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The Long-Term Consequences of Regional Specialization

Guy Michaels

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Abstract

What are the consequences of resource-based regional specialization, when it persists over a long period of time? While much of the literature argues that specialization is beneficial, recent work suggests it may be costly in the long run, due to economic or political reasons. I examine this question empirically, using exogenous geological variation in the location of subsurface oil in the Southern United States. I find that oil abundant counties are highly specialized: for many decades their mining sector was almost as large as their entire manufacturing sector. During the 1940s and 1950s, oil abundant counties enjoyed per capita income that was 20-30 percent higher than other nearby counties, and their workforce was better educated. But whereas in 1940 oil production crowded out agriculture, over the next 50 years it caused the oil abundant counties to develop a smaller manufacturing sector. This led to slower accumulation of human capital in the oil abundant counties, and to a narrowing of per capita income differentials to about 5 percentage points. Despite this caveat, the gains from specialization were large, and specialization had little impact on the fraction of total income spent by local government or on income inequality.

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Data: Oil and Gas Journal Data Book; Oil and Gas Field Code Master List; National Atlas Database; US Census Micro Data from Integrated Public Use Microdata Series (IPUMS); County Data Books: county-level data; Distance to rivers and oceans: Rappaport and Sachs (2003); States with right to work laws: Lumsden and Petersen (1975), Holmes (1998).
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Guy Michaels is a Research Associate with the Labour Markets Programme at the Centre for Economic Performance, London School of Economics. Email: g.michaels@lse.ac.uk

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1 Introduction

Regional specialization is a widespread phenomenon (Krugman 1991; Kim 1995; Ellison and Glaeser 1999; and Fujita, Krugman and Venables 1999), and in many cases a single industry has accounted for a large share of regional employment over many decades. Examples of specialization are numerous: steel manufacture in Pennsylvania, wine production in areas of France, and coffee growing in parts of Central Africa. Yet despite the prevalence of regional specialization, we have relatively little evidence about its long-term consequences.

In this paper I analyze the consequences of specialization in oil production in parts of the Southern US from 1940-1990. The growth of the South over the 20th century is of inherent interest (e.g Wright 1986 and Caselli and Coleman 2001), and this paper sheds light on the role of oil abundance in this process. Moreover, this setting allows us to examine specialization brought about by resource abundance, which is a common phenomenon in developing economies.

Regional specialization allows economies to benefit from their resource endowments, according to both neoclassical and new models of trade. However, much research suggests that specialization, which relies on natural resources, may have adverse consequences (e.g. Corden and Neary 1982). Taking a long-run perspective, Matsuyama (1992) analyzes an open-economy, two-sector model, where better farmland leads an economy to specialize in agriculture, diverting labor from manufacturing and slowing down learning-by-doing and growth.[1]

In addition to these purely economic channels, recent work argues that resource abundance may also affect growth adversely through political economy processes. For example, resource abundance may make institutions worse by inducing severe inequality (Engerman and Sokoloff 1997), incentives for increased spending (Tornell and Lane 1999), or power struggles (Caselli 2006).

[1] A different mechanism through which factor endowments can affect human capital accumulation is discussed in Schott (1998) and Leamer et al. (1999).

In absence of a clear theoretical prediction regarding the net effect of regional specialization in the long run, this question has been examined empirically. For example, Wright (1990) finds that the US leveraged its natural resources intensively during a period of rapid growth from 1880-1920. But Sachs and Warner (2001) find evidence that countries exporting natural resources experienced significantly lower growth rates in recent decades. Moreover, cross-country evidence, although suggestive, typically suffers from omitted variables and measurement error problems, so it do not likely identify the causal effects of resource-driven specialization.

In order to estimate the consequences of regional specialization, we would like to compare a set of economies that specialize in a particular goods due to comparative advantage, to economies that are similar in other respects. Much of the empirical analysis of specialization uses variation across countries and over time (e.g. Imbs and Wacziarg 2003). To better control for confounding factors, recent work examines the effect of demand shocks on specialized regions within a country (e.g. Black, McKinnish, and Sanders 2005; Buckley 2003; and Angrist and Kugler 2005). My work builds on this line of research, but I examine long-term outcomes, rather than short-run effects of changes in demand. Moreover, I use a new source of exogenous variation: the location of geologically defined oilfields.[2]

The geological data I use shows how much oil was taken out of large US oilfields by 1999, and how much oil had not yet been extracted at that time. The hazard rate of discovery of major inland oilfields in the US has declined in recent decades and it is now very low, so we can reasonably assume that we have a close approximation to the exogenous natural variation in oil endowment.

In order to analyze the effects of oil abundance I use county-level data, derived mostly from US Census data, which spans many decades. To ensure that the control counties are similar to the oil abundant counties in other respects, I focus on a region in the South, which includes more than two-thirds of the oil abundant counties in the US. At the same

[2] The location of natural gas is correlated with the location of oil, and an oil field may produce substantial amounts of gas. Throughout the paper "oil" stands for both oil and natural gas.

time, counties adjacent to oil abundant ones may be affected directly by oil (e.g. through commuting), and the empirical analysis is robust to excluding them from the sample. Another advantage of this setting is that the extent of institutional variation in the region is low compared to cross-country settings, so it is less likely that resource endowments are spuriously correlated with variations in institutional quality. Reassuringly, I find that the control counties were similar to the oil abundant counties in terms of industrialization and manufacturing wages in 1890, before the discovery of major oilfields in this region.

The county-level data provide a rich source of potential outcomes, so to guide my empirical investigation I develop a neoclassical model of regional specialization. This model differs from most of the existing literature in two important ways. First, I analyze specialization in a good that is not inherently "worse" than other goods, so this analysis is applicable to a wide range of products. Second, the model does not rely on endogenous institutional change or on learning by doing, so it can be applied to different regions of developed economies with strong institutions and costless transfer of technology.

The model considers two economies, which differ only in their cost of producing a certain specialized tradable good, such as oil. One economy, which has an advantage in producing that good, initially trades it in exchange for a bundle of traditional goods (e.g. agricultural goods). Over time, technological change introduces new goods (e.g. manufacturing goods), and I assume that human capital is more productive in those goods more than in the traditional goods. I also assume that the demand share of the specialized good remains constant, reflecting an ongoing importance of the specialized good, and that the new goods may be produced using the same technology in both economies. In this setting, production of new goods takes place disproportionately more in the non-specialized economy. If workers endogenously invest in human capital, the specialized economy may accumulate human capital more slowly and grow at a slower rate.

Taking the predictions of the model to the data, I find that 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.[3] 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 people were employed in service and manufacturing industries related to oil extraction.

Since oil is a skill-intensive commodity, and in 1940 the region I consider was largely agricultural, the oil abundant counties had similar employment share of manufacturing and a higher stock of educated workers in 1940. I find that oil-abundance had a large effect on income in 1949, raising median family income by about 30 percentage points.[4]

Considering the effect of oil-abundance on industry structure, I find that from 1940-1990 oil production gradually crowded out manufacturing, rather than agriculture, thereby slowing down the process of industrialization. To further understand the impact of oil abundance on industrialization, I examine the differential effect of right-to-work laws on oil-abundant counties. Consistent with Holmes (1998), I find that right-to-work laws increased the employment share of manufacturing in most counties; however, I find some evidence that in oil-abundant counties, right-to-work laws had no significant effect on the employment share of manufacturing.

As the oil abundant counties developed relatively smaller manufacturing and service sectors, they also accumulated human capital more slowly. On average, the fraction of people who had (at least) graduated from high-school increased at a rate that was about 0.8-1 percentage points lower per decade from 1940-1990. In fact, there is some evidence that in 1990 the oil abundant counties had a lower share of people with high-school education or more. The reversal in human capital accumulation is interesting, since it differs from a simple convergence result. This finding is also interesting in light of the high skill intensity

[3] Throughout this paper I use mining as the set of industries that includes extraction of oil and gas. In the region I analyze oil and gas extraction are the primary mining industry.

[4] Data on median family income are available since 1949; data on income per capita, which are available from 1959, give a results that are very similar to the results using median family income. I also find that oil abundance led to an increase in population. Michaels and Redding (2006) discuss in detail the effects of oil abundance on the growth rates of cities of different sizes.

of the oil sector itself, and the fact that the oil abundant counties had higher per capita public expenditure (overall and on education), reflecting their higher per capita income.

Importantly, I also find that the oil abundant counties grew at a slower rate from 1940-1990, and by 1990 their per capita income was only about 5-6 percentage points higher than the other counties in their region. I show that this result is not driven entirely by convergence; rather, it is due at least in part, to the effects of oil on industry composition and human capital accumulation. But despite the relative decline of the oil abundant counties there is no evidence of adverse effects of oil abundance on income inequality. In fact, in 1990 the distribution of family income in the oil abundant counties first-order stochastically dominates that of the control counties.

My main findings on the effects of oil-abundance are statisically significant, even after controlling for geographic and demographic covariates and state-year interactions. I find further support for these results using an orthogonal source of variation in the extent of specialization in the production of oil: a comparison of oil abundant counties with different levels of oil endowment reveals that oil initially crowds out agriculture, and that the most oil abundant counties are initially better educated and richer; over time, these differences decreased significantly.

Taken together, the evidence in this paper indicates that the long-term consequences of regional specialization in oil production were generally favorable. The oil abundant counties enjoyed higher per capita income than the control counties for many decades. Moreover, there is no indication of adverse effects on the income distribution, or of disproportional public spending. However, this paper also suggests that specialization in oil slowed industrialization and human capital accumulation.

The remainder of the paper is organized as follows. Section 2 presents a model of the long term effects of regional specialization. Section 3 discusses the data and the samples I use. Section 4 presents an empirical analysis using data from an oil-producing region in the Southern US, and Section 5 concludes.

2 A Model of Regional Specialization

In order to frame the empirical analysis of the effects of regional specialization, this section presents a simple theoretical framework, based on Dornbusch, Fischer, and Samuelson (1977). Previous work (Matsuyama 1992) finds that specialization in goods that generate no learning-by-doing can have long term costs. I show that there are interesting long-term implications for specialization even when the specialized good is in no sense "worse" than other goods, and when technology transfers are costless. 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, so it specializes in their production. Initially, the specialized goods crowd out traditional goods, but over time exogenous skill-biased technological change introduces new goods, which are more skill-intensive. Production of these new goods takes place disproportionately less in the economy that produces the specialized good, affecting its endoegnous 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 (e.g. oil), 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 $h > 1$.[5] 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

[5] 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).

require that the skill-intensity in the production of the specialized good is similar to that of the other goods.

When considering the cost of investment in education, I assume that it is proportional to the wage rate and convex in the level of investment, so:

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

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.[6]

Having discussed the conditions in the home economy, we can consider another ("foreign") economy, which I shall denoted 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 have identical Cobb-Douglas preferences, so income effects play no role in determining the patterns of trade:

$$U = \int_0^1 b(z) \ln d(z) dz, \tag{2}$$

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

$$\int_0^1 b(z) dz = 1. \tag{3}$$

I assume that a constant share of total income, $B = \int_0^{\underline{z}} b(z)dz$, is spent on the specialized

[6]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.

good, and the remainder of the income is spent on the other types of goods.[7] 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 main predictions.

2.1 Open Economy 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:

$$\omega \equiv \frac{w}{w^*} = \frac{1}{g(\overline{z})}. \tag{4}$$

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:

$$wLS \int_{\overline{z}}^{1} b(z)\, dz = w^* L^* S^* \int_{0}^{\underline{z}} b(z)\, dz \Leftrightarrow \omega \left(\frac{L^* S^*}{BLS} \right) = 1 / \int_{\overline{z}}^{1} b(z)\, dz, \tag{5}$$

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 economy is:

$$P^* = \frac{x_2}{x_2 + (1 - B - x_2)\, h}, \tag{6}$$

[7] 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.

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

$$P_s = \frac{B\left(wLS + w^*L^*S^*\right)h}{B\left(wLS + w^*L^*S^*\right)h + \left(\left(1-B\right)wLS - Bw^*L^*S^*\right)\left(x_2 + \left(1 - B - x_2\right)h\right)h_s} \tag{7}$$

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:

$$\overline{e}^* = P^*h + (1 - P^*) \tag{8}$$

and:

$$\overline{e} = P_s h_s + (1 - P_s)\,\overline{e}^*. \tag{9}$$

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

$$S^* = \left(\overline{e}^*\right)^2 \tag{10}$$

and

$$S = \left(\overline{e}\right)^2 \tag{11}$$

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 1 provides a graphic representation of this equilibrium.

We can now use the model to derive a 4 predictions regarding the differences between the two economies, as new goods replace traditional goods.

Claim 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 4 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. ■

Claim 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. ■

Claim 3 *The foreign economy accumulates education faster than the home economy as new goods fully replace traditional goods.*[8]

Proof. When there are no new goods: $(\overline{e}^* - \overline{e})|_{x_2=0} = -P_s|_{x_2=0}(h_s - 1) \leq 0$, and when there are no traditional goods $(\overline{e}^* - \overline{e})|_{x_2=1-B} = P_s|_{x_2=1-B}(h - h_s) \geq 0$. 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. ■

Claim 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, $S^*|_{x_2=0} \leq S|_{x_2=0}$ and $S^*|_{x_2=1-B} \geq S|_{x_2=1-B}$, and at least one of the inequalities is strict. Therefore, as the new goods replace

[8] 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.

the traditional goods, S^*/S increases. Using equations 4 and 5 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. ■

Before moving to the the empirical analysis of these predictions, we may consider some of the simplifying assumptions of the model. First, the model 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.[9] 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 at length in Michaels and Redding (2006).

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.

[9] A similar set up is discussed in Michaels (2006).

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. In the next sections I examine the effect of oil abundance on education spending.

Given these potential concerns, it is important to test the model's predictions empirically. In order to test these predictions we require data on a set of economies that are similar, except for a specific source of comparative advantage, which causes some of them to specialize in a particular set of goods over a long period of time. The next section explains how I construct such a data set, using geological variation in the location of subsurface oil in the Southern United States, which causes certain counties to specialize in the extraction of oil.

3 Data and Samples

This section explains the construction of the data set, which I use to examine the effects of regional specialization. The Oil and Gas Journal Data Book 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 the oilfield at that time. Major oilfields were first discovered in the US South after 1890 (see Figure 2). 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 was under sea. The oilfield data is therefore a good approximation of the exogenous oil endowment of the different counties.

In order to determine the location of the oilfields I use the Using 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, 150 counties (about two-thirds) are in three adjacent states in the Southern US: Texas (107 counties), Oklahoma (24 counties), and Louisiana (19 counties). Moreover, unlike other oil abundant states (Alaska and California) the 3 states I consider are divided into counties in a fairly regular way, affording a good set treatment and control regions. In order to focus the analysis on counties that are similar in terms of economic opportunities and institutions, other than the availability of oil, I use the Geographic Information System to restrict my sample to counties that are within 200 miles of the oil abundant counties in Texas, Oklahoma, and Louisiana. This leaves a sample of 775 counties, 171 of which are oil abundant (see map in Figure 3).[10]

In the baseline specification, I use all the nearby counties as controls for the oil abundant counties. But in some specifications I use only counties that are nonadjacent as an alternative control group. This creates a larger difference in terms the comparative advantage in oil production for a number of reasons. First, workers in non-adjacent counties are less likely to commute to work in the oil abundant counties. Second, adjacent counties are perhaps more likely to have smaller oilfields, which are not identified in my data. Interestingly, in 1940 the employment share of the mining sector is similar in both adjacent and non-adjacent counties. However, by 1990 these shares diverge, as mining takes up 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 very little oil refining took place in the non-adjacent counties.[11] 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 differences, and find that the non-adjacent counties are plausible controls.

[10] 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.

[11] 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.

Another potential concern is that oil revenues may affect economic outcomes at the state level. For this reason, the next sections also present specifications that contrast the oil 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 non-oil states. 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 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 to obtain county-level data on land, population, industrial composition of employment, education, expenditure on education, and income, for 1940-1990.[12] Micro data from the 1980 census data are used to shed more light on the effect of oil-abundance on education; however, this data is 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 that are not oil abundant, where transition from agriculture to manufacturing is predicted to have taken place more rapidly.

The dataset that I construct has several advantages for examining the consequences of regional specialization. First, it provides a new exogenous source of variation that can lead to specialization. This approach improves over cross-country comparisons (e.g. Sachs and Werner 2001), that use the fraction of raw materials in exports, since total exports may depend on technology and human capital endowment. Second, 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

[12]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.

compensation was about 0.7 percent in 1948 and about 0.6 percent in 1987[13], and it was a major source of income in the counties I analyze. Third, the availability of consistent data over an extended period of time allows me to examine the transition from traditional goods, such as agriculture, to more skill-intensive goods (e.g. manufacturing). Fourth, the data affords a large set of control economies, that are similar in terms of their economy and technology, except for their oil-abundance. Finally, the region I analyze has fairly homogeneous set of institutions, so any spurious correlation between resource abundance and institutions is much less of a concern than in the case of international comparisons. Of course, it is still possible that oil abundance leads to poor economic performance by raising inequality or disproportinal or distorted spending. In the next section I examine whether there is evidence for such effects, in addition to testing the predictions of the model.

4 Empirical Analysis: Specialization in Oil Production

4.1 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 2). 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). Nevertheless, I examine whether economic outcomes were correlated with oil abundance as a specification check. Reassuringly, I find that oil abundance is uncorrelated with the percentage of manufacturing employees in the total population and with log average wage income of manufacturing workers.[14]

In 1940 the region I analyze was still mostly agricultural (Table 1), and mining was more skill intensive than agriculture.[15] Oil-abundance had a large impact on the local economy: in

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

[14] 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.

[15] 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

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.[16]

The model predicts that under these circumstances, oil-abundance raises per capita income. Table 1 shows that in 1949, the first year for which county-level income data are available, the median family income in oil abundant counties was about 28 percent higher than in the other sample counties. In 1959, the first year for which I have data on per capita income, the oil counties had an average per capita income that was about 17 percent higher than the other counties. Regressions using the alternative specifications in Table 1 also show that the oil abundant counties had significantly higher income around the middle of the 20th century.

4.2 Specialization and Industrialization

In the decades following 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).

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

$$Y_c = \alpha d_c + \varepsilon_c, \tag{12}$$

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

from the Integrated Public Use Microdata Series - IPUMS).

[16] Employment in mining includes the extraction of natural resources other than oil and gas.

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:

$$Y_{ct} = \phi_c + \psi_t + \alpha_t d_c + \varepsilon_{ct}, \tag{13}$$

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 4.

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.[17] 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. Thus, as the model predicts, oil increasingly crowded out the production of more skill intensive goods.[18]

We can also examine if specialization in oil affected the transition to manufacturing using variation in pro-business policies across states. 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

[17]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.

[18]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.

employment share of manufacturing in states that are not oil abundant.[19]

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

$$Y_{cst} = \phi_c + \psi_t + \alpha_t d_c + \beta_t l_{st} + \gamma_t d_c l_{st} + \varepsilon_{cst}, \tag{14}$$

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, 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 manufacturing employment.

These results 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. The next section examines the effect of oil-abundance on human capital directly, by looking at the effect of oil-abundance on the stock of educated workers.

4.3 Specialization and Accumulation of Education

The model outlined above predicts that by increasingly crowding out the production of new goods, specialization slows down the rate of accumulation of education. In order to examine this prediction, I consider the fraction of people who had a high-school degree (or more) among people 25 years and older. As the top panel in Table 4 shows, oil abundant counties

[19] In the sample of counties I use, the states that did not enact right-to-work laws are New-Mexico, Colorado, Oklahoma, and Missouri.

had a better educated workforce in 1940, with about 2-3 percentage points more high-school graduates than the control counties.[20]

Over the next 50 years, the fraction of high-school graduates increased at rapid rates in the region I analyze, as shown in Figure 5 and Table 4. In the oil abundant counties the rate of accumulation of education was significantly slower, by about 0.8-1 percentage point per decade. Moreover, in two of the three specifications, the workforce in the oil abundant counties was significantly less educated than in the other counties in 1990.

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.[21] 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

[20] Tables 4 and 5 use the same specifications as Table 2.
[21] Detailed calculations available from author.

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[22], 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, as the model predicts, and to lower net inflows of educated workers.

The finding that oil-abundance slowed down the rate of human capital accumulation is interesting in three 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 give 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 in the oil-abundant counties are higher than in the other counties, and the difference corresponds to per capita income differentials, for both 1970 and 1980 (despite the large oil shock). Moreover, per capita spending on education is correspondingly higher in oil-abundant counties. Yet despite these higher investments, the oil abundant counties accumulated less human capital, consistent with the hypothesis that oil-abundance affects demand for skill. Finally, although the reversal in skill endowments is consistent with the predictions of the model outlined in this paper, it differs from the predictions of standard convergence models with factor accumulation. Indeed this example is reminiscent of larger scale reversals that have characterized the geographic distribution of economic activity over time (Acemoglu, Johnson, and Robinson 2002).

Having found that oil abundant counties accumulate more human capital, we can examine the last prediction of the model, that the specialized oil-producing counties grow at a slower

[22] 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.

rate.

4.4 Specialization and Income

This section tests the effect of specialization in production of oil on income. Table 5 shows that in 1949 the median family income was about 30 percentage points higher in the oil abundant counties. 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 6 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 6 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 6 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.[23]

Another interesting aspect of oil abundance is its effect on the distribution of income. The model makes no clear prediction in this regard, but some of the work on the "resource curse" suggests that oil abundance may lead to a more unequal distribution of income. But the similar effects of oil-abundance on both the levels and the changes of per capita income (Table 5) indicate that oil-abundance may have little effect on the distribution of income. This result is further reinforced in Figure 7, 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.[24]

Given this evidence that the oil abundant counties enjoyed higher levels off income for many decades, we can expect an endogenous response of migration flows towards those counties. Patterns of population change (Appendix Table A1) suggest that net migration to the oil abundant counties was larger during the earlier decades, when income differentials were large. As income per capita differentials decreased, net migration to oil abundant counties appears to have slowed down considerably.[25] Michaels and Redding (2006) discuss in detail the effects of oil-abundance on migration and on the growth rates of cities that of different sizes.

Having established the effects of oil abundance on industry structure, education, and income, I now examine the robustness of these results to a variety of different specifications.

[23]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.

[24]Results using the 1949 data, for which we only observe two points in the distribution of median family income, are also consistent with the hypothesis that the income distribution in the oil-abundant counties first-order dominates that of the control counties.

[25]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 conjestion may have had an offsetting effect on population migration.

4.5 Additional Specification Checks

The results presented thus far indicate that oil-abundance led to specialization in oil production, which raised income, and that the control counties gradually caught up with the oil abundant counties over time. In this section, I examine the robustness of these findings to the addition of time-varying controls. I also introduce an orthogonal source of variation that affects specialization in oil, by using variations in the magnitude of the oil endowment among the oil abundant counties.

One 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 have been settled to the sea bottom. Despite movements of tectonic plates over many millions of years and changes in the sea level, oil 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 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.

Another concern is that oil-abundance may be spuriously correlated with other factors that change over time. The second column in the Appendix Tables also 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). Note that both the distribution of land in 1940 and the percent of nonwhites may be endogenous to oil abundance, so in this specification I may be over controlling for endogenous outcomes. However, the results show that adding these controls has little effect on the magnitude or the precision of the estimates.[26]

Finally, we might be concerned that time varying state-level policies may be spuriously correlated with the location of oil, possibly due to political economy channels. Thus, the second specification in Tables A2-A5 controls for state-year interactions. Even after adding these controlling, the effects of oil-abundance on industry composition, education, and income around the middle of the 20th century remain similar, though somewhat smaller. The effect of oil-abundance on changes over time is smaller than before, though it is still statistically significant. Note that in this specification, variations in the employment share of mining is somewhat smaller and diminishes over time, so the smaller effect on other outcomes is consistent with our expectations.

Whereas all the regressions discussed thus far rely on the distinction between oil abundant and oil-scarce counties, I also explore the effects of differences in the size of the oil endowment among the oil abundant counties on the economic outcomes of interest. One advantage of this of this approach is that it uses a source of variation that is by construction orthogonal to the previous source of variation, since we only consider the oil abundant counties. This serves as a strong robustness check on the estimates presented before. The main drawback of this approach is that I analyze only 171 counties, or about 22 percent of the previous 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. This suggests that the effects of specialization on changes in outcomes

[26] Similarly, controlling for median county age, which is available since 1950, has little effect on the results.

are likely smaller. The next columns indicate that over time oil production differentially crowded out services, rather than manufacturing. My findings also suggest a smaller and less precise effect of oil-abundance on education, and a significant and negative effect on income. The main difference from the results in the previous tables is that the findings here do not represent any reversal: in 1990 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 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 less-specialized economies shift more quickly to new and skill abundant industries.

5 Conclusions

This paper examines the long-term consequences of regional specialization, when it is caused by natural resource endowment. Using geological variation in the location of subsurface oil in the Southern US, I find that oil abundant counties were similar to other nearby counties in 1890, before any major oil discoveries took place. Over the next 50 years, oil abundant counties became highly specialized in oil-production, and their mining sector became as large as their entire manufacturing sector. This natural experiment allows me to examine the effects of regional specialization on a variety of economic outcomes.

My findings suggest that regional specialization has generally had a positive impact on the local economy. In 1940, when the Southern US was very agricultural, oil production crowded out agriculture. Since oil production is more skill intensive then agriculture, the oil abundant counties had a better educated workforce than other counties nearby: the fraction of high school graduates was about 3 percentage points higher. Importantly, the oil abundant counties enjoyed per capita income that was about 30 percentage points higher in 1949.

From 1940-1990, the Southern US transitioned from agriculture to manufacturing and services. I find that this transition was slower in the oil abundant counties, leading to a significantly slower process of human capital accumulation, and there is some evidence that by 1990 the workforce in the oil abundant counties was actually less educated than in the other counties. Moreover, the income per capita differential in favor of the oil abundant counties narrowed to about 5-6 percentage points.

Yet despite the different growth path of the oil abundant counties, I find little evidence that this regional specialization led to negative outcomes. Income distribution in the oil abundant counties first-order stochastically dominated that of the other counties. Moreover, differences in local government expenditures per capita between the oil abundant counties and the other counties seem to reflect income per capita differentials, and not an increased propensity to spend. The only concern about the efficiency of the public sector seems to be a somewhat higher dropout rate in the oil abundant counties, despite significantly higher investments in education per capita.

These findings suggest a balanced view of the long-term consequences of regional specialization in oil production. On the one hand, I find that the specialized counties enjoyed higher per capita income for a long period of time. This suggests that in an economy with strong institutions, resources are not necessarily "cursed", consistent with Wright and Czelusta (2004). Any negative effects of resource abundance, if any, are likely limited to countries with weaker institutions (e.g. Mehlum, Moene, and Torvik 2002). On the other hand, I find evidence that even in a developed economy, specialization crowds out the adoption of new goods and technologies, leading to slower human capital accumulation.

The findings in this paper open a number of interesting avenues for future research. For example, it seems important to examine the consequences of specialization in goods that affect the comparative advantage in the production of new goods, and the transition path of economies that loses it source of comparative advantage.

Appendix: Uniqueness

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 6, 8, and 10). 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 7. But using 11 and 9 the left hand side is increasing in S, so S is unique. We can then use 11 and 9 to obtain the unique values of P_s and $\overline{e}$. Finally, holding S constant, $\overline{z}$ decreases in ω in 4 and increases in ω in 5, 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.

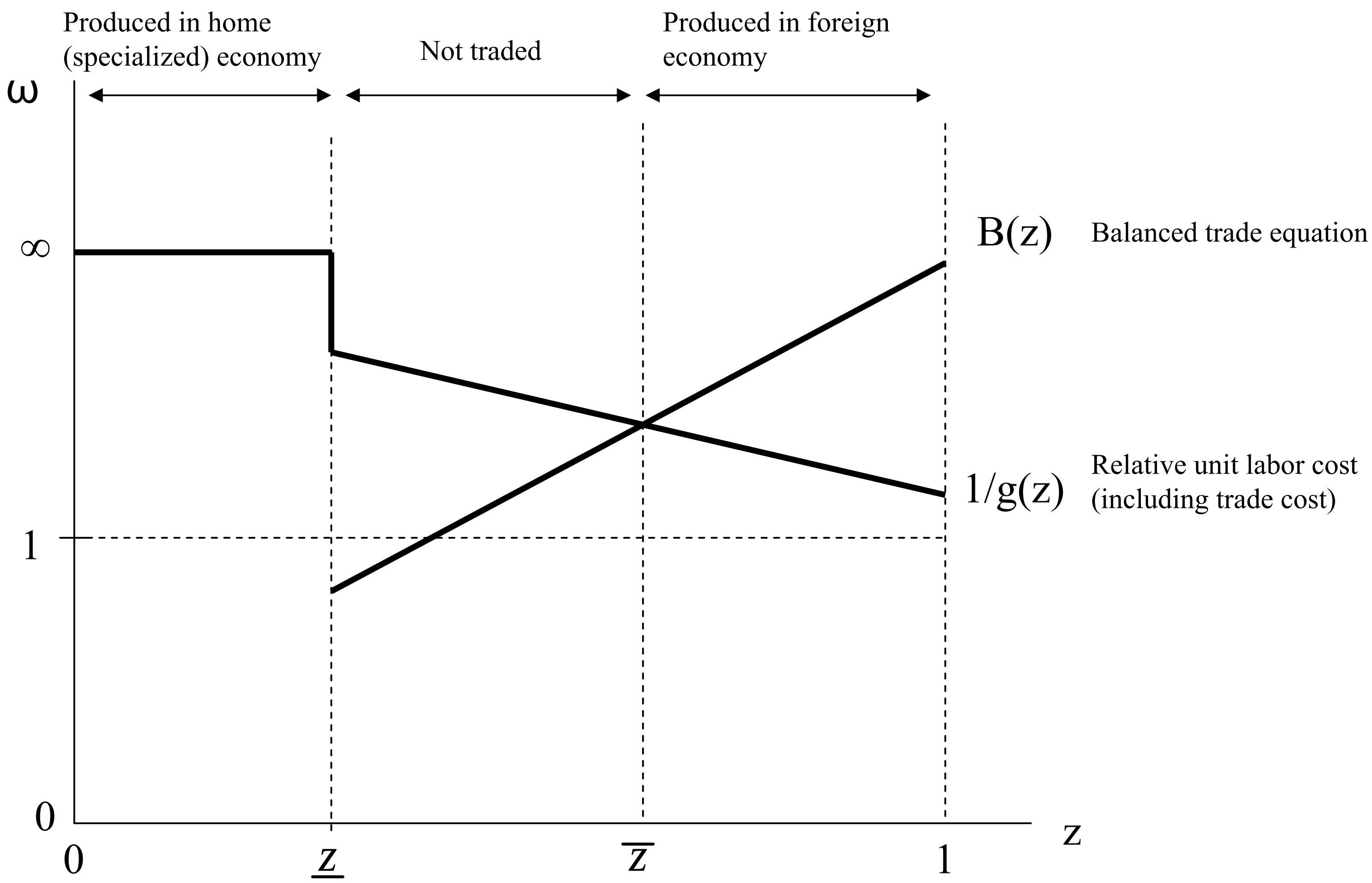

Figure 1. Open economy equilibrium

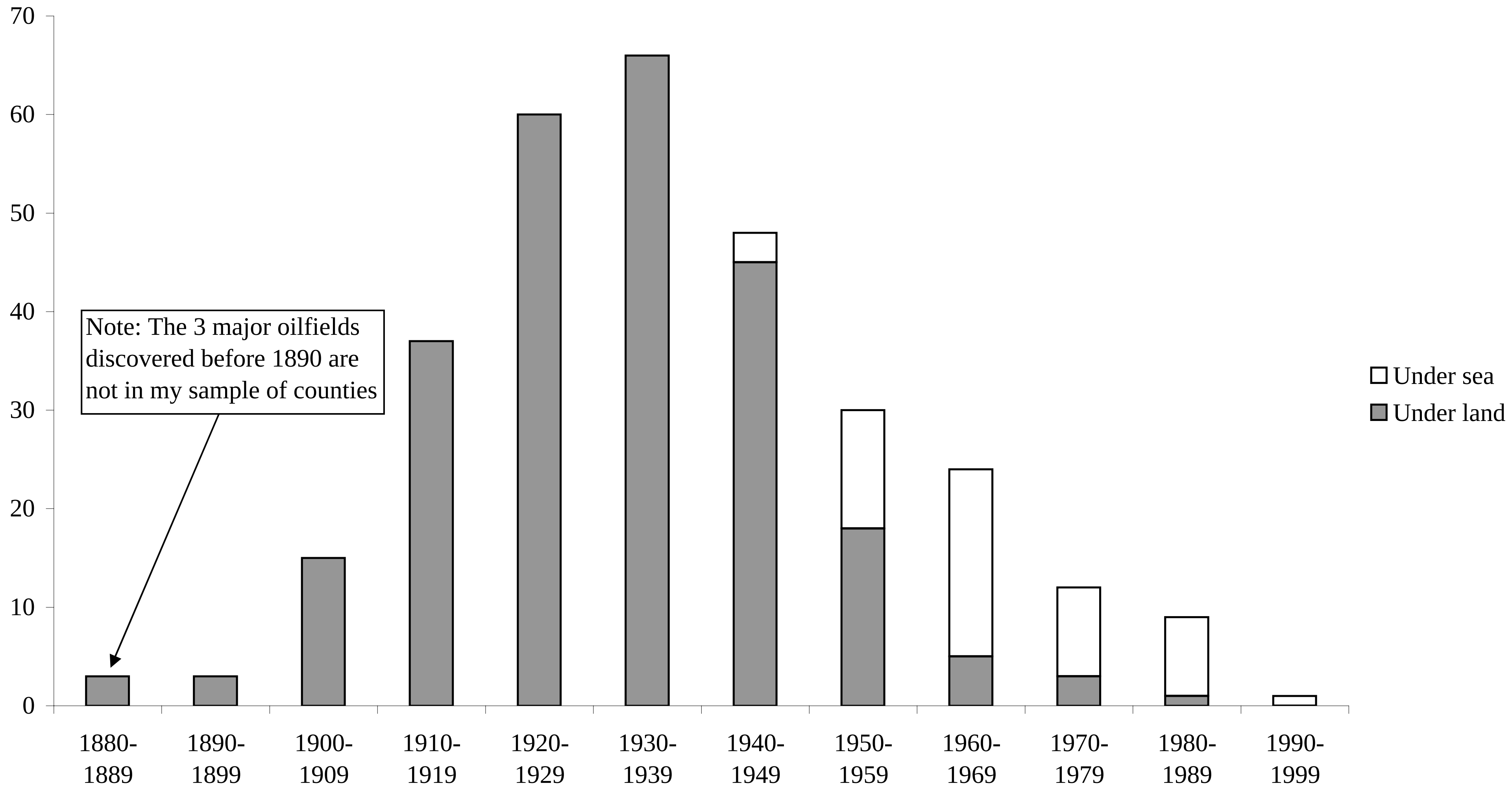

Figure 2. Number of new major US oilfields discovered, by decade

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

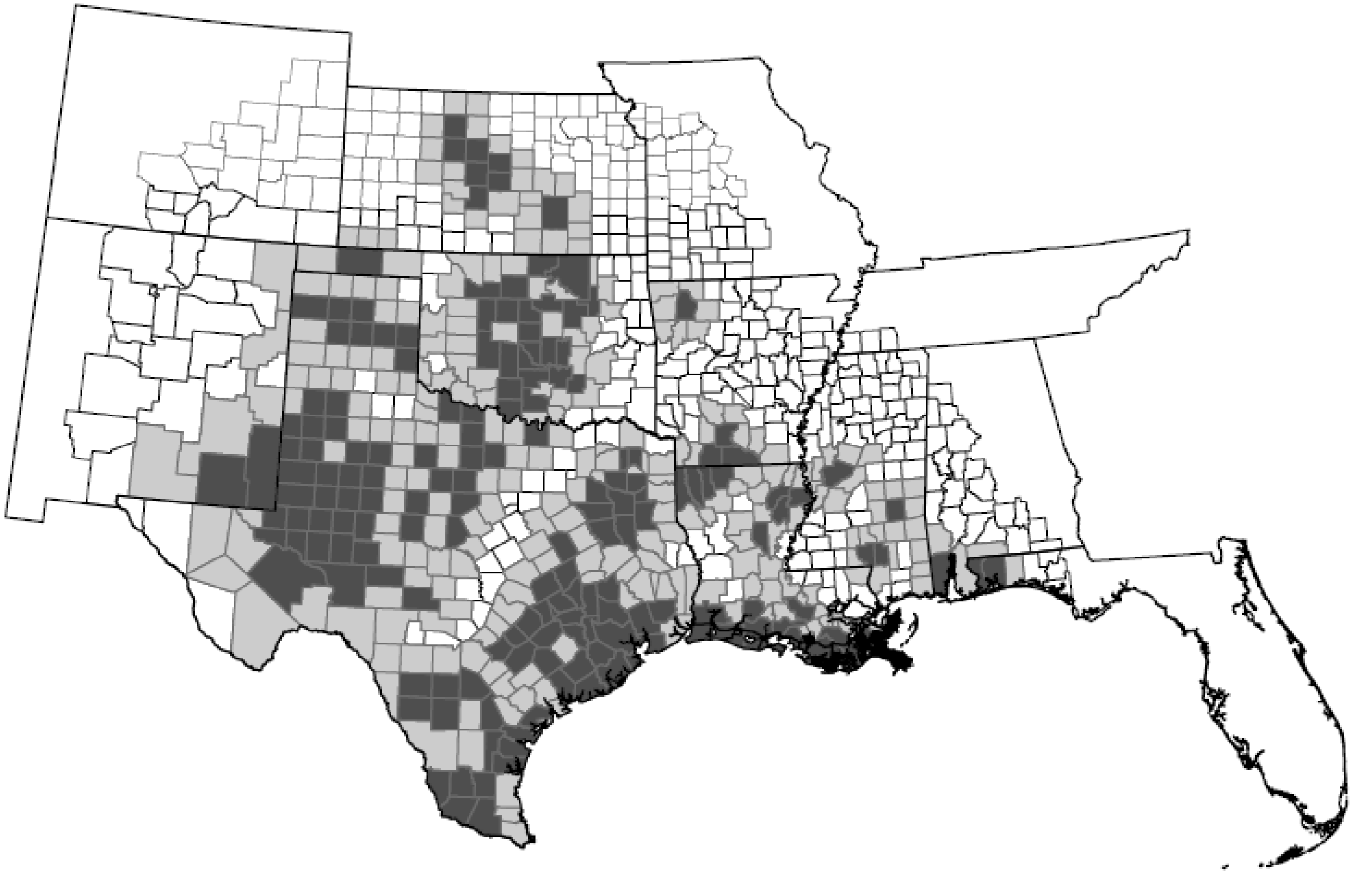

Figure 3. Oil-abundant counties (dark grey), adjacent counties (light grey) and other nearby counties (white)
Note: state borders are in black

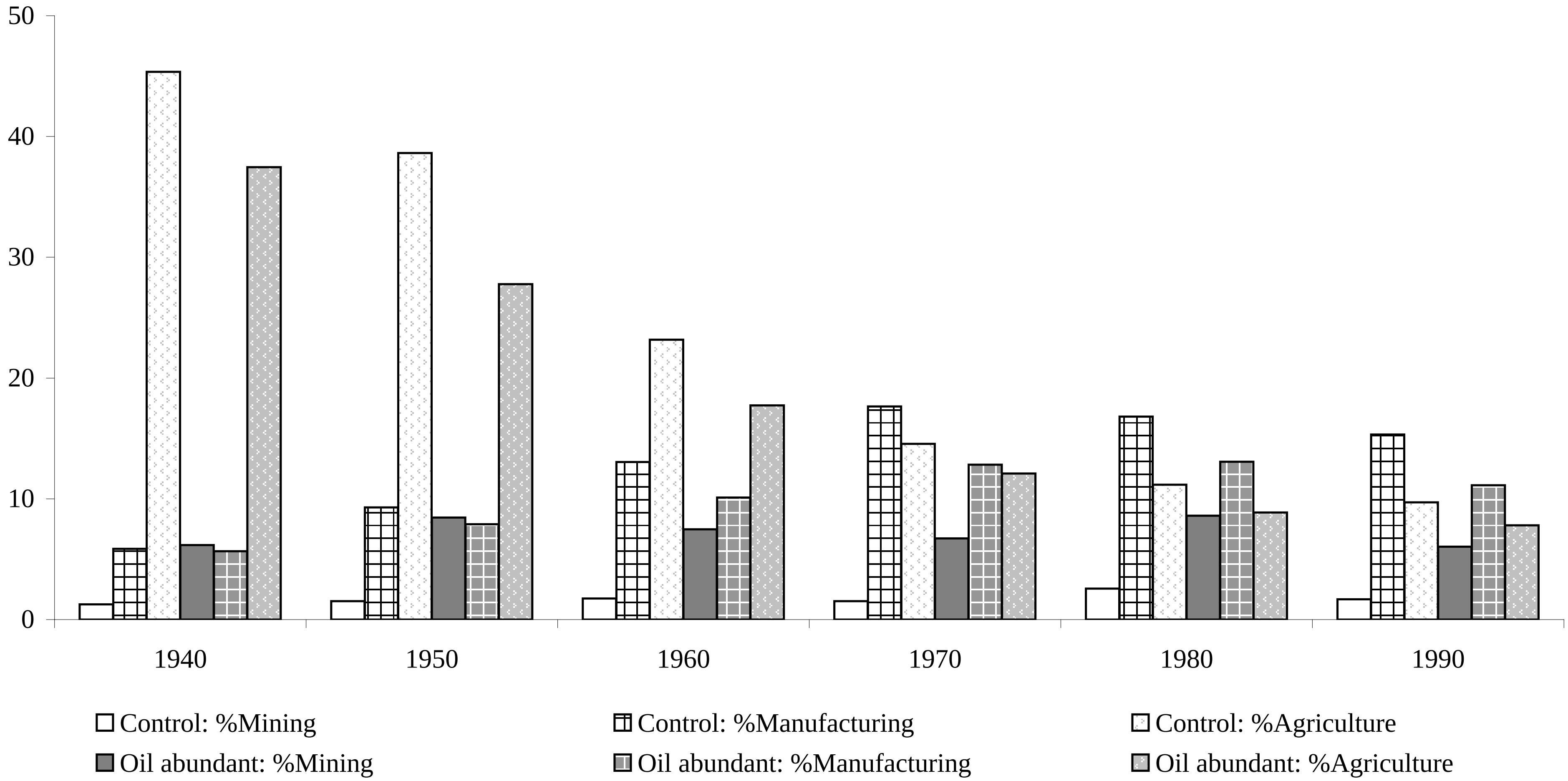

Figure 4. Employment as percentage of labor force in oil-abundant and control counties: 1940-1990

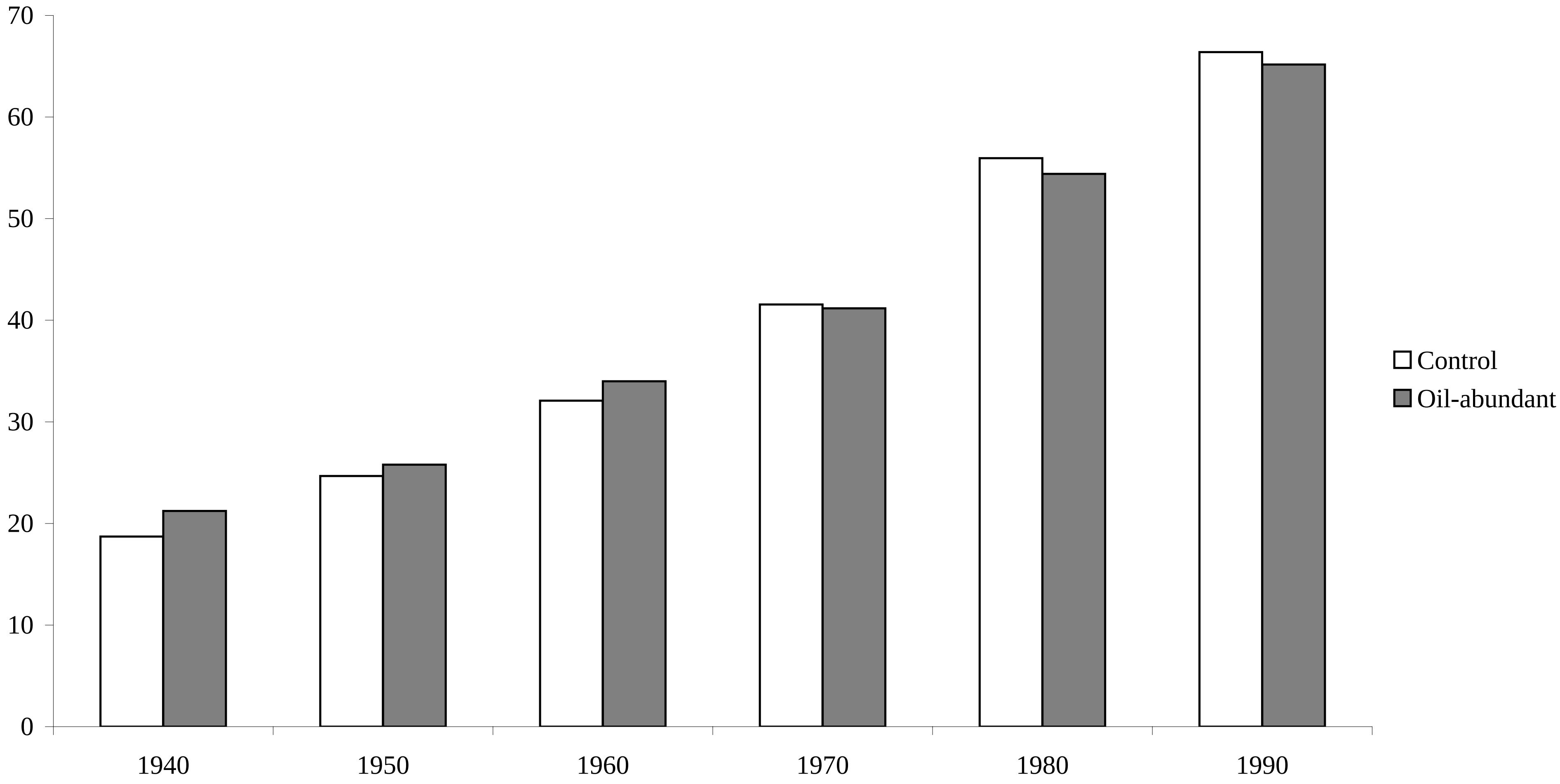

Figure 5. Percent with high school education or more, among people aged 25+: 1940-1990

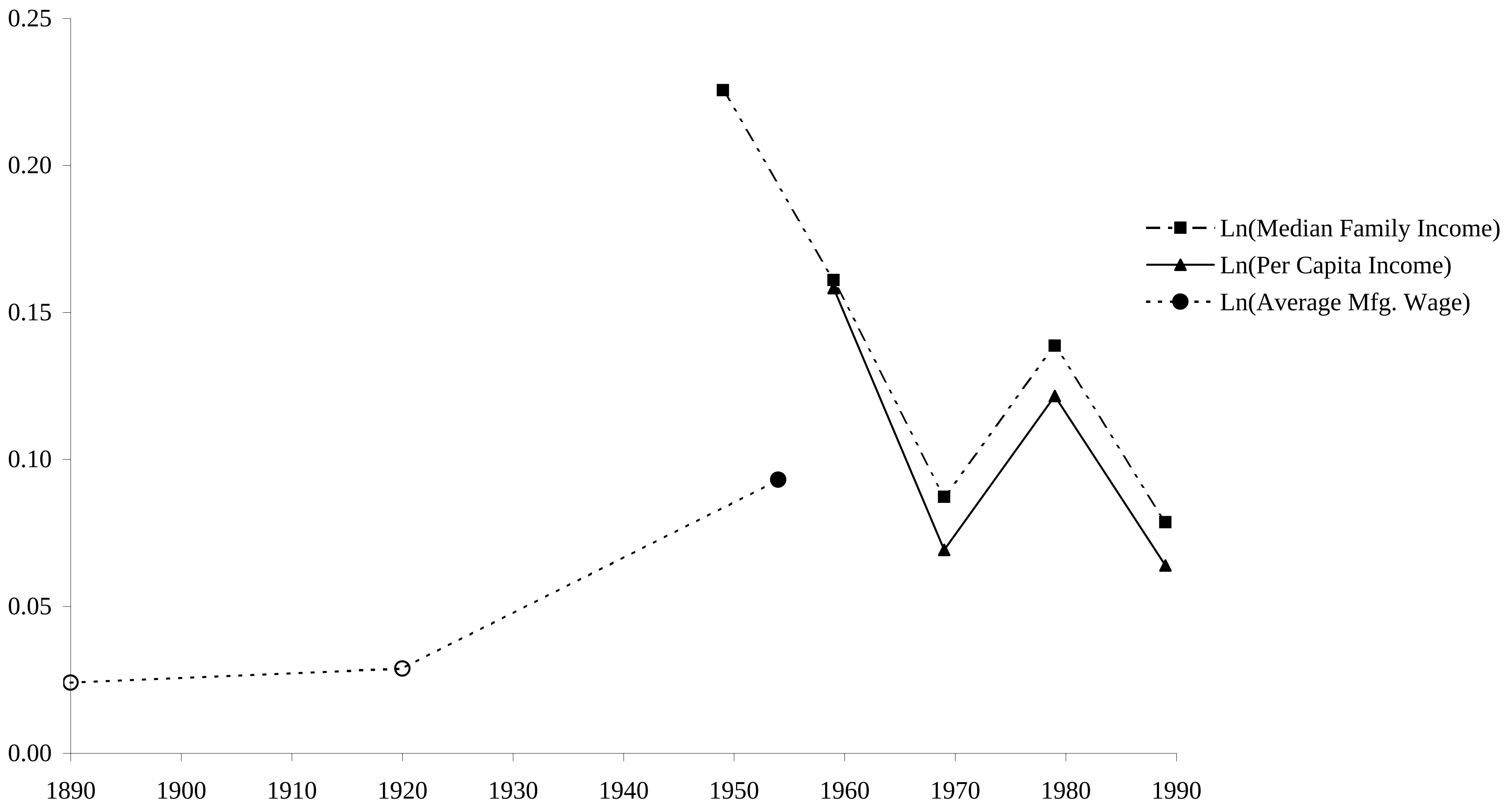

Figure 6. Differences in ln(income) between oil-abundant and control counties: 1890-1989

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

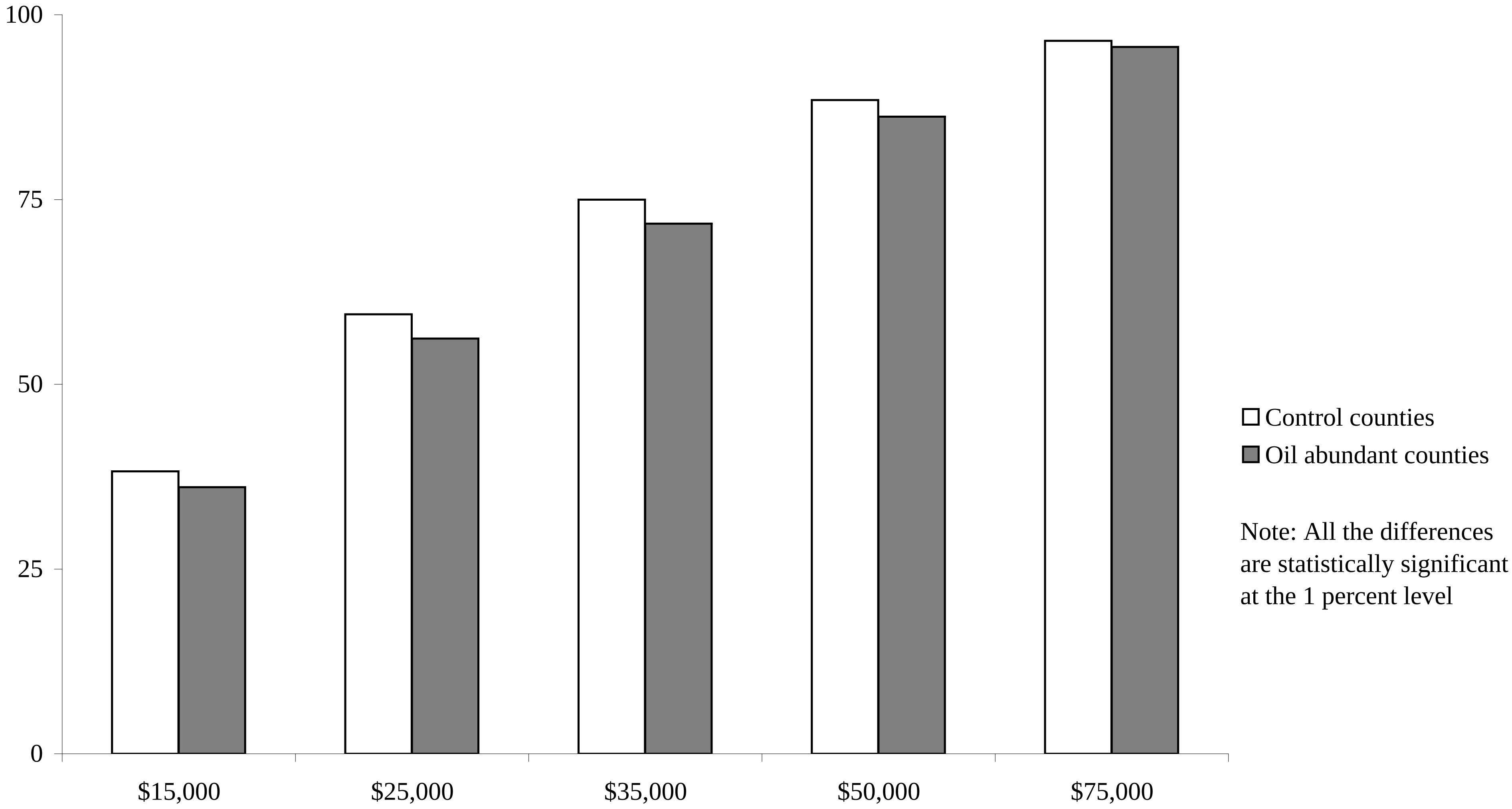

Figure 7. Percent of families below different income levels (1989)

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The Centre for Economic Performance Publications Unit
Tel 020 7955 7673 Fax 020 7955 7595 Email info@cep.lse.ac.uk
Web site http://cep.lse.ac.uk