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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 economic channels discussed in the literature, I investigate whether resource abundance slows industrialization or human capital accumulation, or increases inequality. I examine these channels using geological variation in oil abundance in the Southern United States. In 1890 oil abundant counties were very agricultural and similar to other nearby counties, but after oil was discovered they began to specialize in its production. From 1940-1990 the manufacturing sector in oil abundant counties expanded more slowly in terms of employment share, but not in terms of absolute size. At the same time, oil abundant counties enjoyed a better educated workforce, though this advantage was eventually eroded. Similarly, oil abundance initially raised per capita income and then led to slower growth. Nonetheless, oil abundant counties still had higher per capita income than other nearby counties in 1989, and their income was similarly distributed. Taken together, these results suggest that the overall impact of resource based specialization through purely economic channels is mostly beneficial even in the long run.

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JEL classification: O1, N5, J2, R1

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1 Introduction

Is an abundance of natural resources bad for long term economic performance? This question has puzzled economists and policy makers for a long time, and two recent books reveal that the debate is still ongoing.[1] "Escaping the Curse of Natural Resources" (Humphreys, Sachs, and Stiglitz, eds., 2007) argues that the development of natural resources often leads to adverse economic outcomes. But "Natural Resources: Neither Curse Nor Destiny" (Lederman and Maloney, eds., 2007) contends that the development of these resources can be beneficial for growth.

The debate over the impact of resource abundance has been complicated by the multiplicity of causal channels that have been proposed. While some of these channels involve political and institutional processes, this paper focuses on direct economic effects of resource abundance. I examine an economy that was initially very agricultural, and trace out the consequences of resource based specialization over an entire century. This investigation allows me to assess different economic effects attributed to resource based specialization. First, resource abundance may lead to specialization in commodities that involve little learning by doing, slowing down economic growth (versions of this "Dutch Disease" mechanism have been explored by Lucas 1988 and Matsuyama 1992). Second, resource abundance may lead to low investment in education (Leamer et al. 1999; Gylfason 2001). And third, resource based specialization may increase inequality and adversely affect economic performance (Engerman and Sokoloff 1997; Humphreys et al. 2007).

One of the difficulties in assessing these mechanisms is that most of the existing evidence on the effect of resource abundance comes from cross country studies. Despite considerable research effort, this evidence has been mixed. A number of 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) find that alter-

[1] The argument that resource based specialization may be bad dates back at least to Adam Smith (1776). In recent decades the debate has been sparked again by the work of Corden and Neary (1982), Auty (1993) and many others.

native measures of resource abundance are uncorrelated with growth. The results of these cross country studies are not only at odds with one another - they also face important econometric challenges. First, the extent of resource extraction is endogenous (e.g. David and Wright 1997). Second, differences in institutional quality may cause a problem of omitted variables bias (e.g. Acemoglu et al. 2002). And finally, and the quality of data may vary across countries and over time. These issues complicate the assessment of the causal effect of resource abundance and the channels through which it impacts growth.

In order to overcome these problems and shed light on the effect of resource based specialization, I examine specialization in the production of oil in parts of the US South since 1890. The study of the US South is especially interesting because it had remained largely agricultural for a long time (Wright 1986; Caselli and Coleman 2001). 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.[2] I construct a new dataset that identifies the location of major US oilfields; the data tell us how much oil was extracted from each oilfield by 1999, and how much oil 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 use US Census data on 775 counties.[3] The high quality of these data ensure that I face fewer measurement error problems than most studies that span multiple countries. Using these data, I define a county as oil abundant if it lies above at least one oilfield (or part of an oilfield) that had 100 million barrels of oil before any oil was extracted. To ensure that the control counties are similar to the oil abundant counties in all but their endowment of oil, I use other counties that are relatively close by. We might worry that counties adjacent to oil abundant ones may be affected directly by oil (e.g. through commuting), but my identification strategy is robust to excluding these adjacent

[2]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.

[3]A number of 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).

counties from the sample. The setting I study also involves less institutional variation than cross-country comparisons, so spurious correlation between endowments and institutional quality is less of a concern.

An examination of the sample reveals that the oil abundant counties were very 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 the mining sector from about 1-2 percentage points to about 6-8 percentage points throughout the period 1940-1990. 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 whether it had an effect through the channels mentioned above: "Dutch Disease", decreased educational attainment, or increased inequality. First, I find that in 1940 oil abundant counties were no less industrialized than the control counties, as the expansion of the oil sector crowded out agriculture, rather than manufacturing. But over the next 50 years the entire region transitioned away from agriculture and towards manufacturing and services. I find some evidence for "Dutch Disease," as oil abundance slowed down the expansion of the manufacturing sector as a fraction of employment. I also find 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 net in-migration. In other words, it turns out that factor mobility offset the effect of the "Dutch Disease" on the total size of the rest of the tradable sector.[4]

[4] The flow of workers to resource-rich areas is common even in international settings, as evidenced by the large numbers of foreign workers in the oil-rich Gulf states.

Second, I find that oil abundance a had a non-monotone effect on the level of education. While some studies assume that resource intensive industries require relatively few educated workers, they may actually be more skill intensive than the industries that would have developed in absence of the natural resource. Since oil extraction is more skill intensive than agriculture, oil abundant counties had about 2.5 percentage points (or about 13 percent) more high school graduates than the control counties in 1940. I also find that for many decades oil abundant counties spent more per capita on education. Nevertheless, after 1940 oil abundant counties experienced lower growth in the fraction of high school graduates, and the other counties caught up with them around 1980. There is also some evidence that this slower growth was due to both lower graduation rates from high school among both natives and workers who migrated to the oil abundant counties. The reversal in educational attainment is due at least in part to the fact that newer industries (e.g. manufacturing) accounted for a smaller share of employment in the oil abundant counties. Yet despite the slowdown in human capital accumulation in the oil abundant counties, there is little evidence that resource abundance creates a very poorly educated workforce.[5]

Third, I examine whether oil abundance affected the level or the distribution of income. I find that oil abundance raised income per capita by about 20-30 percentage points around 1950. Over the next 40 years this advantage narrowed considerably, but in 1989 income per capita in oil abundant counties was still about 5-6 percent higher than in the control counties. Interestingly, I find no evidence that oil abundance had any adverse effect on income inequality: in fact, it appears that it shifted the entire income distribution to the right.

My main findings on the effects of oil abundance are statistically significant even after controlling for geographic and demographic covariates and for state-year interactions. I find further support for my results using an orthogonal source of variation: a comparison of oil abundant counties with different levels of oil endowment reveals that oil initially crowds out

[5] Throughout the paper I use human capital and education interchangably.

agriculture, and that the most oil abundant counties are initially better educated and richer; over time, these differences decreased significantly.

Taken together, the evidence suggests that the long-term consequences of specialization in oil production were generally favorable, though specialization did introduce some inertia that had long term costs. I further explore these implications using a simple model of specialization's effect on an economy that shifts from agriculture to more skill intensive goods, such as manufacturing. I conclude that the economic effects of resource based specialization may be similar to those of specialization in many other commodities.

The remainder of the paper is organized as follows. Section 2 discusses the data and the samples I use, and Section 3 presents an empirical analysis using these data. Section 4 presents a simple model of the effect of specialization. Finally, section 5 concludes.

2 Data and Samples

I begin by describing the data set that I use to examine the effects of regional specialization. The Oil and Gas Journal Data Book (2000) lists the names of US oilfields that had at least 100 million barrels of oil before any oil was extracted from them. This includes the amount extracted by 1999 and the amount that was projected to have remained in each oilfield at that time. 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.

In order to determine whether a county is oil abundant, I use the Oil and Gas Field Code Master List, and I define a county as oil abundant if it lies above one or more of these oilfields or part thereof. 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 two other oil abundant states (Alaska and California) the 3 states I consider are divided into counties in a fairly regular way, offering a good 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).[6]

In the baseline specifications in the next section, I use all the counties in the sample, but in other specifications I exclude those that are adjacent to the oil abundant counties. This alternative specification has a number of advantages. First, workers in non-adjacent counties are less likely to commute to work in the oil abundant counties. Second, adjacent counties may have more small oilfields that are not identified in my data. In fact, 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. Finally, 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.[7] The main drawback of using only non-adjacent counties as controls is that they may differ from the oil abundant counties 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.

Another potential concern is that oil revenues may affect economic outcomes at the state level. For this reason, the next section also present specifications that contrast the oil abundant counties in the three oil abundant states (Texas, Oklahoma, and Louisiana) with

[6] 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).

[7] 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.

the sample counties that are not oil abundant and lie in the other nearby states shown in Figure 2.[8] The shortcoming of this specification is, that it may attribute to oil abundance any state-specific policies that are unrelated to oil. For that reason, I also discuss specifications that use only within-state variation when I consider the robustness of my findings.

Having constructed the sample of counties, I use the County Data Books (Haines 2004) to obtain county-level data on land area, population, industries, education, local taxation and expenditures, and income.[9] Micro data from the 1980 census data are used to shed more light on the effect of oil abundance on education; however, these data are more coarsely aggregated, and identify only the county group in which each individual resides.

In addition to the data on county-level 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 consequences of regional specialization. First, it provides a new and exogenous source of variation for resource abundance. This improves over cross-country comparisons (e.g. Sachs and Warner 2001), that use the fraction of raw materials in exports, since total exports may depend on technology and human capital endowment. 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[10], and as I discuss below it was a major source of income in the counties I analyze.

[8] 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.

[9] The data on agricultural employment from 1960 onwards includes forestry and fisheries, which are relatively small. I use data from 1960 to impute employment in forestry and fisheries in 1940 and 1950.

[10] However, it did fluctuate over time, especially with the rise and decline of energy prices.

Third, 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 afford 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. Having set the scene, I now go on to examine whether there is evidence of a "Resource Curse" in this setting.

3 Empirical Analysis: Specialization in Oil Production

3.1 Specialization in an Agricultural Economy

In 1890 the economy of the Southern US was primarily 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 it is not entirely consistent with subsequent decades (e.g. due to subsequent changes in county boundaries). This caveat notwithstanding, I examine whether economic outcomes of interest 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.[11]

The next few decades saw the discovery and development of many oilfields (Pratt 1980). Despite these discoveries, in 1940 the region I analyze was still mostly agricultural (Table 1). 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

[11] 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.

percent of the labor force in other nearby counties.[12] Table 1 also shows that oil abundant counties performed well around 1940 in terms of their level of the employment share of manufacturing, the level of education and income per capita. These results are discussed in more detail in the next sections, as I examine the impact of oil abundance over time.

3.2 Specialization and Industrialization

Can an abundance of natural resources slow down industrialization? In his analysis of a two sector open economy, Mastuyama (1992) argues that an absolute advantage in a certain tradable sector translates into a comparative advantage in that sector and slows down the growth of manufacturing. When learning by doing takes place only in manufacturing, an economy might be better off without its absolute advantage. The differences in oil abundance in the US South offers an interesting source of variation to test this channel.

In the decades after 1940 the US South underwent substantial economic changes (Wright 1986). The transition from agriculture to manufacturing and services in the counties I analyze was very 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 change allows us to examine the effect of specialization in the production of oil on the transition from traditional tradable goods (agriculture) to newer and more skill intensive tradable goods (manufacturing). As I discuss below, oil abundance may raise local factor prices (an effect equivalent to a real exchange rate appreciation, even though all the counties were using the same nominal currency). I therefore examine whether oil abundant counties became less attractive locations for the new manufacturing plants.

The top panel in Table 2 shows the effect of oil abundance in 1940, using the following cross-section specification:

$$Y_c = \alpha d_c + \varepsilon_c, \tag{1}$$

[12] 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.

where Y_c is the county-level outcome, d_c is an indicator for oil abundance, and ε_c is an error term.

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. Thus, in an economy that produces (almost exclusively) traditional goods, oil crowded out traditional goods.

The bottom panel in the Table 2 show results from regressions of the form:

$$Y_{ct} = \phi_c + \psi_t + \alpha_t d_c + \varepsilon_{ct}, \tag{2}$$

where Y_{ct} is the outcome in county c at year t; ϕ_c and ψ_t are county fixed effects and year effects; α_t is a time-varying coefficient on the indicator for oil abundance, d_c; and ε_{ct} is a residual. The employment shares of mining, manufacturing, and agriculture, which are the outcomes of interest, are also shown in Figure 3.

As the results show, there was very little change in the employment share of mining over time, with the exception of the temporary rise in 1980 due to the oil boom.[13] However, now the employment share of agriculture in the oil abundant counties was only about 1.5-2 percentage points lower than in the control group, and the employment share of manufacturing was 4-7 percentage points higher. In other words, oil increasingly crowded out the production of more skill intensive goods.[14]

Interestingly, though, oil abundance had no adverse effect on the total size of the manufacturing sector (results not shown). This is because, as I discuss below, oil abundant

[13]The discovery of new major oilfields, as shown in Figure 2, and the depletion of some existing fields may have also affected the employment share of mining over time, but in practice the net effect of these changes appears to have been relatively small.

[14]Results described in a later section of this paper show that population growth in the oil abundant counties. This implies that over time land became relatively more scarce in the oil-abundant counties. But if this effect were important, we would have expected a faster transition away from agriculture in the oil-abundant counties, whereas in practice the share of agriculture decreases more rapidly in the control counties.

counties attracted more population.[15] This offsetting effect of factor mobility, which has the opposite effect from the usual "Dutch Disease" mechanism, is often ignored in the literature. 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 may vary. In some countries migration in response to oil discoveries was limited, but in other cases, such as the Gulf States and Saudi Arabia, substantial migration did take place.

In addition to examining the direct impact of oil abundance, we can also examine whether this impact differed with the implementation of pro business policies. Holmes (1998) finds that right-to work laws and related pro-business policies, enacted during the 1940s and 1950s, promoted the expansion of the manufacturing sector. If specialization in the production of oil slows down this expansion, we expect that right-to-work laws would have a larger effect on the employment share of manufacturing in states that are not oil abundant.[16]

In order to estimate the differential impact of right-to-work laws in oil abundant counties, I estimate the following regression:

$$Y_{cst} = \phi_c + \psi_t + \alpha_t d_c + \beta_t l_{st} + \gamma_t d_c l_{st} + \varepsilon_{cst}, \tag{3}$$

where Y_{cst} is the outcome in county c, state s, at year t; ϕ_c and ψ_t are county fixed effects and year effects; α_t, β_t,and γ_t are time-varying coefficients on the indicator for oil abundance, d_c, the indicator for a right to work law in state s at time t, l_{st}, and the interaction of these two terms; and ε_{cst} is a residual. The first three columns in Table 3 show estimates for the right-to-work laws alone ($\alpha_t = \gamma_t = 0$), while the next three columns show the unrestricted estimates.

The results show that right-to work laws did indeed expand manufacturing. Moreover,

[15] Appendix Table A1 shows that the population in oil abundant counties grew at a more rapid rate than in the control counties.

[16] In the sample of counties I use, the states that did not enact right-to-work laws are New-Mexico, Colorado, Oklahoma, and Missouri. One limitation of using this data is that right to work laws may be endogenous to the development of manufacturing.

Table 3 shows that the effect of the laws was larger in counties that were not oil abundant, but in oil abundant counties right-to-work laws had no significant effect on the employment share of manufacturing.

My findings suggest that oil abundance led counties to specialize in the production of oil, initially crowding out agriculture, and later on crowding out more skill-intensive industries (at least as a fraction of total employment). Could oil abundance have slowed down the growth of education? I now address this question directly.

3.3 Specialization and Accumulation of Education

The possibility that resource abundance slows down the accumulation of education has been proposed in several studies. For example, Leamer et al. (1998) argue that natural resources may have slowed down the process of human capital accumulation 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 my sample I require a relevant and consistent measure of the stock of educated workers. Due to data limitations, I choose to focus on the fraction of people with a high-school degree (or more) among people 25 years and older. As the top panel 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.[17]

Over the next 50 years, the fraction of high-school graduates increased at rapid rates in the region I analyze, as shown in Figure 4 and Table 4. In the oil abundant counties the rate of accumulation of education were significantly slower. Moreover, in at least some of the specifications, the workforce in the oil abundant counties was significantly less educated than in the other counties in 1990, although this difference is economically small.

[17] 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).

To what extent can the more rapid transition from agriculture to manufacturing in counties that are not oil abundant explain their more rapid accumulation of human capital? Using census data on the differences in human capital between agriculture, 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 industry composition can explain about 20-30 percent of the variation in the rate of human capital accumulation.[18] 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.

In order to examine the channels through which oil abundance affects human capital accumulation, I further examine the relationship between oil abundance and education. Estimated coefficients using three different specifications as in the top panel of Table 4 and data for 1990 indicate that the fraction of high-school graduates in oil abundant counties were about 1.3-3 percentage points and high-school dropout rates for people aged 16-19 were about 0.8-1.7 percentage points higher. In addition, I use micro data from the 1980 census, which identify individuals' county group of residence. Using data for the three oil abundant states in this region (Texas, Louisiana, and Oklahoma) and the adjacent states (New Mexico, Colorado, Kansas, Missouri, Arkansas, and Mississippi), I find that among people aged 25 years or older residents of county groups with at least one oil abundant county are 5.2 percentage points less educated. I find a similar coefficient when I run this regression separately for people who moved into the county in the last 5 years and for people who stayed in the county over the past 5 years. Although these estimates should be taken with caution[19], they suggest that the slower accumulation of human capital in the oil abundant counties is likely due to both lower education of people born in these counties and to a lower net inflow of

[18] Detailed calculations available from author.

[19] The estimates using the 1990 cross-section of counties are not robust to controlling for state fixed effects, while the estimates using the 1980 county groups are robust to those controls. However, in both cases I have no panel dimension, so the identification is only from a cross-section.

educated workers.

The finding that oil abundance slowed down the rate of human capital accumulation is interesting in two respects. First, oil has remained a skill-intensive good throughout the period I analyze, so the direct effect of demand for skill in the oil-producing industry is unlikely to have given rise to lower level of human capital accumulation. Second, the oil abundant counties have higher per capita income throughout the period, 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). Per capita spending on education was also correspondingly higher in oil-abundant counties. This implies that a supply based explanation for the slowdown in human capital accumulation in oil abundant counties seems inadequate.

What seems more likely is 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 offset the increase in the share of educated workers in the workforce caused by oil abundance in earlier decades. This suggests that impact of oil abundance on human capital accumulation was limited. But if its impact on education was limited, could oil abundance have still affected the income distribution?

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. This may be due to purely economic channels (e.g. Leamer et al. 1999) or to political and institutional channels (e.g. Engerman and Sokoloff 1997). In our setting, we might be concerned that oil abundance may have a negative effect on the distribution or the level of income. But as Table 5 shows, in 1949 the median family income was about 30 percentage 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 had narrowed in every decade except the 1970s, when the price of oil increased steeply. 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 despite limited availability of historical data, Figure 5 shows the results for a fixed subsample of 451 counties. 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. 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 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 human capital accumulation. 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.[20]

[20]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

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 1989 the distribution of family income in the oil abundant counties significantly dominates the income distribution of the control counties across the different levels of the income distribution.[21]

Since the oil abundant counties enjoyed higher levels of income per capita for many decades, we might expect that there were endogenous migration inflows to those counties. Patterns of population change (Appendix Table A1) suggest that net migration to the oil abundant counties was larger during the earlier decades after 1940, when income differentials were large. As income per capita differentials decreased, net migration to oil abundant counties appears to have slowed down considerably.[22]

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 the other nearby counties.

3.5 Additional Specification Checks

In this section I reexamine the robustness of the estimated effect of oil abundance on industry structure, education, and income. These robustness checks use data on the timing of oil discovery, time varying controls for other covariates, and variations in the magnitude of the oil endowment across the oil abundant counties.

One concern about using the oil endowments is that variations over time may reflect, at

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.

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

[22] It is difficult to construct consistent panel data on housing prices. Available data suggest that on average, the median rental rate in oil-abundant counties was about 6 percent higher in 1990 (this estimate is highly significant). This suggests that congestion may have had an offsetting effect on population migration.

least in part, a process of discovery of oilfields that were previously unknown. To address this potential concern, I re-ran the regressions discussed above excluding counties where major oilfields were discovered only after 1940, and the results changed very little.[23]

Another concern with using geological variation in oil abundance is that it 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.

The first specification in Appendix Tables A2-A5 is the same as the first specification in Tables 2-5, except that I add controls for time-varying effects of distance to the ocean and to the nearest navigable river. These interactions appear to have little impact on the magnitude and precision of most estimates. The only exception is in Table A3, where adding controls weakens the precision of the differential effect of right-to-work laws on oil abundant counties. This caveat notwithstanding, the results on the main effect of oil abundance in the other tables are quite robust.

We might also be concerned that oil abundance might be spuriously correlated with other factors that change over time. The second column in the Appendix tables 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 human capital (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.[24]

Finally, we might be concerned that time varying policies at the state level might be correlated with the location of oil. The second specification in Tables A2-A5 controls for state-year interactions. Even after adding these controlling, the effects of oil abundance on

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

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

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 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.[25] One advantage of this 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, and had higher income per family and per capita in 1949 and 1959.

The bottom panel of Table A6 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,

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

the pattern that emerges from Table A6 is quite consistent with the previous evidence: endowment-driven specialization in oil production initially improves economic outcomes, but over time this advantage is eroded as the less specialized economies shifted more quickly to newer and more skill abundant industries.

4 A Model of Specialization

The empirical analysis presented above shows how an abundance of a particular natural resource, oil, affects long term economic outcomes. But there is little evidence that the economic effects would have been different for counties that specialized in other types of commodities. In other words, it is the persistence of specialization, rather than resource abundance, that seems to affect the economy. In this section I present a simple framework, based on Dornbusch, Fischer, and Samuelson (1977), that explores the effect of such specialization.

The main intuition of the model can be summarized as follows. Assume that one economy has an advantage in producing a certain set of goods, such as oil and closely related products, so it specializes in their production. Initially, the specialized goods crowd out traditional goods, such as agriculture. But over time, exogenous technological change introduces new goods that are more skill-intensive. Production of these new goods has a smaller impact on the economy that produces the specialized good, and this affects its endogenous investment in human capital and its growth rate.

I begin by considering an economy ("home"), where perfectly competitive firms use labor to produce a continuum of goods of measure 1. This economy has a continuum of workers of measure L, and each worker can invest in human capital, which increases the number of units of labor she can supply. The continuum of goods can be divided into three types: a measure $\underline{z}$ of specialized goods, a measure x_1 of traditional goods, and a measure $x_2 = 1 - \underline{z} - x_1$ of new goods. A worker with education e supplies eh_s units of labor in the production of the specialized goods, e units of labor in the production of the traditional goods, and eh units of labor in the production of the new goods. To reflect the higher skill-intensity of new goods relative to traditional goods I assume that $h > 1$.[26] For simplicity, I assume that $h_s \in [1, h]$, so the skill requirements in production of the specialized good are not lower than in the traditional goods, but not higher than in the new goods. However, the results below hold when $h_s \in (1 - \varepsilon, h + \varepsilon)$, for some $\varepsilon > 0$. In other words, the results only require that the skill-intensity in the production of the specialized good is similar to that of the other goods.

I assume that the cost of investment in education is proportional to the wage rate[27] and convex in the level of investment:

$$c(e) = \frac{1}{2} e^2 w. \tag{4}$$

Individuals must choose their level of investment in education before they are assigned to an industry. Since all individuals are identical, I assume that they are randomly assigned to the different industries.[28]

Having discussed the conditions in the home economy, we can consider another ("foreign") economy, which I denote with an asterisk. The foreign economy is identical to the home economy, except that it has a disadvantage in the production of the specialized good. For simplicity assume that the specialized good can only be produced in the home economy.

The workers in both economies spend their wage income on consumption goods. I assume that they all maximize an identical Cobb-Douglas utility function, so income effects play no role in determining the patterns of trade:

$$U = \int_0^1 b(z) \ln d(z) dz, \tag{5}$$

[26] Using US manufacturing data for the late 1970s and the 1980s, Xiang (2005) finds that new goods' average skilled-labor intensity exceeds the old goods' by over 40%. For a different discussion of new goods and increased demand for skill see also Xiang (2006).

[27] This is could be thought of as a reduced form way of representing payment to teachers.

[28] This is a simplifying assumption that allows me to work with a single factor of production in each economy, facilitating the derivation of simple analytic solutions. It captures the fact that students have some uncertainty regarding their industry of employment, and that there is high persistence of employment across industies.

where $d(z)$ is the quantity of good z consumed, and

$$\int_0^1 b(z)dz = 1. \tag{6}$$

I also assume that a constant share of total income, $B = \int_0^{\underline{z}} b(z)dz$, is spent on the specialized good, and the remainder of the income is spent on the other types of goods.[29] I also assume that there are transportation costs of an iceberg form, so a fraction $g(z)$ of each unit of z shipped from one economy to the other arrives at its destination. The traditional goods and the new goods can be ranked in a strictly decreasing order of shipping cost, so $g'(z) > 0$, and I assume that both types of goods have the same distribution of trade costs. Having outlined the assumptions of the model, we can now characterize its equilibrium.

The open economy equilibrium is characterized by the following conditions. First, there is a unique threshold good $\overline{z}$, such that consumers in the home economy face the same price for an imported good and a domestically produced good:

$$\omega \equiv \frac{w}{w^*} = \frac{1}{g(\overline{z})}. \tag{7}$$

Second, home exports the goods $[0, \underline{z}]$ and imports the goods $[\overline{z}, 1]$, while the goods $(\underline{z}, \overline{z})$ are not traded in equilibrium. Trade is balanced, so the value of imports to the home economy equals the value of its exports:

$$wLS \int_{\overline{z}}^{1} b(z)\, dz = w^* L^* S^* \int_0^{\underline{z}} b(z)\, dz \Leftrightarrow \omega \left(\frac{L^* S^*}{BLS}\right) = 1/\int_{\overline{z}}^{1} b(z)\, dz, \tag{8}$$

where S and S^* are the average number of units of labor supplied by a worker in the home and foreign economies.

In equilibrium, the fraction of workers employed in production of new goods in the foreign

[29] Note that if B is not constant, but decreases to zero as new goods are introduced, the home economy ceases to be specialized in a meaningful way.

economy is:

$$P^* = \frac{x_2}{x_2 + (1 - B - x_2)\, h}, \tag{9}$$

and the fraction of workers producing the specialized goods in the home economy is:

$$P_s = \frac{B\,(wLS + w^*L^*S^*)\, h}{B\,(wLS + w^*L^*S^*)\, h + ((1 - B)\, wLS - Bw^*L^*S^*)\, (x_2 + (1 - B - x_2)\, h)\, h_s} \tag{10}$$

Note that this assume that home expenditure on the non-specialized good $((1 - B)\, wLS)$ are at least as big as foreign expenditures on the specialized good $(Bw^*L^*S^*)$, so $P_s \leq 1$.

Taking the employment shares and $\omega, \overline{z}$ as given, workers choose their level of education, equating marginal returns to marginal cost, so the levels of education in the foreign economy an the home economy are:

$$\overline{e}^* = P^*h + (1 - P^*) \tag{11}$$

and:

$$\overline{e} = P_s h_s + (1 - P_s)\, \overline{e}^*. \tag{12}$$

The measure of units of labor supplied in the two economies is therefore:

$$S^* = (\overline{e}^*)^2 \tag{13}$$

and

$$S = (\overline{e})^2 \tag{14}$$

Taking the wage in the home economy, w, as numeraire, we have 8 equations in 8 unknowns:

$(\omega, \overline{z}, P^*, P_s, \overline{e}^*, \overline{e}, S^*, S)$. The Appendix characterizes sufficient conditions for the uniqueness of an equilibrium, and Figure 7 provides a graphic representation of this equilibrium.

We can now use the model to derive 4 results that characterize the differences between the two economies.

Result 1. *When both economies produce only specialized goods and traditional goods, per capita income is higher in the home economy, or in other words:* $wS > w^*S^*$.

Proof. Equation 7 shows that the wage per efficiency unit of labor is higher in home: $\omega > 1$. Intuitively, home imports goods that can be produced with the same unit labor cost at home and incurs transport costs. Before any new goods are introduced $x_2 = 0$. If $h_s = 1$ then $S = S^* = 1$, so per capita income in home is ω times higher than in foreign. Since S is continuous and increasing in h_s and S^* is constant in h_s, per capita income is higher in the home economy. ■

In the setting we analyze in this paper, this result means that specialization is initially unambiguously beneficial. For example, until around 1940 oil production essentially crowded out agriculture, raising income per capita. Over time, however, new goods (e.g. new types of manufacturing goods) are introduced. Because the home economy keeps producing the specialized good, the employment share of the new goods becomes larger in the foreign economy.

Result 2. *Production of the specialized good initially crowds out traditional goods, but over time it increasingly crowds out new goods.*

Proof. The employment share of new goods in foreign is P^*, while in home it is only $P^* \times$ (1−employment share of specialized good). This implies that when new goods are introduced, their production takes place disproportionately more in the foreign economy. ■

Since the transition from traditional goods to new goods is more rapid in the foreign economy, its demand for skill grows more quickly.

Result 3. *The foreign economy accumulates education faster than the home economy as new goods fully replace traditional goods.*[30]

[30] The effect of investment in education is not modelled here. If the specialized economy is richer, it may invest more in education, reducing the cost of acquiring education. Such a supply response may offset the demand-side effect outlined in the model.

Proof. When there are no new goods: $(\overline{e}^{*}-\overline{e})\left|_{x_2=0}\right. = -P_s\left|_{x_2=0}\right.(h_s-1)\leq 0$, and when there are no traditional goods $(\overline{e}^{*}-\overline{e})\left|_{x_2=1-B}\right. = P_s\left|_{x_2=1-B}\right.(h-h_s)\geq 0$. Moreover, since $h>1$, at least one of those inequalities must be strict, so the foreign economy starts with a less educated workforce and ends up with a better educated workforce. Therefore, it experiences a more rapid accumulation of human capital as the new goods replace the traditional goods. ■

Finally, the faster growth of human capital in the foreign economy implies that its income per capita also grows more quickly.

Result 4. *The foreign economy grows at a faster than the home economy as new goods replace the traditional goods.*

Proof. Based on the results of the previous claim, $S^{*}\left|_{x_2=0}\right. \leq S\left|_{x_2=0}\right.$ and $S^{*}\left|_{x_2=1-B}\right. \geq S\left|_{x_2=1-B}\right.$, and at least one of the inequalities is strict. Therefore, as the new goods replace the traditional goods, S^{*}/S increases. Using equations 7 and 8 we conclude that ω declines, but proportionally less than the increase in S^{*}/S. At the same time, $\overline{z}$ also declines, as the range of goods imported to home increases. In other words, as the effective supply of labor increases more rapidly in the foreign economy, its terms of trade worsen, and it exports more goods. At the same time, its wage per efficiency unit of labor decreases relative to the home economy. But the net effect is an increase in per capita income in the foreign economy, compared to the home economy. ■

These results reflect the economic fortunes of the oil abundant counties I analyzed in previous sections. Oil abundance initially crowded out agriculture and increased the level of education and per capita income. But over time, as the economy moved away from agriculture and towards more skill intensive goods, specialization slowed down human capital accumulation and growth.

In deriving these results, the model makes a number of important simplifying assumptions. First, it assumes no migration between the two economies. If we relax this assumption and allow frictionless migration, then all the population migrates to the oil abundant economy, since any good can be produced there at the same cost and there are no trade costs. To make the model more realistic, we can assume that each economy has a local scarce consumption good, such as housing. In this case, differences in housing cost offset the difference in wages, so in equilibrium workers are indifferent between living in the two economies.[31] In the empirical section of the paper I test whether population increased more rapidly in the oil abundant economies, and whether housing rental rates are positively correlated with oil abundance. Further implications of endogenous migration, including its effects on cities of different sizes, are discussed in detail in Michaels and Redding (2007).

Second, the model can also be expanded to accommodate within-industry skill upgrading, as long as it is orthogonal to the introduction of new goods. In this case, oil abundant economies still accumulate human capital more slowly, since the oil industry increases its demand for skill at the same rate as other industries. Third, I assume that workers do not anticipate the changes in industry composition when making their education investment decisions. But this is not likely a major concern when a long period of time is required for the technological change to have a large economic impact.

Fourth, I do not model the role of capital in the production function. But if capital flows freely across the different economies, the returns to capital are equated, and any differences in capital intensity across sectors are unlikely to affect the demand for skill. Finally, the model does not account for the effects of income on public education spending. For example, if the specialized economy is richer, higher investments in human capital may offset (or partially offset) the effect of specialization on human capital accumulation.

The caveats notwithstanding, the model allows us to consider some of the long term benefits and costs of economic specialization outlined in this paper. This model suggests that these economic effects are due more to the nature of specialization than to the specific source of comparative advantage.

[31] A similar extension is discussed in Michaels (2006).

5 Conclusions

This paper examines the long-term consequences of resource based specialization. I trace the impact of specialization brought about by large endowments of oil on parts of the Southern US, as this region transitioned from agriculture to 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 first 50 years after oil was discovered in the 1890s, its effects were large and beneficial. The development of the oil sector increased education and income per capita, and it had no adverse effects on industrialization or inequality. From 1940 onwards oil abundance reduced the employment share of manufacturing, but not its absolute size. Oil abundance also led to a slower accumulation of human capital, and I find some evidence that this was due both to the composition of migration and to (slightly) higher dropout rates of natives in the oil abundant counties. I argue that these costs are due to the fact that the economy remained specialized in a particular commodity over a long period of time. In other words, the costs are due more to the nature of long term specialization than to its specific cause, natural resources.

Yet despite these long term costs, oil abundant counties continued to enjoy higher levels of per capita income than other nearby counties at least through 1989. There is also no evidence of any adverse effect of specialization in oil on income inequality.

Taken together, the results in this paper suggest that economies rich in natural resources can perform well over a very long period of time. These findings are consistent with much of the research presented in Lederman and Maloney (2007), which argues that natural resources can be leveraged for sustained growth. While I cannot rule out the possibility that natural resources might have negative effects through political channels in economies with weak institutions (e.g. Mehlum, Moene, and Torvik 2006; Humphreys, Sachs and Stiglitz 2007), this paper concludes that the purely economic effects of the "Resource Curse" are likely quite modest.

Appendix: Uniqueness of Equilibrium

This Appendix gives sufficient conditions for the uniqueness of the open-economy equilibrium. First, note that there is a unique solution for P^*, $\overline{e}^*$, and S^* (using equations 9, 11, and 13). Second, for S such that $(1-B)\,wLS - Bw^*L^*S^* = 0$, when the home economy is fully specialized, an increase in S raises the right-hand side of 10. But using 14 and 12 the left hand side is increasing in S, so S is unique. We can then use 14 and 12 to obtain the unique values of P_s and $\overline{e}$. Finally, holding S constant, $\overline{z}$ decreases in ω in 7 and increases in ω in 8, so there is a unique solution in $\overline{z}$ and ω. This shows that there the solution to the 8 equations is unique at least when the home economy is nearly specialized.

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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	962	974	954
	(561)	(828)	(771)	(869)
Population (1940)	30,493	25,243	24,413	25,865
	(49,112)	(41,842)	(40,850)	(42,618)
Population density (1940)	36.1	38.4	38.4	38.3
	(50.3)	(117.8)	(156.0)	(78.2)
Percent employed in mining (1940)	6.2	1.3	1.4	1.1
	(7.8)	(3.4)	(3.2)	(3.6)
Percent employed in agriculture (1940)	37.5	45.4	44.0	46.4
	(18.6)	(16.5)	(15.8)	(17.0)
Perecnt employed in manufacturing (1940)	5.7	5.9	5.9	5.8
	(5.7)	(5.8)	(6.6)	(5.2)
Percent of high-school graduates among 25+ year-olds (1940)	21.2	18.7	19.6	18.1
	(8.4)	(7.4)	(7.3)	(7.4)
Median family income (1949 US Dollars)	2,403	1,874	2,017	1,770
	(806)	(764)	(732)	(772)
Per capita income (1959 US Dollars)	1,415	1,214	1,274	1,169
	(394)	(380)	(365)	(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 Employment, by Sector

	Mining			Manufacturing			Agriculture		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
	A. Cross-Section of Counties (1940)								
Oil-abundant	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)
Intercept	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)
Observations	774	516	508	774	516	508	770	514	504
	B. Panel of Counties (1940-1990)								
Oil-abundant x 1950	2.0	2.4	2.4	-1.2	-1.4	-1.4	-3.0	-4.2	-4.7
	(0.3)	(0.4)	(0.4)	(0.3)	(0.3)	(0.3)	(0.7)	(0.7)	(0.7)
Oil-abundant x 1960	0.8	1.4	1.3	-2.7	-3.6	-4.2	2.5	2.8	2.6
	(0.4)	(0.4)	(0.4)	(0.4)	(0.5)	(0.5)	(1.0)	(1.1)	(1.1)
Oil-abundant x 1970	0.3	0.7	0.7	-4.6	-6.3	-7.2	5.4	7.0	6.9
	(0.4)	(0.4)	(0.4)	(0.7)	(0.8)	(0.8)	(1.3)	(1.5)	(1.5)
Oil-abundant x 1980	1.1	2.1	2.2	-3.5	-4.8	-5.6	5.6	6.9	6.8
	(0.5)	(0.5)	(0.5)	(0.6)	(0.7)	(0.7)	(1.4)	(1.5)	(1.6)
Oil-abundant x 1990	-0.6	0.1	0.2	-4.0	-5.5	-6.5	6.0	7.4	7.2
	(0.5)	(0.5)	(0.5)	(0.6)	(0.7)	(0.7)	(1.4)	(1.6)	(1.6)
1950	0.3	-0.2	-0.1	3.4	3.6	3.6	-6.7	-5.5	-5.3
	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)	(0.2)	(0.3)	(0.4)	(0.4)
1960	0.5	-0.1	0.0	7.2	8.1	8.3	-22.2	-22.5	-22.2
	(0.1)	(0.2)	(0.2)	(0.3)	(0.4)	(0.4)	(0.5)	(0.7)	(0.6)
1970	0.3	-0.1	0.0	11.8	13.5	13.8	-30.8	-32.4	-32.2
	(0.2)	(0.2)	(0.2)	(0.4)	(0.6)	(0.6)	(0.7)	(0.9)	(0.9)
1980	1.3	0.3	0.4	10.9	12.2	12.7	-34.2	-35.5	-35.3
	(0.2)	(0.2)	(0.2)	(0.4)	(0.5)	(0.5)	(0.7)	(0.9)	(0.9)
1990	0.4	-0.2	-0.1	9.5	11.0	11.7	-35.6	-37.0	-36.9
	(0.1)	(0.2)	(0.2)	(0.4)	(0.5)	(0.5)	(0.7)	(0.9)	(0.9)
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 regression include county fixed effects and time effects. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table 3. Effect of Oil Abundance and Right-to-Work Laws on Industrialization

	(1)	(2)	(3)	(1)	(2)	(3)
Oil-abundant x 1950				-0.7	-1.1	-0.7
				(0.5)	(0.5)	(0.6)
Oil-abundant x 1960				-2.2	-2.8	-2.0
				(0.6)	(0.7)	(0.7)
Oil-abundant x 1970				-2.4	-2.9	-1.3
				(0.9)	(1.0)	(1.1)
Oil-abundant x 1980				-1.0	-1.3	0.4
				(1.0)	(1.1)	(1.2)
Oil-abundant x 1990				-2.2	-2.4	-1.1
				(1.0)	(1.0)	(1.1)
Pro-business x 1950	1.2	1.4	1.4	1.1	0.5	-0.7
	(0.4)	(0.5)	(0.5)	(0.5)	(0.8)	(0.7)
Pro-business x 1960	0.3	0.3	1.0	0.4	0.8	1.9
	(0.4)	(0.5)	(0.5)	(0.4)	(0.6)	(0.6)
Pro-business x 1970	1.7	2.4	3.6	2.4	4.3	5.9
	(0.6)	(0.7)	(0.8)	(0.7)	(1.0)	(1.0)
Pro-business x 1980	0.7	1.4	2.8	1.4	2.9	4.8
	(0.6)	(0.8)	(0.8)	(0.7)	(1.0)	(1.0)
Pro-business x 1990	0.3	1.3	2.7	0.8	2.9	4.7
	(0.6)	(0.7)	(0.8)	(0.7)	(1.0)	(1.0)
Oil-abundant x Pro-business x 1950				-1.3	-0.7	-0.5
				(0.8)	(1.0)	(1.0)
Oil-abundant x Pro-business x 1960				-0.8	-1.2	-3.1
				(0.7)	(0.9)	(0.9)
Oil-abundant x Pro-business x 1970				-3.2	-5.0	-7.9
				(1.0)	(1.3)	(1.3)
Oil-abundant x Pro-business x 1980				-3.1	-4.6	-7.7
				(1.2)	(1.4)	(1.4)
Oil-abundant x Pro-business x 1990				-2.2	-4.2	-6.9
				(1.1)	(1.3)	(1.3)
Observations	4,649	3,101	3,053	4,649	3,101	3,053

NOTES. The dependent variable is the percentage of the labor force employed in manufacturing. "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 regression include county fixed effects and time effects. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

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

	(1)	(2)	(3)
	A. Cross-Section of Counties (1940)		
Oil-abundant	2.5	3.2	2.3
	(0.7)	(0.8)	(0.8)
Intercept	18.7	18.1	18.7
	(0.3)	(0.4)	(0.4)
Observations	775	517	509
	B. Panel of Counties (1940-1990)		
Oil-abundant x 1950	-1.4	-2.4	-3.3
	(0.4)	(0.4)	(0.4)
Oil-abundant x 1960	-0.6	-0.9	-1.7
	(0.4)	(0.4)	(0.4)
Oil-abundant x 1970	-2.9	-4.2	-5.7
	(0.6)	(0.6)	(0.6)
Oil-abundant x 1980	-4.1	-5.8	-6.9
	(0.7)	(0.7)	(0.7)
Oil-abundant x 1990	-3.7	-5.0	-5.3
	(0.7)	(0.8)	(0.8)
1950	6.0	6.9	7.5
	(0.2)	(0.2)	(0.2)
1960	13.4	13.7	14.2
	(0.2)	(0.3)	(0.3)
1970	22.8	24.2	24.9
	(0.3)	(0.3)	(0.3)
1980	37.2	38.9	39.2
	(0.3)	(0.3)	(0.3)
1990	47.7	49.0	48.6
	(0.3)	(0.3)	(0.3)
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 regression include county fixed effects and time effects. 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)
	Cross-Section (1949)			Cross-Section (1959)		
Oil-abundant	0.27	0.34	0.35	0.17	0.21	0.21
	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
Observations	759	510	502	774	517	509
	Panel (1949-1989)			Panel (1959-1989)		
Oil-abundant x 1959	-0.08	-0.11	-0.14			
	(0.01)	(0.01)	(0.01)			
Oil-abundant x 1969	-0.18	-0.23	-0.25	-0.10	-0.12	-0.13
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Oil-abundant x 1979	-0.15	-0.19	-0.20	-0.06	-0.07	-0.07
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
Oil-abundant x 1989	-0.21	-0.28	-0.29	-0.12	-0.16	-0.16
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
1959	0.65	0.69	0.70			
	(0.01)	(0.01)	(0.01)			
1969	1.27	1.33	1.34	0.60	0.63	0.63
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
1979	2.15	2.19	2.20	1.57	1.59	1.58
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
1989	2.64	2.71	2.71	2.14	2.17	2.17
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
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 regression include county fixed effects and time effects. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table A1. Effect of Oil Abundance on Ln(Population)

	(1)	(2)	(3)
		A. Cross-Section of Counties (1940)	
Oil-abundant	0.13	0.09	0.06
	(0.08)	(0.09)	(0.09)
Observations	774	516	508
		B. Panel of Counties (1940-1990)	
Oil-abundant x 1950	0.11	0.12	0.10
	(0.02)	(0.02)	(0.03)
Oil-abundant x 1960	0.21	0.24	0.21
	(0.04)	(0.04)	(0.05)
Oil-abundant x 1970	0.19	0.21	0.21
	(0.05)	(0.05)	(0.05)
Oil-abundant x 1980	0.23	0.24	0.28
	(0.05)	(0.05)	(0.06)
Oil-abundant x 1990	0.24	0.25	0.30
	(0.06)	(0.06)	(0.06)
1950	-0.05	-0.06	-0.04
	(0.01)	(0.01)	(0.01)
1960	-0.09	-0.12	-0.10
	(0.02)	(0.02)	(0.02)
1970	-0.09	-0.11	-0.10
	(0.02)	(0.02)	(0.02)
1980	0.03	0.02	0.00
	(0.02)	(0.03)	(0.03)
1990	0.05	0.04	0.00
	(0.29)	(0.34)	(0.32)
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 county fixed effects and time effects. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table A2. Effect of Oil Abundance on Employment, by Sector

	Mining			Manufacturing			Agriculture		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
					A. Cross-Section of Counties (1940)				
Oil-abundant	5.1	4.9	4.8	-0.8	-0.7	0.4	-9.3	-7.1	-6.4
	(0.6)	(0.6)	(0.6)	(0.5)	(0.5)	(0.5)	(1.6)	(1.6)	(1.6)
Intercept	0.1	1.0		9.2	8.3		51.7	41.1	
	(0.3)	(0.4)		(0.5)	(0.7)		(1.3)	(1.8)	
Observations	774	774	774	774	774	774	770	770	770
					B. Panel of Counties (1940-1990)				
Oil-abundant x 1950	1.9	1.9	1.6	-1.6	-1.6	-1.0	-1.2	-1.4	-1.0
	(0.4)	(0.4)	(0.3)	(0.3)	(0.3)	(0.3)	(0.6)	(0.6)	(0.6)
Oil-abundant x 1960	0.6	0.7	0.3	-3.1	-3.0	-1.4	4.8	4.6	2.4
	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.5)	(1.0)	(0.9)	(1.0)
Oil-abundant x 1970	0.1	0.1	-0.1	-5.0	-4.8	-2.0	8.1	7.6	3.7
	(0.4)	(0.4)	(0.4)	(0.6)	(0.6)	(0.6)	(1.2)	(1.2)	(1.2)
Oil-abundant x 1980	0.8	0.8	0.1	-3.4	-3.2	-1.4	8.4	7.1	4.1
	(0.5)	(0.5)	(0.5)	(0.6)	(0.6)	(0.6)	(1.3)	(1.2)	(1.3)
Oil-abundant x 1990	-0.8	-0.8	-1.2	-3.8	-3.4	-1.3	8.5	6.4	3.8
	(0.5)	(0.5)	(0.5)	(0.6)	(0.6)	(0.6)	(1.3)	(1.3)	(1.3)
1950	0.7	0.7		5.5	5.4		-13.0	-12.4	
	(0.2)	(0.2)		(0.3)	(0.3)		(0.5)	(0.5)	
1960	1.1	1.2		10.0	9.9		-32.6	-31.9	
	(0.2)	(0.2)		(0.5)	(0.5)		(0.9)	(0.9)	
1970	1.1	1.1		16.4	16.1		-43.6	-41.8	
	(0.2)	(0.2)		(0.7)	(0.7)		(1.1)	(1.1)	
1980	2.3	2.4		13.4	13.1		-47.0	-45.1	
	(0.3)	(0.3)		(0.7)	(0.7)		(1.2)	(1.2)	
1990	1.3	1.3		11.2	10.9		-47.7	-46.2	
	(0.2)	(0.3)		(0.7)	(0.7)		(1.2)	(1.2)	
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 county fixed effects and time effects. Robust standard errors are in parentheses; standard errors are clustered by county in the panel regressions.

Table A3. Effect of Oil Abundance and Right-to-Work Laws on Industrialization

	(1)	(2)	(3)	(1)	(2)	(3)
Oil-abundant x 1950				-0.8	-0.7	-1.0
				(0.5)	(0.5)	(0.5)
Oil-abundant x 1960				-3.3	-3.2	-1.6
				(0.6)	(0.6)	(0.7)
Oil-abundant x 1970				-4.9	-4.7	-2.3
				(0.9)	(0.9)	(0.9)
Oil-abundant x 1980				-2.9	-2.7	-1.8
				(1.0)	(1.0)	(1.1)
Oil-abundant x 1990				-3.6	-3.2	-2.9
				(1.0)	(1.0)	(1.0)
Pro-business x 1950	0.6	0.3	4.3	0.7	0.4	4.4
	(0.4)	(0.4)	(0.7)	(0.5)	(0.5)	(0.7)
Pro-business x 1960	-0.2	-0.3	9.2	-0.4	-0.4	9.3
	(0.3)	(0.3)	(2.3)	(0.4)	(0.4)	(2.3)
Pro-business x 1970	0.8	0.8	5.8	0.7	0.8	6.0
	(0.5)	(0.5)	(1.4)	(0.6)	(0.6)	(1.4)
Pro-business x 1980	0.2	0.1	16.6	0.3	0.2	16.7
	(0.6)	(0.6)	(6.8)	(0.6)	(0.6)	(6.8)
Pro-business x 1990	0.4	0.3	15.1	0.4	0.3	15.2
	(0.6)	(0.6)	(8.0)	(0.6)	(0.7)	(8.0)
Oil-abundant x Pro-business x 1950				-1.5	-1.5	-0.1
				(0.8)	(0.8)	(0.8)
Oil-abundant x Pro-business x 1960				0.3	0.2	0.4
				(0.7)	(0.7)	(0.8)
Oil-abundant x Pro-business x 1970				-0.2	-0.2	0.5
				(1.0)	(1.0)	(1.0)
Oil-abundant x Pro-business x 1980				-0.6	-0.6	0.5
				(1.1)	(1.1)	(1.2)
Oil-abundant x Pro-business x 1990				-0.3	-0.2	1.9
				(1.1)	(1.1)	(1.2)
Observations	4,649	4,644	4,644	4,649	4,644	4,644

NOTES. The dependent variable is the percentage of the labor force employed in manufacturing. "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 A4. Effect of Oil Abundance on the Stock of Educated Workers

	(1)	(2)	(3)
		A. Cross-Section of Counties (1940)	
Oil-abundant	4.3	3.7	2.5
	(0.6)	(0.6)	(0.6)
Intercept	11.7	14.7	
	(0.4)	(0.6)	
Observations	774	774	774
		B. Panel of Counties (1940-1990)	
Oil-abundant x 1950	-0.3	-0.2	0.3
	(0.4)	(0.4)	(0.4)
Oil-abundant x 1960	0.1	0.2	-0.1
	(0.4)	(0.4)	(0.4)
Oil-abundant x 1970	-1.7	-1.3	-0.4
	(0.6)	(0.6)	(0.5)
Oil-abundant x 1980	-3.1	-2.3	-1.5
	(0.7)	(0.6)	(0.6)
Oil-abundant x 1990	-3.4	-1.8	-2.0
	(0.7)	(0.6)	(0.6)
1950	2.2	1.8	
	(0.3)	(0.3)	
1960	10.4	9.7	
	(0.3)	(0.3)	
1970	18.8	17.4	
	(0.5)	(0.5)	
1980	34.2	32.7	
	(0.5)	(0.5)	
1990	46.8	45.7	
	(0.5)	(0.5)	
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 county fixed effects and time effects. 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)
	Cross-Section (1949)			Cross-Section (1959)		
Oil-abundant	0.35	0.26	0.17	0.23	0.17	0.11
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
Observations	759	758	758	774	773	773
	Panel (1949-1989)			Panel (1959-1989)		
Oil-abundant x 1959	-0.10	-0.09	-0.02			
	(0.01)	(0.01)	(0.01)			
Oil-abundant x 1969	-0.22	-0.19	-0.09	-0.12	-0.11	-0.06
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Oil-abundant x 1979	-0.21	-0.16	-0.07	-0.10	-0.08	-0.04
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Oil-abundant x 1989	-0.26	-0.19	-0.10	-0.17	-0.12	-0.07
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
1959	0.74	0.73				
	(0.01)	(0.01)				
1969	1.48	1.43		0.70	0.68	
	(0.02)	(0.02)		(0.01)	(0.01)	
1979	2.43	2.39		1.75	1.72	
	(0.02)	(0.02)		(0.01)	(0.01)	
1989	2.90	2.86		2.31	2.30	
	(0.02)	(0.02)		(0.01)	(0.01)	
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 A6. Effect of Variations in Oil Abundance

	Percent employment			Percent Educated Workers	Ln(Median Family Income)	Ln(Per Capita Income)
	Mining	Manufacturing	Agriculture			
	Cross-Section (base year)					
Ln(oil endowment)	3.68	0.72	-7.29	2.75	0.17	0.14
	(0.61)	(0.30)	(1.13)	(0.55)	(0.02)	(0.02)
Observations	171	171	171	171	166	171
	Panel (base year and end year only)					
Ln(oil endowment) x (end year)	-1.75	-0.60	5.96	-0.62	-0.10	-0.08
	(0.46)	(0.39)	(1.07)	(0.73)	(0.02)	(0.01)
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.

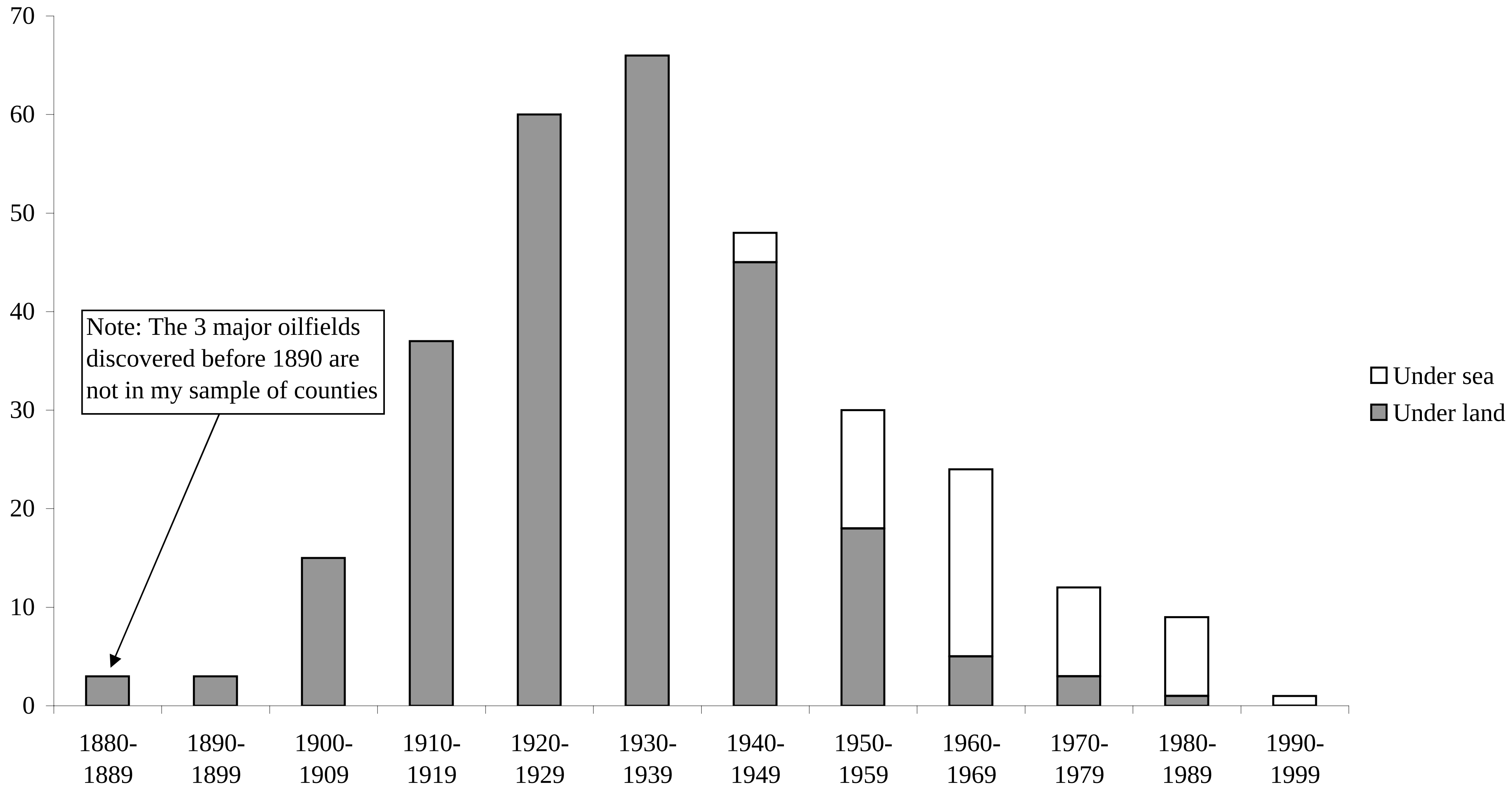

Figure 1. Number of new major US oilfields discovered, by decade

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

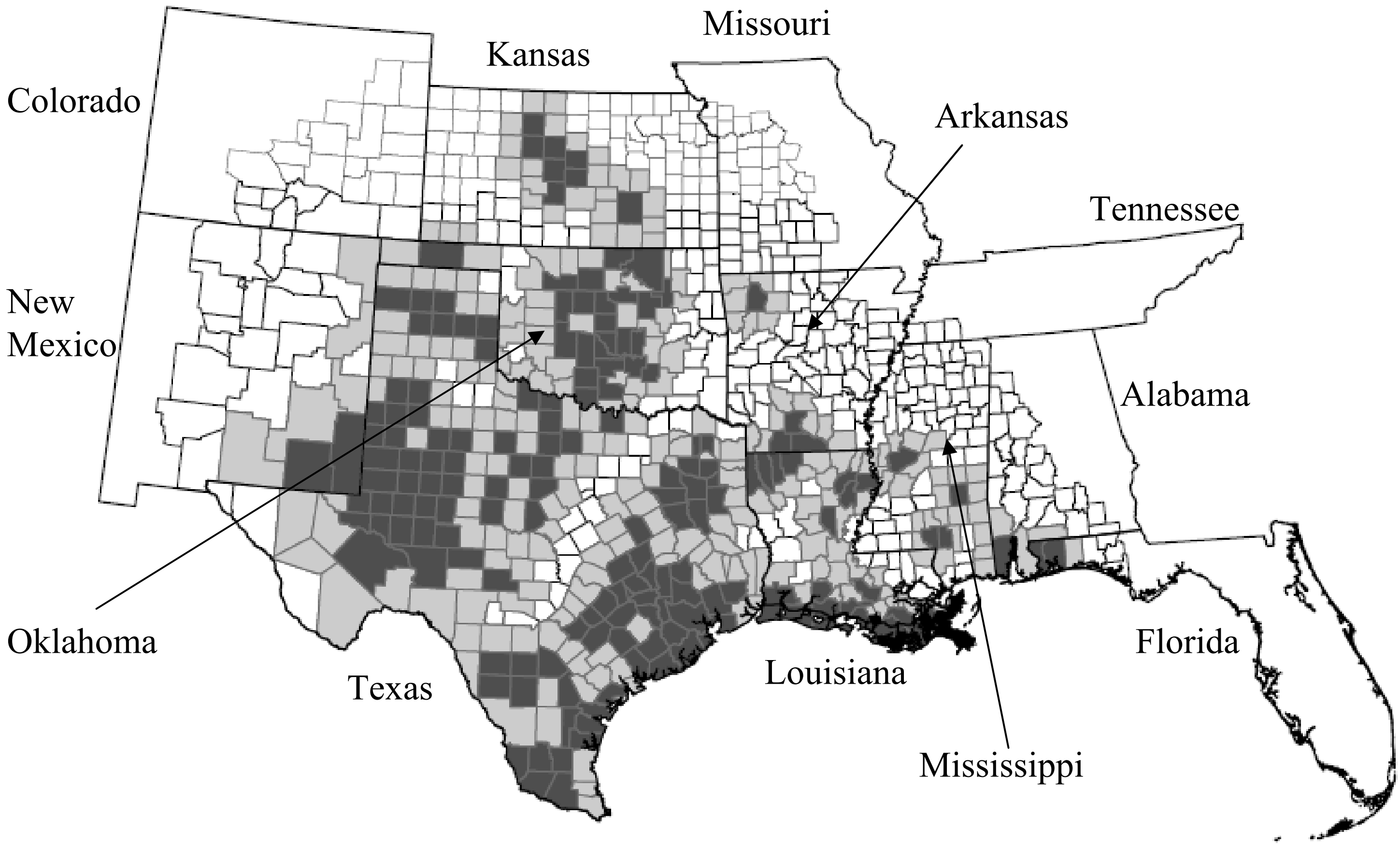

Figure 2. Oil-abundant counties (dark grey), adjacent counties (light grey) and other nearby counties (white)
Note: state borders are in black

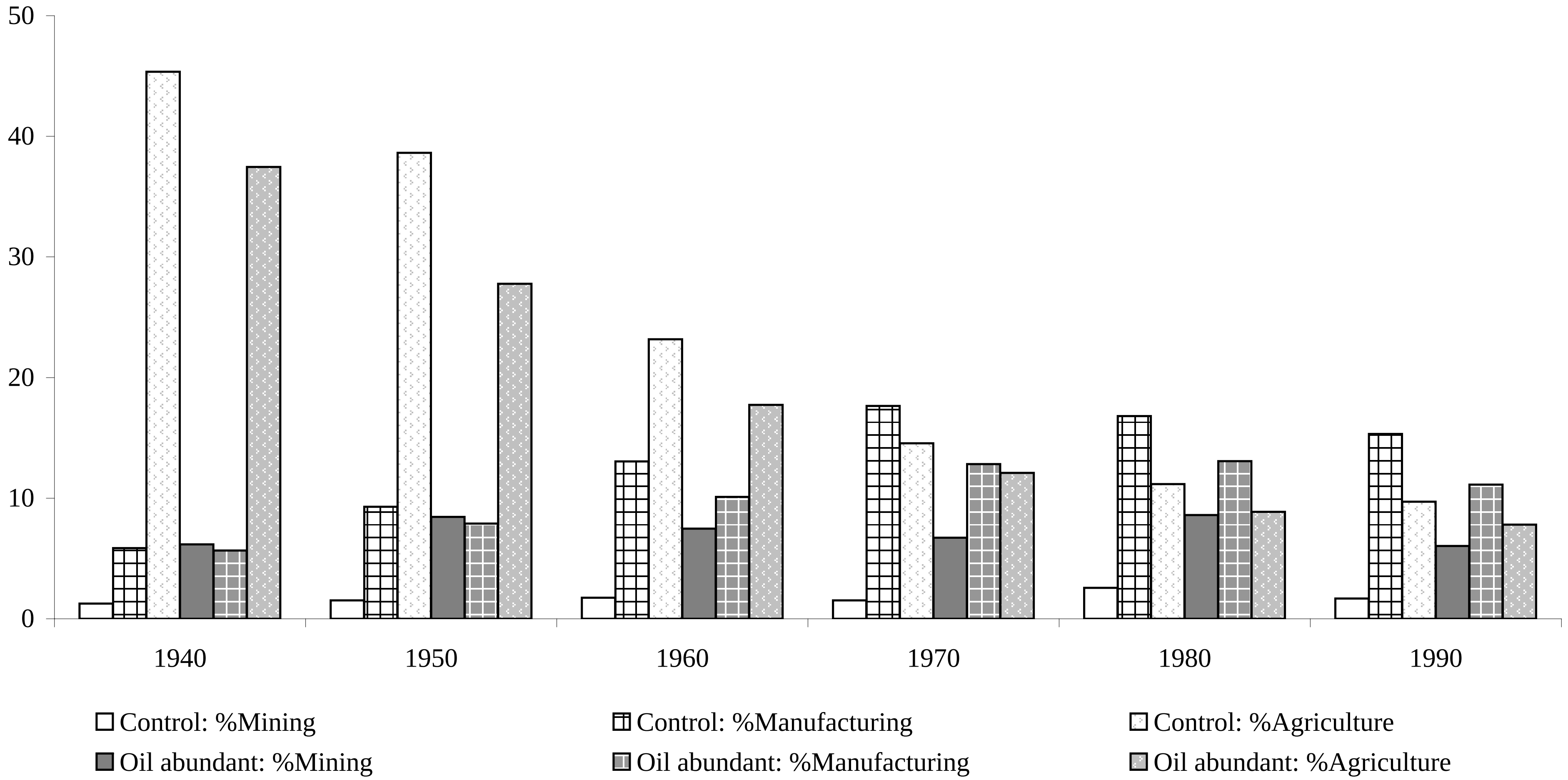

Figure 3. Employment as percentage of labor force in oil-abundant and control counties: 1940-1990

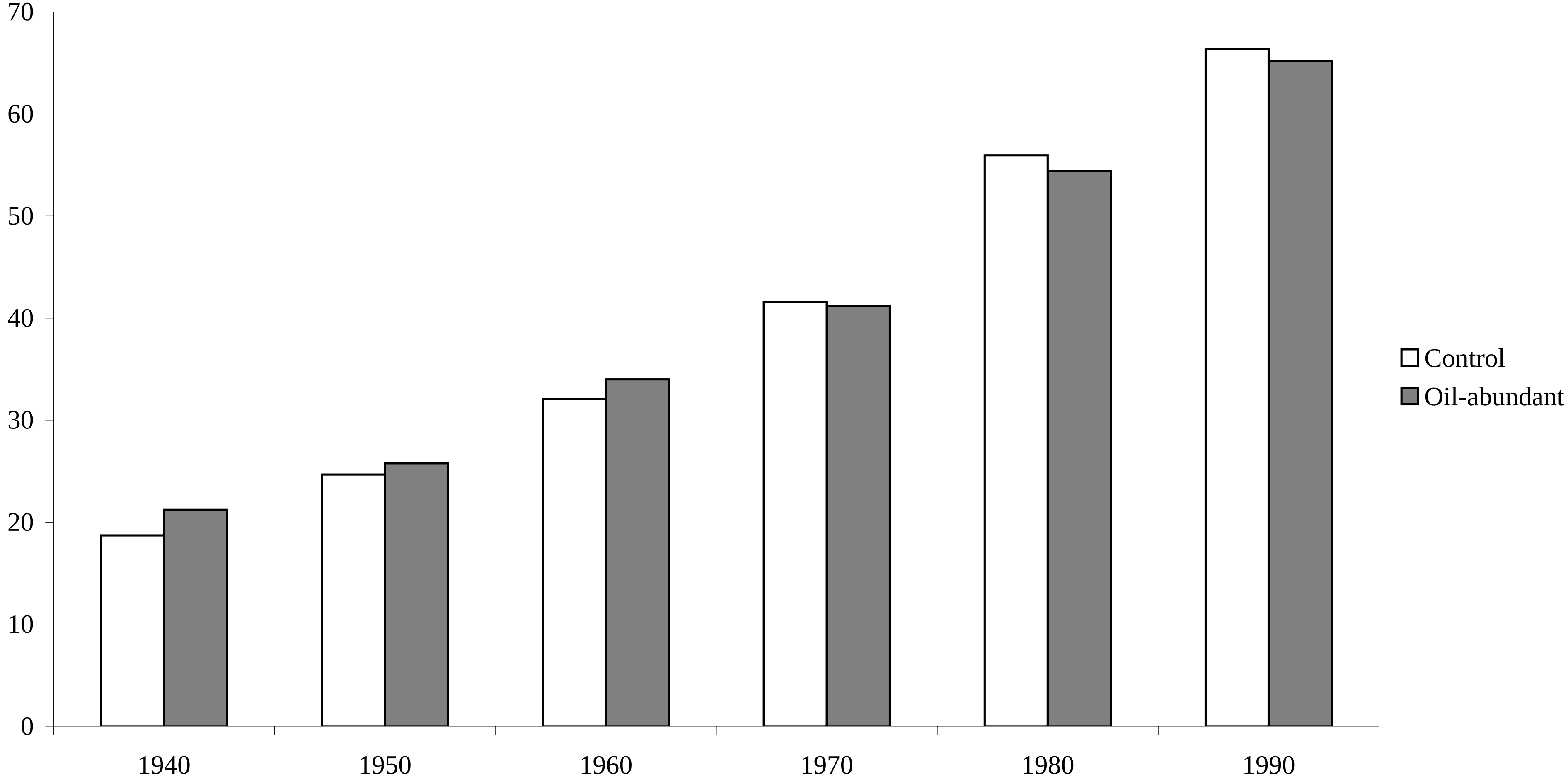

Figure 4. Percent with high school education or more, among people aged 25+: 1940-1990

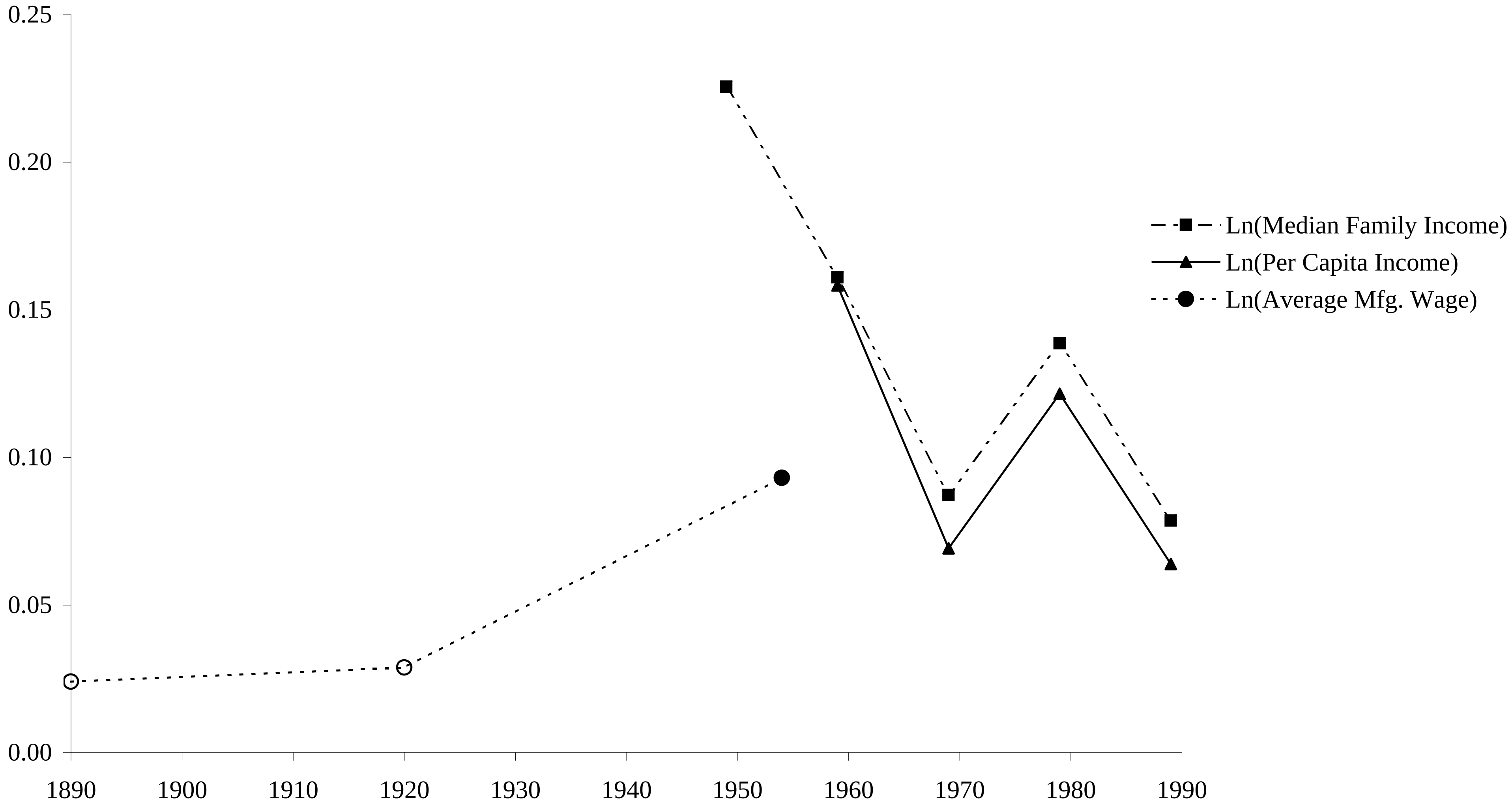

Figure 5. Differences in ln(income) between oil-abundant and control counties: 1890-1989

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

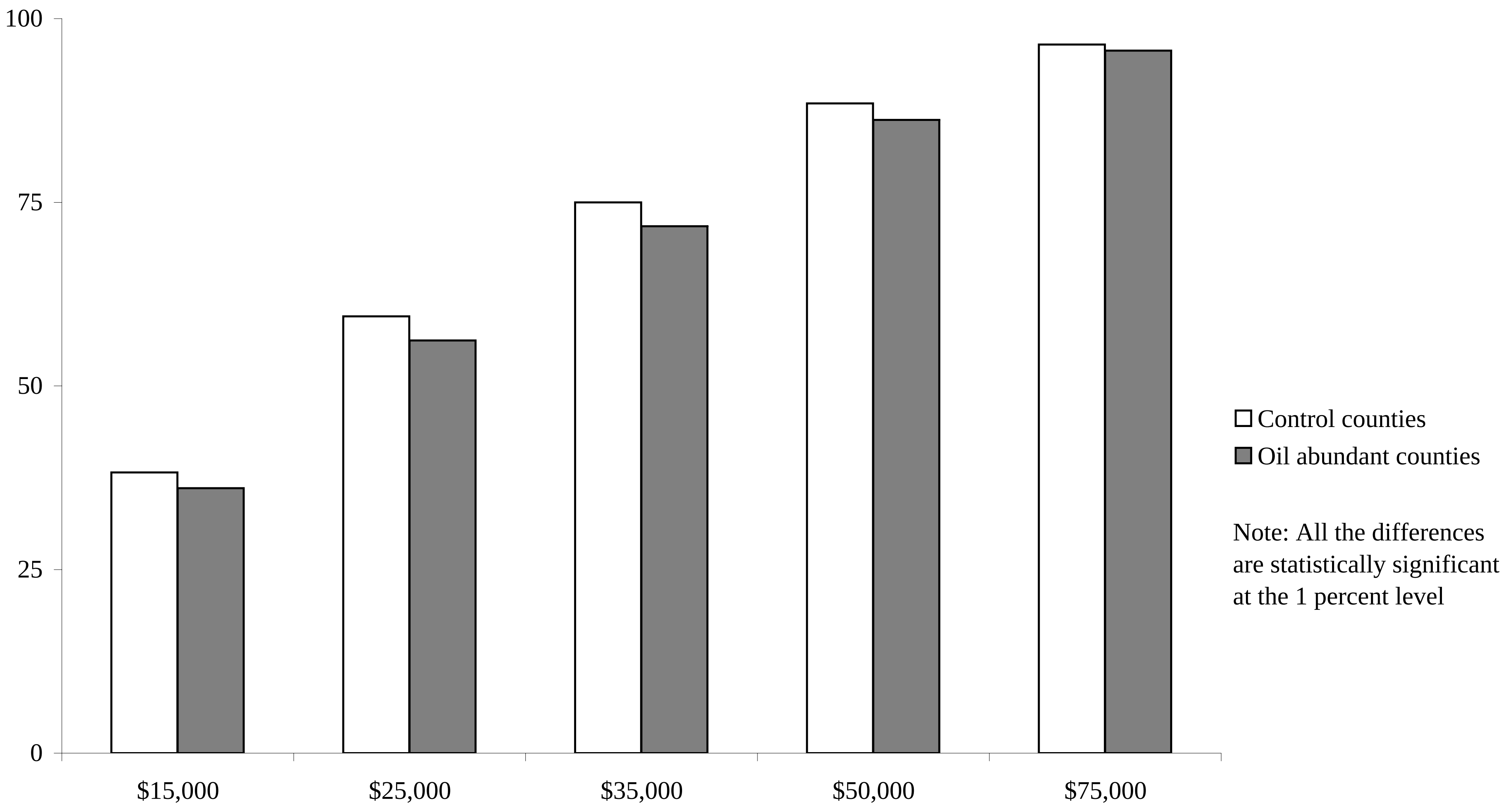

Figure 6. Percent of families below different income levels ($1989)

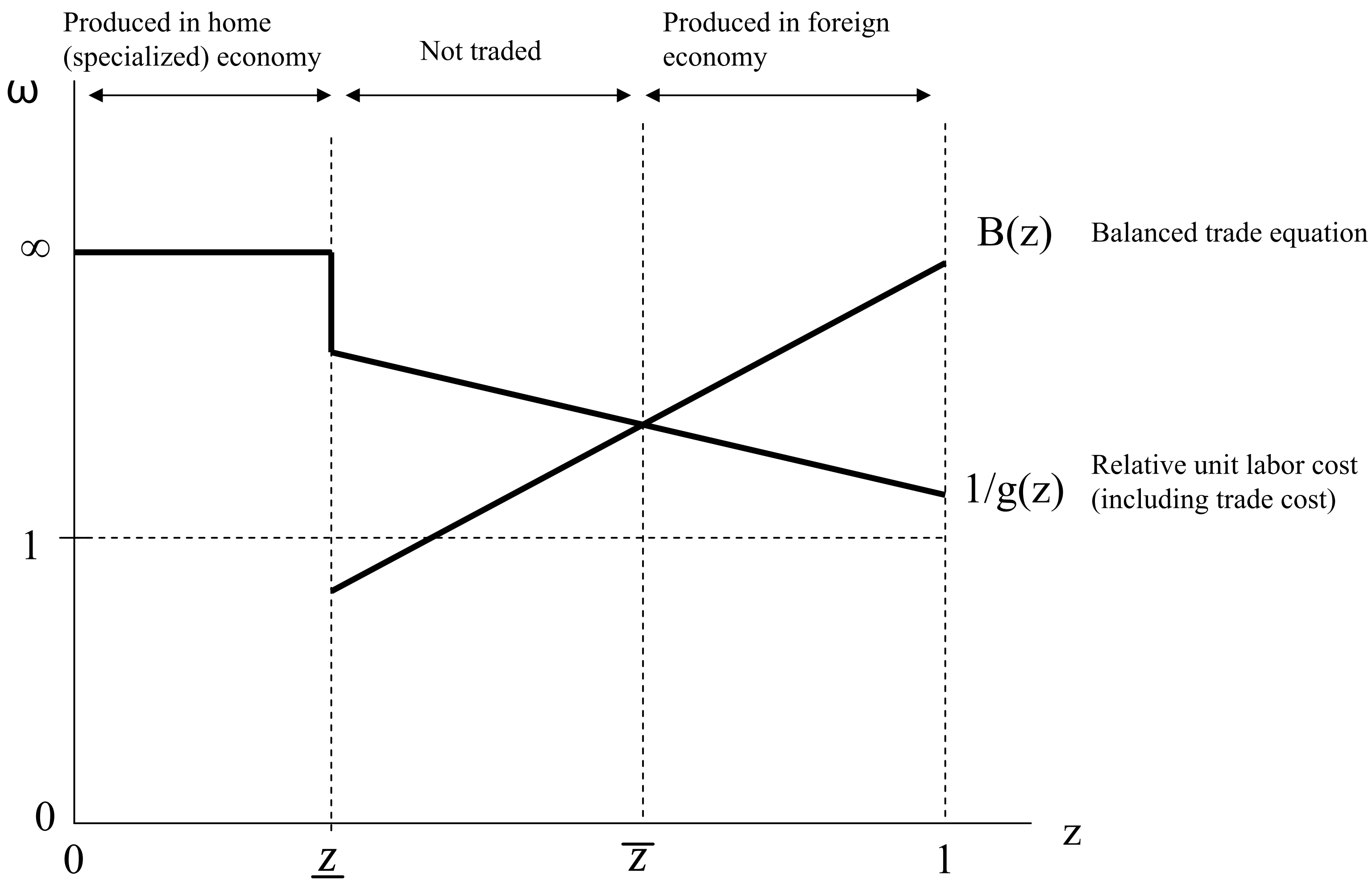

Figure 7. Open economy equilibrium