the end year is 1989. Panel regressions include county fixed effects. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

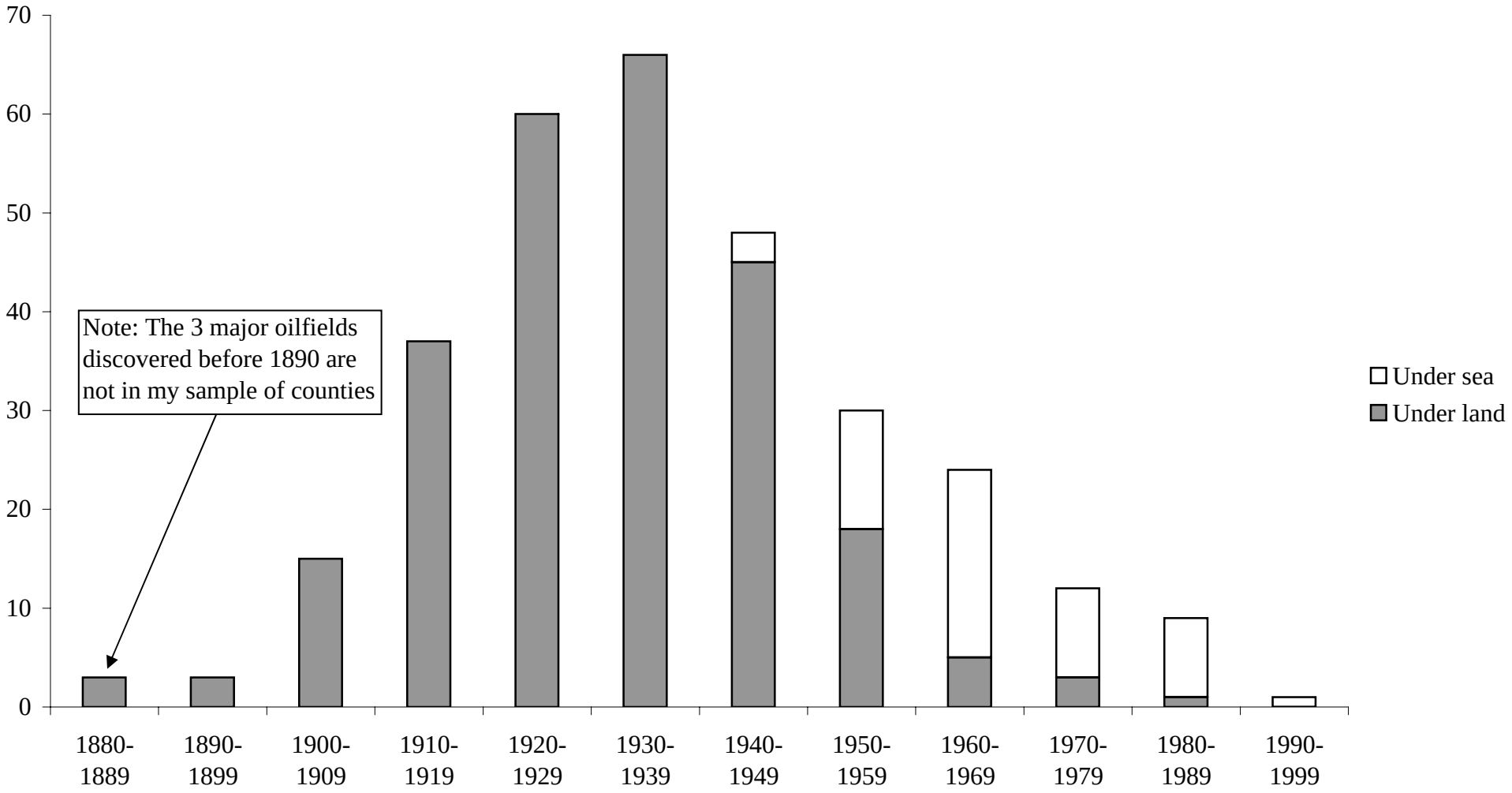

Figure 1. Number of new major US oilfields discovered, by decade

The data are for oilfields that initially contained at least 100 million barrels of oil

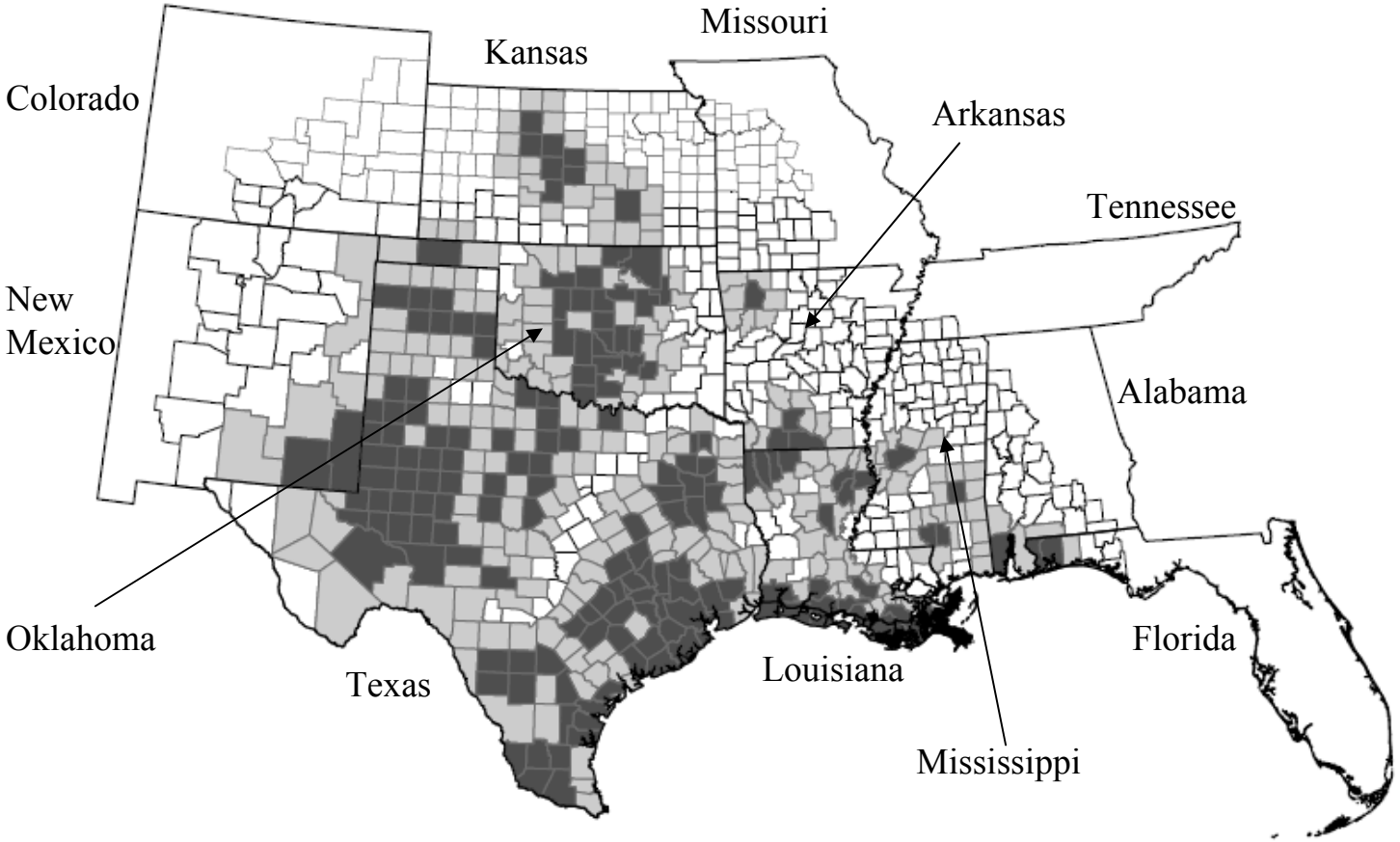

Figure 2. Oil-abundant counties (dark grey), adjacent counties (light grey) and other nearby counties (white)
Note: state borders are in black

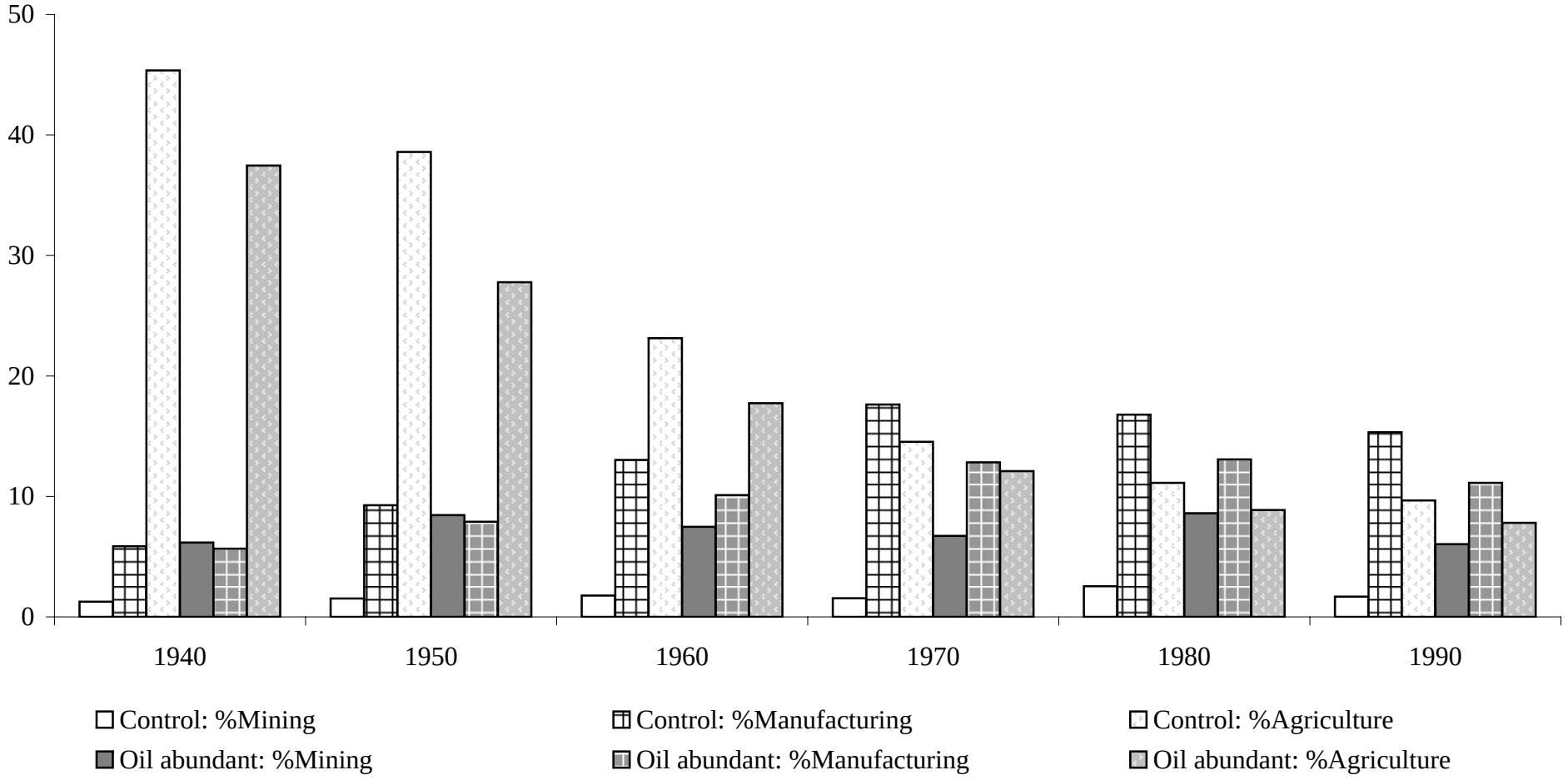

Figure 3. Industry employment shares of labor force in oil-abundant counties and controls: 1940-1990

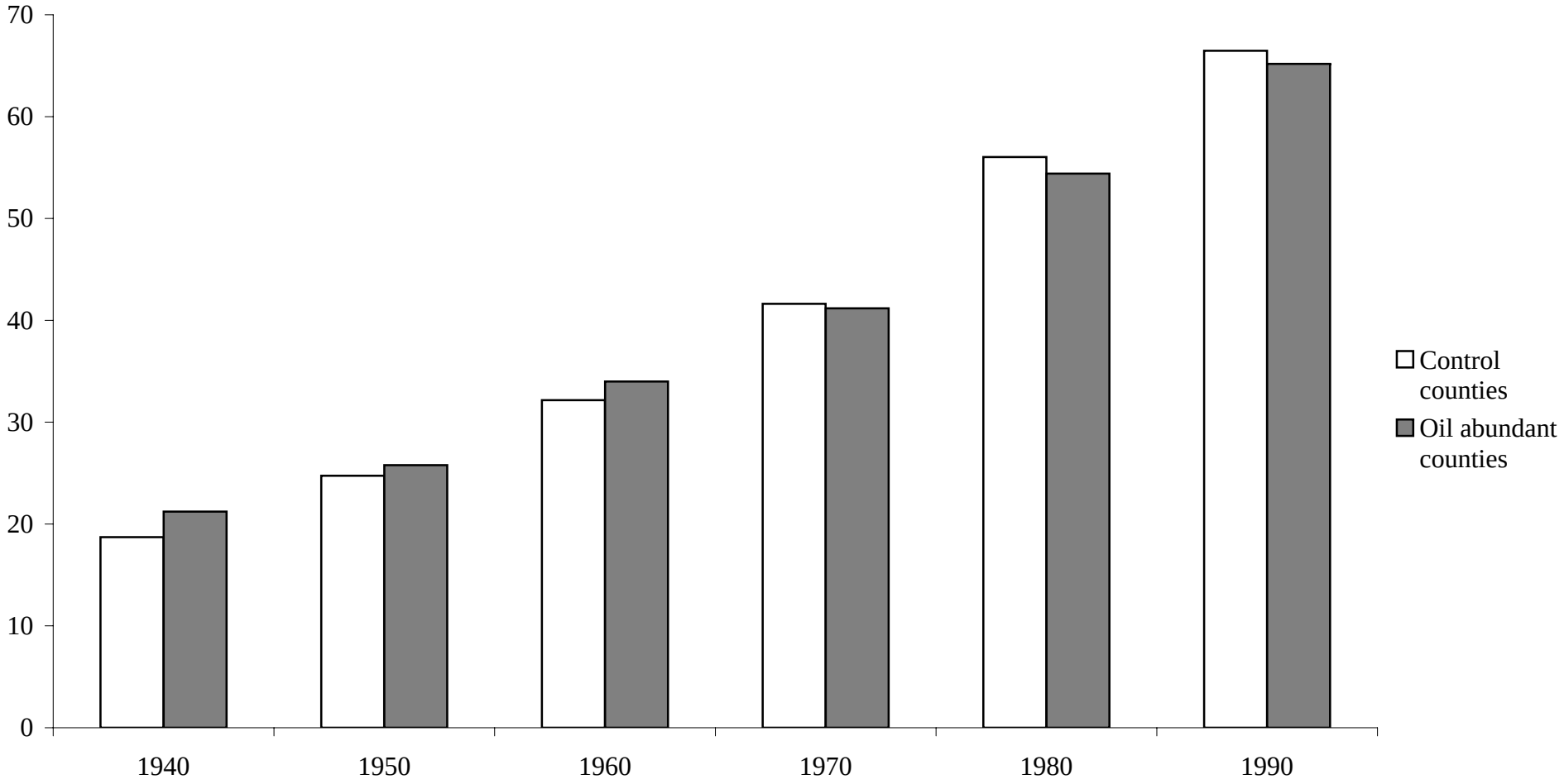

Figure 4. Percent with high school education or more among people aged 25 and over: 1940-1990

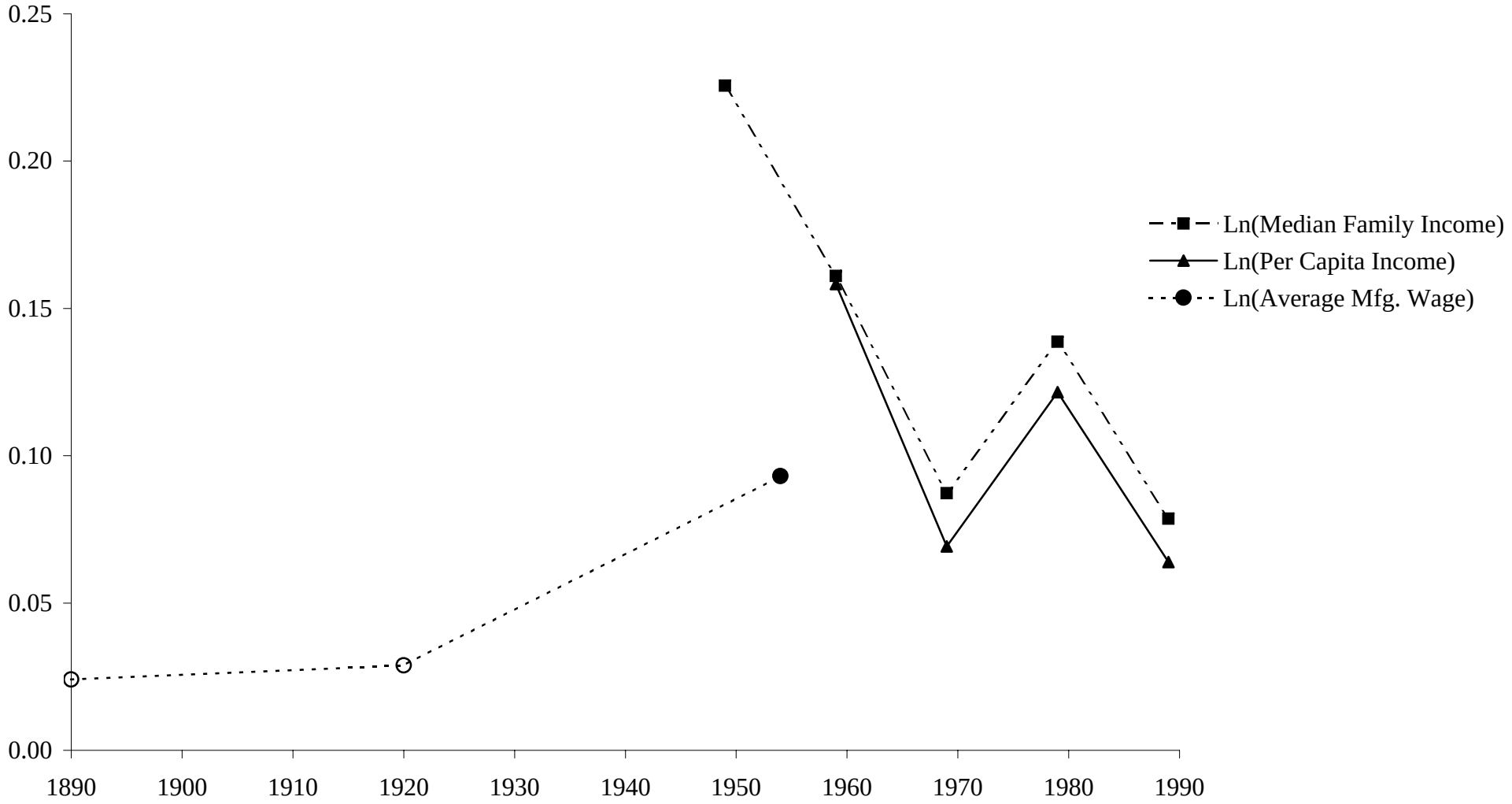

Figure 5. Differences in income and wages between oil-abundant counties and controls: 1890-1989

Based on separate regressions for a fixed subsample of 451 counties. Blank circles: statistically insignificant estimates

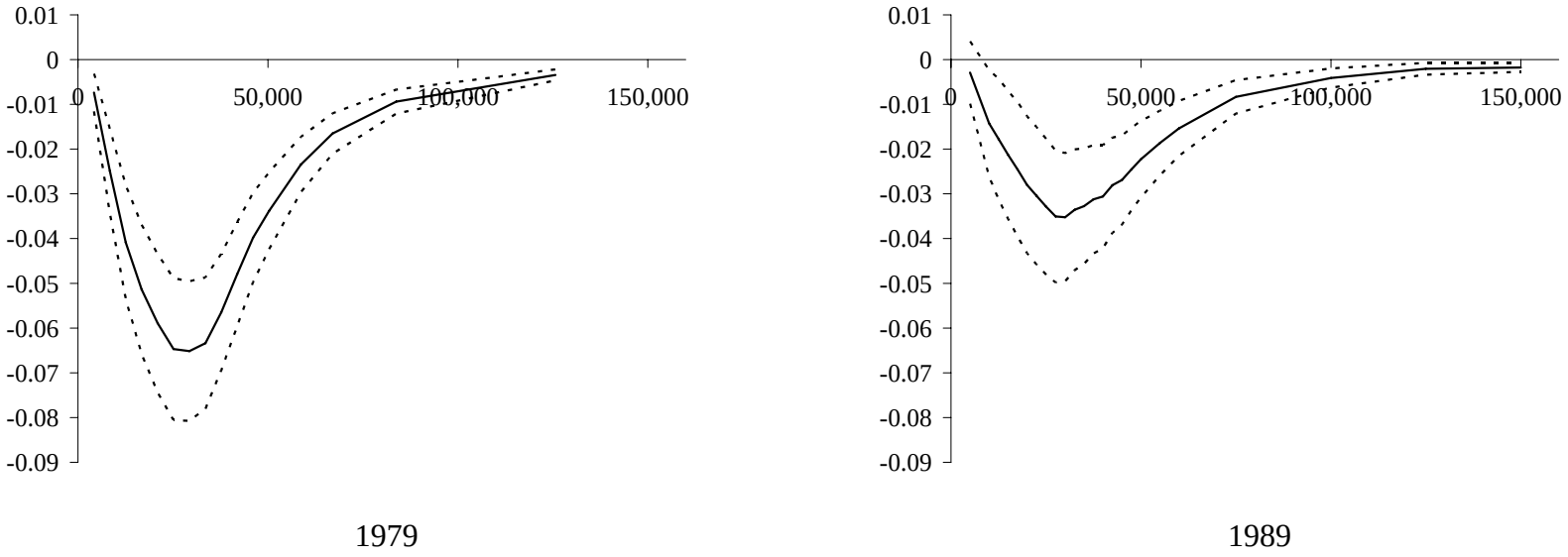

Figure 6. Differences in the CDF of the Household Income Distribution Between the Oil Abundant Counties and the Other Sample Counties, With 95 Percent Confidence Intervals ($1989)