Factor Endowments and the Returns to Skill: New Evidence from the American Past

March 2011

Joseph P. Kaboski and Trevon D. Logan

Abstract

The existing theory of skill-biased technical change predicts that heterogeneity in factor endowments will affect technological adoption and the returns to skill. This paper considers the relationship between the marked heterogeneity in factor endowments and the returns to skill in early twentieth century America. Using a variety of historical sources, we document the heterogeneous technology levels by region in the American past. We then estimate the returns to education of high school teachers for selected states using a new data source– a report from the U.S. Commissioner of Education in 1909. Overall, we find significant regional variation in the returns to education that match differences in resource endowments, with large (within-occupation) returns for the Midwest and Southwest (7%) but much lower returns in the South (3%) and West (0.5%). We show that our results appear generalizable to broader returns to education in the United States.

JEL Classifications: I2, J2, J3, N3

[1]This paper previously circulated under the title "The Returns to Education in the Early Twentieth Century: New Historical Evidence." Kaboski: Department of Economics, University of Notre Dame, 434 Flanner Hall, Notre Dame, IN 46556 and NBER; e-mail: Joseph.P.Kaboski@nd.edu. Logan: Department of Economics, The Ohio State University, 410 Arps Hall, 1945 N. High Street, Columbus, OH 43210 and NBER; e-mail: logan.155@osu.edu. We thank Audrey Light, Peter Meyer, Rick Steckel, Robert Whaples, and participants at the NBER Summer Institute, Economic History Association Annual Meetings, the Social Science History Association Annual Meetings, the editors and referees for comments on a previous version of this paper. We thank Joshua Cepluch, Sharmistha Dey, and Britney Williams for excellent research assistance. We gratefully acknowledge the financial support of the OSU Economics fund for Junior Faculty Research. The usual disclaimer applies.

1 Introduction

Theories of skill-biased technical change (SBTC) posit that heterogeneity of factor endowments will affect the type and rate of technology adoption and the evolution of the skill premium (e.g., Acemoglu 1998, Caselli and Coleman 2006). These theories have given rise to a new literature linking education, technology, and economic growth. There is also a growing body of contemporary evidence that factor endowments related to recent technologies play a role in the returns to skill.[1] An open question, which this paper addresses, is whether there was any link between factor endowment heterogeneity, technology adoption, and skill premia in earlier historical episodes of skill-biased technical change.

The existing evidence shows that in particular U.S. regions, returns to skill were quite high in the past (Goldin and Katz 1995, 1998, 1999, 2000, 2008), but we know little about whether this was true for all regions. Potential correlates and precursors of high rates of return to education were not evenly distributed across the U.S. at the start of the last century. Not only would changes in demand for skill have varied across regions, but the relative supply of skilled workers and investments in education and infrastructure varied considerably. For example, in the South and Southwest in 1910, high school graduation rates were only four percent, while they were triple that in the Midwest and Pacific Coast, and still higher in New England (Goldin 1999). Finally, the transportation and information technologies at the beginning of the twentieth century were not uniform, and as such the first half of the twentieth century saw a significant integration of regional and local labor markets into a national market, spurred not only by wage controls, but also by the national minimum wage, which spurred capital investment in Southern agriculture (Wright 1987, Mitchener and McLean 1999, 2003).

In light of the historical fact of regional heterogeneity and the contemporary theory and evidence about the role of factor endowments in SBTC, this paper asks the following question: To what extent did differences in factor endowments affect the return to skill during the first era of skill-biased technical change? Indeed, it may well be true that existing factor endowments played a large role in the adoption of new technology, and, as such, adoption of skill-biased technologies would have

[1] Abowd, et al. (2007) show that firms that use sophisticated techologies demand more skilled workers. Autor, Levy and Murname (2003) show a similar link between PC adoption and increased demand for skilled workers, leading to increasing returns to education. Beaudry, Doms, and Lewis (2006) found similar patterns using city-level data.

been a function of pre-existing conditions. Any discussion of the technology-skill complementarity in American history should, therefore, take into account the regional differences in the American economy in the early twentieth century. Doing so highlights the importance of the educational and capital endowments in the early stages of SBTC, and provides a strong link between the SBTC literature and contemporary studies of local and regional labor markets. We use a number of historical sources to document the significant regional heterogeneity in factor endowments at the beginning of the twentieth century.

Our primary contribution to the historical evidence comes from a new data source that allows us to estimate the returns to education by region, to see if significant differences existed and if those differences aligned with factor endowment differences. We use a report from the U.S. Commissioner of Education in 1909, to estimate the returns to education of high school teachers for selected states in the early twentieth century. Our data list not only the education and earnings of the teachers individually for a number of different states, but they also include actual years of experience in the teaching profession, allowing us to estimate the returns to schooling while controlling for experience directly.[2] These returns are for a single occupation – the absolute levels may understate returns generally, since one of the important gains of schooling comes from enabling workers to choose higher paid occupations. Nonetheless, secondary teachers returns are of interest since they likely reflect the rising demand for high school education relative to the current stock of high school educated workers (the pool of potential teachers). That is, rising demand for high school education creates a *derived demand* for educated teachers. Overall, we find significant regional variation in the returns to education, with large returns congruent to Goldin and Katz's Iowa estimates for the Midwest (7%), but substantially lower returns in the South (3%) and West (0.5%).

In considering the generalizability of our main finding, we uncover several facts which strengthen our conclusion. The geographical patterns we find hold for male teachers and for less experienced teachers, for whom outside options may be more relevant and may therefore be more closely connected to the wider labor market. We also use Census returns (IPUMS) to show that the returns to education for teachers track quite closely with the overall returns to education from 1940 onward

[2]Note that the requirements to teach at the secondary level varied greatly in the past, and the professionalization of the teaching profession, in terms of certification and degree requirements, did not begin until after the high school movement. For example, from 1909 to 1919 only eleven states began requiring a high school diploma for the lowest level of teacher certification; Washington, Oregon, Idaho, Montana, Illinois, Indiana, New Jersey, Utah, Vermont, New Hampshire, and Maine (Law and Marks 2007).

(1940 is the earliest Census year that can be used to estimate returns to education). Similarly, we show that the returns to education for the states in our historical data track well with national returns over this later period.

We emphasize that the heterogeneity of returns to schooling, schooling levels, and technological differences persisted into the twentieth century. The South (Georgia) continued to lag behind in the high school movement, so by 1940s returns to schooling were quite high, but low returns in California persisted as did higher returns in the Midwest. Incomes were similarly persistent with incomes in the South well below those in the West and Midwest, and levels of industry much higher in the Midwest. It is not until the latter half of the century, when these began to converge, and we show evidence that returns to schooling also converged across regions. We conjecture that this evidence shows the long-run impact of the endowment on the speed of SBTC and returns to education more generally.

The paper proceeds as follows. The next section reviews the facts about regional economic heterogeneity at the beginning of the twentieth century and discusses the theoretical literature which predicts variation in the returns to education given these substantial differences in endowments. The third section presents the empirical results, which are based on the 1909 Commissioner of Education Report. They show that there was significant regional variation in the returns to education in the early twentieth century. The fourth section addresses the robustness and extensions of the empirical results. The fifth section looks at subsequent regional changes in techology and returns over time, while the final section concludes.

2 Skill, Technology, and the Returns to Education

This section emphasizes the importance of variation in factor endowments, both empirically in the historical United States, and for existing theory. In the appendix we offer additional historical evidence and a fully articulated model of the process for interested readers, but in the main text we concentrate on the key factors. We first discuss the historical literature on the extent and causes of regional heterogeneity in the United States. We then supplement this discussion with data quantifying variation in education and other factor endowments by region in the early twentieth century. Finally, we appeal to existing theory for implications on the returns to schooling and subsequent technology adoption patterns.

2.1 The Historical Record

It is well-known that large regional differences in the factor endowments existed in the early twentieth century U.S. These differences included differences in natural resources, capital, and technologies. Moreover, education levels varied as well, and labor markets were segmented. We briefly review the record on these factors below.

The literature has emphasized heterogeneity in capital, natural resources, and technology across regions. Capital development in the South was inefficient relative to the East and Midwest (Davis 1965, Sylla 1969, Wright 1987, Ransom and Sutch 2001). The South did not have as many capital intensive industries as the Northeast and Midwest at the beginning of the twentieth century, and North (1961) has argued that the South did not re-invest the gains made from its productive agricultural sector. Similarly, the South, with its sharecropping system and Jim Crow legislation, had a large supply of unskilled labor of both races (Ransom and Sutch 2001, Collins 1997). The West had a relatively sparse population, had an abundant resource endowment that was only beginning to be exploited in the early twentieth century (Nelson and Wright 1992). In general, this implies that substitution of raw materials and unskilled labor substituted for skilled labor would have been more prevalent in the South and West since they had an abundance of the former.

The processes leading to increased demand for education were less prevalent in the South and West as well. Given the South's low levels of capital intensity and warm climate, there were relatively few of the new large-scale processing technologies highlighted by Goldin and Katz (1998) in the South and West at the end of the nineteenth century. As Wright (1987) has shown, the South was simply not in a position to industrialize (beyond the harvesting of raw materials) to any large extent before the first World War with textiles a possible exception (Carlson 1981, Wright 1981). Similarly, the South's agriculture, with its dependence on labor-intensive work and the cattle ranching see in the West were not as sophisticated as the agriculture of the Northeast and Midwest. Indeed, Goldin and Sokoloff (1984) have argued that industrialization first appeared in the Northeast and Midwest because of the crops grown there, which led to agricultural technology that made women relatively less productive than men in agriculture. On the supply side, racial diversity in the South caused lower investments in schooling, and low investments in education left large portions of the southern workforce relatively unskilled at the turn of the last century (Margo 1990).[3]

While it is not true that every locality had its own independent labor market, it is true that the South and North had different labor markets that were not fully integrated to any large degree until after the first World War. Rosenbloom (1990, 1996) has shown that the labor market in the early years of the twentieth century was fragmented, and North-South wage differentials suggest that a national labor market did not exist before the first World War. Wright (1987) contends that the Southern labor market was not integrated until the New Deal forced the South to invest in capital for the agricultural sector, and that the South was finally brought into the rest of the national labor market by the end of the second World War.[4]

2.2 Measuring the Historical Factor Endowments

Neoclassical theory suggests that educational and technological factors help determine the returns to education in the early twentieth century.[5] Skill-biased technologies are associated with capital intensity. If a region had a relatively high educational levels and small amounts of capital, we would expect relatively low returns to education. If a region had low educational levels and relatively large amounts of capital, we would expect for the returns to education to be high.[6] But was there heterogeneity in the factor endowment by region in the late nineteenth and early twentieth century?

Table 1 shows the stark differences in real labor productivity across regions of the United States and across states for the years 1900 and 1920. Of particular interest to this study, real productivities vary by roughly a factor of two across regions (the West vs. the South) and by over a factor of

[3] Bleakley (2007) notes that the eradication of hookworm in the South, begun in 1910, raised the lifetime return to education in the region.

[4] While there is broad agreement on the relative fragmentation of capital and labor markets in the late 19th and early 20th centuries, economic historians have not agreed on the level of fragmentation. For example, Fishback (1998) has argued that Rosenbloom and Wright overstate the isolation of Southern labor markets. He argues that while unskilled wages showed significant gaps, the regional wage gaps of skilled workers were smaller, suggesting that skilled labor was quite mobile during this time period. Similarly, Eichengreen (1984, 1987) argues that the regional differences in mortgage rates documented by Snowden (1987) can be explained by differences in transactions costs and risk between the Northeast and the South. Regional and state-level interest rates collected by Bodenhorn (1996) do show interest rate convergence by the middle of the twentieth century, but before this time rates in the Northeast were lower than elsewhere. Due to the disagreement on the degree of fragmentation, which largely concerns broader measures such as labor mobility and interest rates, we use historical sources to measure specific factor endowments that we believe are most important for SBTC.

[5] Intuitively, one could think of educational factors as supply and technological factors as demand.

[6] A priori, we cannot form firm hypotheses about the returns to education in regions that had large levels of both education and technology or small levels of both education and technology.

two across the states we study, with California and Illinois, and even the other midwestern states having substantially higher incomes than Georgia. We emphasize two points. First, substantial differences in factor and technology endowments must drive these differences in labor productivity. Second, since such differences were sustained over decades, factor markets – especially labor, since wages are closely linked to productivity – must have been substantially segmented.

Table 2 delves more closely into the types of technological and factor heterogeneity that existed across regions in 1910 using assembled evidence from the *Historical Statistics of the United States*, historical *Statistical Abstracts of the United States*, and *Abstracts of the Censuses.*[7] The first panel of the table presents measures designed to capture the level and type of industrialization in 1910. The patterns of heterogeneity are clear: Georgia, Texas, and Iowa are less industrial, with a smaller fraction of the population employed in manufacturing, fewer establishments per capita, and less horsepower, capital and value-added per worker. We chose these measures because they are available consistently over time, other measures produce the same pattern, including measures linked to electrification, internal combustion engines and other technologies that Goldin and Katz (1998) emphasize as skill-biased. California is also less industrial to some extent, although their labor productivity is high. While Georgia, Texas, and Iowa are all both less industrial and lower productivity. The second panel of Table 2 shows that these three states are more agrarian, but the nature of their agriculture varies substantially. In particular, relative to Georgia, the levels of livestock and capital per farmworker are much larger in Iowa (factor of 8 difference for each) and even Texas (factors of 2 and 3, respectively). Again, other metrics show this similar pattern. Thus, Georgia stands out as an outlier, in terms of having little industry and less capital-intensive agriculture.

The third panel of Table 2 looks at the variation in education measures across states. Here, the particular measure of the education endowment matters. In terms of literacy, a stock measure, Texas and especially Georgia lag behind. Public spending, a measure of both the rate of investment and the subsidy to investing in education, is also low in Texas and Georgia, but it is particularly high in California, over 50 percent higher than in the other states. Finally, we show enrollment rates for the population aged 14-20. (The age range is dictated to ensure later comparability.) Again, Georgia lags behind, but Texas is now one of the leaders, with enrollment rates higher than

[7] We present more detailed evidence of factors in the appendix.

Illinois, Ohio and Wisconsin.

2.3 Evidence in Light of Theory

Existing theory predicts many potential sources of variation in returns to schooling and the paths of future technical change stemming from regional heterogeneity in factor endowments and technology. We highlight four important predictions. First, imperfect substitution between more and less educated workers would predict that given identical technologies (i.e., identical downward sloping relative demand for high-skilled labor), exogenous variation in the relative supply of skilled labor would result in variations in the return to skill. Thus, *ceteris paribus*, regions with higher levels of schooling would have lower returns. Second, according to Goldin and Katz (1998), available large-scale technologies (e.g., electrification, internal combustion engines, and other processing techniques) were skill-biased. Thus, *ceteris paribus,* regions that implemented more skill-biased technologies would have a higher relative demand for schooling, and thus higher returns to schooling. Third, both the levels and returns to schooling could affect the future implementation of technologies – regions with fewer complementary factors may have lower rates of adopting/implementing (Caselli and Coleman, 2006) or even developing (Acemoglu, 1998) skill-biased technologies. Thus, the low level of industrialization, capital and schooling may have prevented or delayed the implementation of these new, skill-biased technologies. These theories act as an explanation for existing heterogeneity, but also make predictions for the paths of technological change in conjunction with schooling investment. Fourth, the desired demand for higher levels of education (e.g., high school education) can increase the return to schooling for teachers, through a derived demand. We present a formal model of this derived demand, as well as the implications on factor heterogeneity and new technology implementation, in the theoretical appendix. We also note that public subsidies to education should increase the level of investment but also reduce the returns to schooling.

Viewed in this light, the midwestern states appears to have been a region with higher relative demand for schooling but also reasonably high relative supply of educated workers. In contrast, in Georgia, both relative demand and relative supply were lower. California appears to have been a state with potentially lower demand, but a high supply of skilled workers. Texas is more nuanced with an intermediate level of demand, a lower stock of skilled workers (based on literacy data) but a higher rate of investment in education (based on the public spending and enrollment data). Theory predicts that these differences in endowments and investments would be related to differences in the returns to skill. Below, we exploit new historical data to test these theoretical predictions.

3 The Returns to Education in the Early 20th Century

3.1 Data

We estimate the returns to education with a new and unique data source, a 1909 report from the U.S. Commissioner of Education which allows us to estimate the returns to education of secondary teachers in the early twentieth century by region. The data come from a report by Edward L. Thorndike, entitled *"The Teaching Staff of Secondary Schools in the United States,"* prepared for then U.S. Commissioner of Education Elmer Ellsworth Brown on the labor force of teachers. Thorndike spent a large part of his professional life researching features of secondary education, many of which have implications for the issues analyzed here.

As noted elsewhere (Goldin and Katz 1995, 2008) the rise of the high school movement in the United States was changing the relationship between schooling and wages in the early twentieth century. These changes in high school enrollment changed the high school curriculum and the requirements one had to meet to become a teacher.[8] Thorndike (1922) and Thorndike and Robinson (1923) show that the homogenized training of high school students that was the norm in the late nineteenth century had given way to a curriculum that emphasized science and mathematics at the expense of English literature and Latin. In addition to a different focus, the high school curriculum was now highly specialized, the expansion of the curriculum meant that students were rarely taking identical courses of study, which is now a common feature of high school education. Thorndike and Symonds (1922) saw these changes as altering the returns to skill for high school graduates, but they also noted that demand for high school education would remain strong.

> It seems unlikely that the enviable status shown for graduates in 1892 to 1901 in respect to occupations can be fully maintained now and in the future. To maintain it would require that the favored occupations be practically closed to all but high school graduates. This may perhaps be taking place. The supply of high school graduates is increasing so fast that any profession or reputable semi-profession may demand such. Even if it is not fully maintained—indeed, even if there is a considerable movement downward—the

[8] Only beginning in 1909, after our survey, did any states begin to require a high school diploma for the lowest level of teacher certification.

> high school graduates will still have noteably high occupation status; the correlation between amount of education and dignity of occupation will still be close. (Thorndike and Symonds, p. 451)

These changes in the function and curriculum of high schools had implications for teachers, and they mirrored the changes in the larger labor market. Thorndike (1923) found that in a survey of teachers own interest in academic subjects that teachers themselves preferred courses with "modern" content such as science and mathematics to literature. Older teachers, who themselves had been trained in "traditional" high schools, were more interested in Latin and English literature, while young teachers expressed strong interest in physical and biological sciences. As students in high schools sought out these "modern" subjects more than "traditional" ones, the returns to education for teachers will reflect both derived demand for skill and the same market forces that were operating in the labor market more generally.

The report we use was designed to uncover the relationship between experience, education, and wages among high school teachers. It presents tabulated data on the (i) income, (ii) experience, (iii) education, and (iv) gender of U.S. secondary school teachers in 1908, which was collected from a survey corresponding to the 1906-1907 academic year. The data were collected via survey for approximately five thousand teachers, chosen to be a representative sample of the nation's secondary teaching workforce at the time and to be directly comparable across regions. While there are several sources of data that list the education and experience of teachers in specific localities and school districts, Thorndike's goal of a nationally representative picture of the relationship makes his data unique – and it is the only source we know of that allows us to address the issue of geographic heterogeneity in returns to education at this time. Indeed, Thorndike took great care to consider and eliminate the regional and idiosyncratic biases in the data, and the report which accompanies the data used here details many of the potential sources of error that he attempted to eliminate with his survey. The Thorndike report's systematic and consistent measures of education, experience, and wages across space allows us to estimate geographic variation in the returns to education before the 1940 Census.

The data were collected using a two-part survey sent by the Office of Education to administrators for a sample of secondary schools. The first survey collected the salaries, years of secondary and post-secondary education, and actual years of experience of all teachers in the schools surveyed. The fact that years of experience are directly reported is a major strength of the data, since imputed "potential years of experience" (i.e., the traditional $age - years\ of\ schooling - 6$) can diverge strongly from actual experience. This is particularly true for women, who are not as closely tied to the labor force and who constituted a significant share of secondary school teachers at the time.[9] Thorndike spent a great deal of effort discussing potential sources of measurement error and trying to quantify or minimize them.[10]

We stress, however, that great care must be taken with the Thorndike data, and any data on education from this period. As Goldin (1999) notes, the very meaning of high school education differed in the United States before the coming of the high school movement. High school did not always imply four years of education in all locations, and the certification standards for teachers varied widely (Law and Marks 2007). This has advantages and disadvantages. While it is unclear if Thorndike was sampling from all types of high schools, we have substantial variation in the education levels of high school teachers.[11] We focus on two sets of tables, Tables 7-10 in the original Thorndike Report. The first is individual public school teacher data tabulated separately for California, Georgia, and Texas, and tabulated together for Illinois, Ohio and Wisconsin.[12] These states cover the West Coast (California), Southwest (Texas), Southeast (Georgia), and Midwest (Illinois, Ohio and Wisconsin). The second set of tables gives separate details on Illinois, Ohio and Wisconsin teachers, and provides the median income level for each experience-education-gender cell. This allows creation of a dataset of median incomes by gender, experience, education and state for all six states separately.[13]

In general, the data appear to be of extremely high quality. For example, Thorndike mentions that income may vary somewhat due to varying lengths of the school year, such that low salaries in the South are partially explained by shorter school years. The data would nonetheless reflect

[9] On the other hand, this does introduce a discrepancy between our estimates and estimates based on the more common potential experience.

[10] A second survey was a follow up survey sent with the intent of measuring any biases or measurement error in years of education (e.g., adding in primary schooling) and experience (e.g., reporting years of service at the particular school surveyed). The second survey showed that the larger initial survey did not suffer from any aggregate biases. The data we use comes from the first survey.

[11] A search of the Thorndike papers at Teacher's College did not uncover any additional information on the survey or the specific schools solicited.

[12] Thorndike explained that the data were calculated together because the data were similar.

[13] All data from the tables was entered twice, in separate files, to assure accurtate data entry. The use of tabulated data does introduce additional sources of measurement error in the data as both income and experience are grouped into small ranges. Neither of these should substantially change our estimates of the returns to education, and indeed replicating the corresponding groupings in the U.S. census data does not alter the results substantially.

the actual income received. For years of education, the distinction between secondary and post-secondary education was not always clear, but this will not affect our results since we look only at the sum of these two. For experience, Thorndike mentioned a tendency to report roughly and to include the current year of service.

3.2 Summary Analysis

Table 3 presents summary statistics for the individual data by state and gender. We note several interesting observations. First, secondary teachers averaged 12.6 to 13.8 years of education, having completed not much beyond high school education themselves. These low levels of education are of particular interest because they indicate that increased demand for more modern schooling might have immediate effects on the derived demand for teachers education. Education levels are also fairly similar across states, with the exception of California, whose teachers appear to be particularly well-educated. Second, average salary levels vary greatly, both between men and women and across states. For example, men in California earn about three times what women in Georgia earn. Salaries in California are substantially higher (roughly \$300/year or 35% higher) than in Georgia and the Midwest states, while those in Texas are significantly lower (about \$100/year or 12%). Again, these wage patterns are in line with the patterns in output per worker, indicating that schooling wages reflected broader labor market conditions. Third, teachers average between 8.2 and 9.6 years of experience, with male teachers having on average 2.0 to 3.6 more years of experience. Thus, experience levels were not particularly high, and there were likely many teachers with limited occupation specific on-the-job training, who may have entertained options in the broader labor market. Finally, it should be noted that secondary teaching is a mixed-gender occupation. For the sample overall about half (fifty five percent) of the teachers are men.

3.3 Regional Variation in the Returns to Education

We estimate the returns to education using a standard Mincerian regression

$$\log(w) = \alpha + \beta_1 s + \beta_2 x + \beta_3 x^2 + \beta_4 g + \varepsilon$$

where w is the wage of a person with s years of schooling, x years of experience, and gender g. Table 4 presents the regression results for each of the states. The estimates show considerable geographic variation in the Mincerian return to schooling.[14] The three midwestern states and Texas had high returns, 7.0 and 7.1 percent, respectively. Recall that the midwestern states had high levels of industry, and so likely rapidly rising demand for skill, while Texas had a small educational endowment relative to its technological endowment. The returns are much lower in Georgia and especially California; the return in Georgia is just 3.3 percent which is significantly different from the returns in Texas and the Midwest states, despite the smaller sample size in Georgia and the consequently larger standard error. This suggest that the low supply of educated labor and low demand for skill in Georgia combined to yield low returns to education. The return in California is a miniscule 0.5 percent and not statistically significant. Recall that California teachers averaged 1.2 more years of education than teachers in the other states, and that California had a large educational endowment relative to its technological endowment.

As described in the previous section, the individual data for Illinois, Ohio and Wisconsin is pooled together. We do, however, have data on median incomes (by sex, education, and experience) separately for each of these three states. Regressions can therefore be run separately using median-level data for these three states as a way to disaggregate the returns to education estimates. A key question in interpreting this data is the extent to which estimates from median-level regressions are comparable to individual-level regression results. To answer this question, we construct comparable median-level data for the states that have individual data and compare regression results. If the estimates for the returns to education are similar then the median regressions for the individual midwestern states will give us reliable estimates of the returns to education for each midwestern state. Table 5 shows that median regressions do in fact express much of the same information about returns to schooling that individual-regressions do and the qualitative interpretations remain the same. Focusing on the schooling coefficients, Mincerian returns are low in California and Georgia, and relatively high elsewhere.[15] We conclude that the qualitative patterns in the median-level

[14] We formally tested for differences in the regional returns to education in a pooled regression (unreported), in which we rejected the hypothesis of equal returns between the Midwest and South. As the purpose of this study is to document the extent of the variation and to estimate the returns by region, we present the separate regressions throughout.

[15] Focusing on the constant term results, we see that constant terms are somewhat higher in the median regressions. The difference in levels is not surprising since the individual- and median-level regressions weight individuals differently; the median regressions give each experience-education cell equal weight, while the individual data use the

estimates are strongly indicative of patterns in the individual-level estimates.

The median level estimates are presented separately for Illinois, Ohio and Wisconsin in Table 6. The main lesson from Table 6 are that wage returns to schooling found in the Midwest using the individual-level data do not appear to be at the same high level across all three states. Mincerian returns are high in Illinois and Ohio, but much lower in Wisconsin. These lower Mincerian returns are accompanied by higher wage levels in Wisconsin, reflected in the significantly larger intercept. Thus, even amongst similar states in the same geographic region, there appear to be important differences in the returns to schooling.

Overall, there is substantial variation in the returns to education for these secondary teachers in 1909. As predicted, the returns to education vary with the factor endowments. The Midwest, with its large endowment of education but also large and growing levels of capital and capital-intensive, skill-complementary technologies, had high returns to education. The South, with its small factor endowments, had low returns to education. California and Texas had similar levels of capital and capital-intensive technologies, but California had a much larger educational endowment and much larger expenditures on public education. Consistent with a relative oversupply of skill, the relatively large educational endowment in California yields low returns to education, and the small educational endowment yields higher returns in Texas.[16] If these returns to education are indicative of general returns to education for these regions the claim of U-shaped returns to education over the twentieth century – where returns to skill were all high in the early twentieth century, declined in midcentury, and rose again at the end of the century (Goldin and Katz 1999, 2008) – would have to be augmented to reflect this regional heterogeneity.

We note one shortcoming of these results. Our interpretation depends on the relative supply and demand for skill, and our ability to identify these separately is limited, especially in 1909. We can, however, perform a rough assessment of the quantitative fit of the explanation. We start by estimating a relative demand curve from a production function that is constant elasticity of

weights in the sample population. The patterns by sex across states also match up well. The one exception is that returns are typically lower for women in the median-level estimates and slightly higher for men.

[16] Given the estimates of income per worker in the previous section, low returns in California could also partly be due to labor scarcity, which would raise the wages of the unskilled relative to the skilled.

substitution in high-skilled and low-skilled labor, H and L, respectively :

$$Y = \left[AH^{(\rho-1)/\rho} + (1-A)\, L^{(\rho-1)/\rho} \right]^{\rho/(\rho-1)}.$$

Competitive wages yields the following regression equation:

$$\ln (w_H / w_L) = \alpha + \beta E - \frac{1}{\rho} \ln (H/L) + \varepsilon$$

where we have assumed that $\ln (A/(1-A))$ takes the form of $\alpha + \beta E$, and E is electrification. This captures the idea that electrification is potentially skill-biased, increasing the demand for high-skilled workers.

We estimate the above equation using cross-state data from the 1940 census. We construct stocks of high and low-skilled workers by using denoting those with less than 12 years of schooling as low-skill, and those with more than 12 years as high-skill. Within these categories we construct nationwide gender-experience-education cells, and use average wages to construct relative efficiency units of these cells. Aggregates L and H are then measured in efficiency units; we define w_H and w_L as wages per efficiency unit. We measure E in thousands of kilowatts of electricity per capita. Finally, we instrument for $\ln (H/L)$ using state educational expenditures per capita. The 1940 estimates are (standard errors are listed in parentheses under coefficient estimates):

$$\ln (w_H / w_L) = \underset{(0.0564)}{0.0183} + \underset{(0.0105)}{0.0314} E - \underset{(0.1390)}{0.3817} \ln (H/L).$$

The estimates imply an elasticity of substitution of 2.6, somewhat larger than typically assumed for the elasticity between college and high school-educated workers. The electrification term ranges between 1.6 and 5.5 percentage points across the states of interest, so it is small but non-negligible in the 1940 regression.

We then apply this equation to the available data in 1909. Here we cannot attain results for Illinois, Ohio and Wisconsin separately, since we lack individual level data for education in these states. We compare the predict the actual log relative wage results with the predicted results, as well as the Mincerian returns from Table 4 in Table 7. (The predicted relative wage has been normalized to zero in California.) We note three patterns between the actual and predicted data. First, with the exception of Illinois-Wisconsin-Ohio, the actual relative wages are much higher than the predicted returns, suggesting that perhaps our 1940 estimates overstate the extent of substitutability, or overestimate the extent to which electricity is skill-biased. Second, the relationship does seem nonetheless to be capturing something. With the exception again for Illinois-Ohio-Wisconsin, the predicted relative wages increase with the actual relative wages. Finally, the relative pattern in the predicted data is actually more in line with the measured Mincerian returns from Table 4 than with the relative wages we construct, this suggests perhaps that some aggregation in cells – necessary given limited data – may be distorting measurement of these relative wages in 1909.

In 1909, electrification levels are an order of magnitude lower than in 1940. The $0.0314E$ term amounts to less than 0.002 in each state. Hence, the predicted variation comes from labor endowments, which may be a reason that the returns in Illinois-Ohio-Wisconsin and Texas are underpredicted. The fact that the fit is imperfect may point to the limitations of predicting low levels of electrification from the higher 1940 levels, the limitation of our proxies for the supply and demand of skill, or the limitations of a purely neoclassical approach to technological change and the demand for skill. Technological change may itself be endogenous to human capital accumulation or relative factor prices (as in Acemoglu, 1998), or both may be driven ultimately by institutions.[17] Next we look to additional confirmatory evidence and consider the generalizability and robustness of the results presented in this section.

4 Robustness

We have argued that the geographic variation uncovered in teachers' returns to schooling is indicative of variation in returns in the overall labor force. We use two checks to test the robustness of this assumption. First, we estimate the returns for men only, as women teachers may have had fewer outside options in the broader labor market.[18] To the extent that variation in schooling identifies the returns to education in a Mincerian regression, separating the sample by gender would tell us if the total returns were biased. Second, we estimate the returns for teachers with few years of

[17] Ehrlich (2007) gives an overview of research on the role of institutions driving both human capital accumulation and technical change. It would be difficult to get separate institutional instruments for both supply and demand factors.

[18] Carter and Savoca (1991) have suggested that different levels of education and wages by gender were due to the fact that women were expected to be less attached to the labor market than males, making it unwise to invest heavily in education and lowering the wages that they received in the labor market at this time.

experience, which we define as five years or less in the profession.[19] We focus on teachers with little experience because these teachers would presumably have invested less in teacher-specific human capital, and so would hold relatively more general human capital for potential use in the broader labor market. As we noted earlier, younger teachers were more likely to be skilled in science and mathematics, and thus were different in training and orientation than older teachers. We posit that teachers with less experience have more and varied outside options, and are less likely to benefit from firm-specific investments, which could bias the estimates.

Table 8 shows that the pattern in overall returns holds for men's returns as well (despite the fact that women were an important fraction of teachers) and in returns for the young. The returns in California and Georgia are low, while those in the Midwest and Texas were high. These results further support the contention that our estimates of the return to education do not simply reflect regional salary differentials. The returns for men in Georgia would be higher than those in Table 8 if their high salaries and the same average schooling, as reported in Table 3, were used to predict the return to education. The same holds for teachers with few years of experience in the profession. We note, however, that the results do not hold for women only. This is likely due to the fact that women had fewer labor market opportunities, and fits with our argument that the returns for women would likely not track general market returns at the time (Carter and Savoca 1991). Overall, the results of Table 8 give us further confidence that the geographic variation in teachers' returns to schooling reflect geographic variation in schooling returns of the workforce overall.

4.1 Generalizability and Secular Implications

4.1.1 Generalizability

Applying the evidence for secondary teachers to our story of relative endowments in the overall economy raises the question of whether these estimated returns to education are informative about the returns to education in the labor force overall. Specifically, does variation in teachers' returns to education track with the variation in returns to education of the overall labor force? What can these data tell us about the overall returns to schooling in 1909 relative to 1940? To answer

[19] Considering that teachers in the sample averaged more than eight years of experience, this cut-off certainly captures the less experienced teachers while at the same time being a large enough sample to yield robust estimates of the returns to education for the group of teachers with the least attachment to the profession.

these questions we must look at comparisons of teachers with U.S. workers more generally. We use IPUMS census data to confirm the relationship between teachers' returns and overall returns over time, and then compare our 1909 results with later results. One caveat is that the census occupational code for teachers includes all teachers (except for professors/instructors and music, dance or art teachers), and not just secondary teachers. To the extent that education selects people into higher paying secondary school teaching, the IPUMS data will overstate the return to schooling *within* secondary education and thus exceed our estimates.

Figure 1 answers the question about secular variation, showing that the relationship between teachers' returns and overall returns is strong over time. The four different series represent teachers' returns for the states we examine, teachers' returns for all states, overall returns for the states we examine, and overall returns for the nation as a whole. Again the number of teachers in the sample states is relatively few (especially in the 1950 census), so we present robust regression results.[20] All four series move substantially together with a mid-century decline followed by rising returns. Indeed, the results for all workers across the nation and all workers in the sample states are nearly identical. While the estimates of teachers' returns in the sample states have perhaps the weakest relationship with overall returns across the nation, the relationship is still quite strong. The correlation between the two series is 0.81 and a regression of overall returns on teachers' returns in the sample states explains 66 percent of the variation in overall returns. We further note that these results hold within states – the correlation of teachers' returns with returns overall from 1940 to 2000 is quite strong. At the state level, sample sizes of teachers are limited, but, even by state, the correlations over time are high, especially for the larger states: 0.89 for California, 0.63 for Georgia, 0.42 for Iowa, 0.74 for Illinois, 0.92 for Ohio, 0.91 for Texas, and 0.65 for Wisconsin. We therefore again conclude that comparing teachers' returns over time can give us a strong indication of patterns in overall returns over time.

Table 9 does precisely this, comparing the 1909 return to several benchmarks from the 1940 census. The 1909 return is based on a weighted regression of the individual data in 1909. Since the sample sizes varied greatly over region and were not entirely representative, the weights were chosen

[20] Robust regressions incorporate a recursive algorithm for reweighting observations that downweights outliers that have too strong an influence on regression results. Robust regressions produced substantially lower estimates than OLS in 1950 (0.075 vs. 0.096), but otherwise similar results. Robust regression also has little effect on the 1909 sample estimates.

to make the sample representative of the sample of teachers in 1940. This required weighting the California sample by a factor of 1.92, the Georgia sample by a factor of 1.94, and the Texas sample by a factor of 1.74, and weighting the Midwest sample by a factor of 0.59. The resulting estimate for the return to education was 8.3 percent in 1909. At first glance, the returns seem quite high for a within-occupation return to schooling. Comparing with 1940, however, the return is not overly high. Indeed it is slightly less than the Mincerian return of 9.1 percent estimated for teachers in these same states in 1940 though not significantly different. The returns for all workers in these states were somewhat higher at 9.6 percent per year in 1940, while those for the nation overall were slightly lower at 8.9 percent.

Using 1940 as a benchmark, we surmise that since the return to schooling for teachers in the sample states was representative of the returns to workers for the nation overall, the same may be true for 1909. In this case, returns in 1909 would be relatively high (since 1940 preceded the Great Compression and was a year of relatively high returns to schooling), but lower than the most comparable evidence, the returns in Iowa in 1914. Recall the caveat that the returns from 1940 are for all teachers, not just secondary teachers. The 1940 teachers' regressions include both primary and secondary teachers, while the 1909 estimates are based on only secondary teachers. Secondary teachers tend to be more educated and substantially better paid. To the extent that schooling enables teachers to sort into higher paying secondary education jobs, the 1940 estimates would be biased upward as an estimate of the return to education of secondary teachers.

5 Changes in Returns to Education and Technology Over Time

Earlier, we noted that effects of initial endowments would not only influence returns to education at a point in time, but they would also influence the evolution of the returns to skill and the adoption of technology as well. Theories therefore argue for persistent differences in the education of the labor force and technology. The returns to education are not available until 1940, but Figure 2 plots enrollment rates for ages 14-20 for each state (a proxy for schooling investment) and Figure 3 plots manufacturing value-added per capita (a proxy for the adoption of industrial technologies). We note several things. First, while enrollment rates increase in all states, the differences in educational investment rates are persistent. Second, the proxy for the spread of manufacturing broadly increases between 1910 and 1930, before declining in 1940, which may well be a lingering effect of the Great Depression. Nonetheless, substantial differences persist across states. Third, Georgia falls markedly further behind the other states, since it does not exhibit a steep increase in enrollments during the 1920s.

The states appear to fall into two groups. California, Illinois, Ohio and Wisconsin show rapid industrialization and high levels of education growth, while Texas, Georgia and Iowa show slower growth along both dimensions. The rapid growth in industrialization in California may be consistent with its high initial levels/low relative price of high-skilled labor, and with technology chasing this complementary factor. Texas and Iowa also had high levels of education but the higher initial relative price of high-skilled labor in these states indicate that there may not have been an oversupply. In any case, the fact that our measures of technology adoption and skill acquisition seem to move together is consistent with their complementarity.

In later periods, with increased migration and more integrated labor markets, we would expect returns to converge into a single market. We might also expect patterns of technology adoption, and therefore income, to be less related to endowments of labor since labor is increasingly mobile. A cursory examination of later data is consistent with this.

After 1940, we are able to track returns to schooling at a higher frequency using IPUMS data for 1940 to 2000. We show the results in Table 10, which shows the returns to education for all of the states we consider for 1940 to 2000. As the table shows, the returns to education among all workers converge from 1940 to 2000. In 1940, with the exception of Georgia, the relative pattern of returns is similar to 1909. The fact that Georgia was particularly slow to join the high school movement, and this lagging behind in higher education may play a role in the higher returns. Over time, however, the returns across regions converge over the second half of the twentieth century and by 1990 they are quite comparable.

These convergence patterns parallel those in education and income. In 1940, average years of schooling were just 7.9 in Georgia, as compared to the higher levels of 10.4 to 11.1 in the midwestern states, 11.6 in California, and even 9.9 in Texas. By 1990, all states are between 12.4 and 12.9 years. In 1940, personal income per capita in Illinois and California were more than twice as large as in Georgia. By 1990, this gap had shrunk to just 20 percent. Before 1940, more direct measures of technologies themselves also showed persistent effects that eventually lessened as the American economy integrated. In keeping with the need to use time-consistent measures, we concentrate on electric capacity and value-added per establishment, related to the scale technologies that Goldin and Katz (1998) emphasize. The results, available upon request, show that the states with relatively modest returns to education in 1909 saw substantial increases in both measures. We also find that the midwestern states, particularly Ohio and Illinois, saw lower increases in both measures over that time period. As with the historical measures presented earlier, we caution that these measures are only rough proxies, but show a significant amount of convergence, consistent with increased demand for skilled labor in Georgia.

6 Conclusion

We have presented evidence that differential factor endowments and differential prevalence of technologies are important parts of the story of how skill-biased technical change the returns to education. We have argued that the shape of these changes over time will be related to factor endowments before the skill-biased technical change. If capital intensity or electrification is related to skill-bias, then we would predict that regions with greater degrees of capital intensity would experience higher returns to education than those with less capital-intensive technologies.

We have shown, using historical evidence on the returns to education for secondary teachers in the U.S., that the returns to education showed marked geographic variation. Our data on the returns to skill for secondary teachers in the very earliest part of the twentieth century is consistent with our theoretical predictions. Teachers in the Midwest had greater returns to education than those in the South. Furthermore, we found that this result is robust – the returns to teachers tracks with the returns to skill more generally, and our result was robust to considering only men and younger teachers. In sum, we find strong evidence that returns to education were large in 1909 in the Midwest, consistent with Goldin and Katz, but that they may have varied considerably across states. As such, the study of U-shaped returns to education should be modified to reflect the fact that returns for some regions rose more persistently across the twentieth century. We emphasized, however, an important caveat to our interpretation. Our results hinge on the relative supply and demand for skilled workers, and since we do not have direct evidence on either, there remains a fundamental identification problem with these returns. While we believe that our proxies do capture those supply and demand conditions as best we can document them, direct evidence would act as stronger support.

The variation in returns to education has important implications for the study of the returns to skill more generally, and for education and immigration policies in many developing nations in particular. Rather than states or regions of one nation, we could easily imagine different nations or individual cities with sufficiently segmented factor markets, where locations with large capital endowments will see large returns to education, while those with relatively small capital endowments will see small returns initially. For example, Uwaifo (2006) notes considerable debate over the size and shape of returns to education in Sub-Saharan Africa, with most anecdotal evidence pointing to low returns. Her estimates of the return to education in Nigeria in the 1990s (3.6%) are similar to the returns we found in Georgia in 1909. Our results suggest that while skill-biased technological change eventually lead to universal large returns to skill in the long run as markets integrate and capital intensity diffuses, in the short run locations with relatively small capital endowments may see negligible returns to education. This has important implications for immigration, emigration, and urban policies in locations with small factor endowments – to create incentives for the high-skilled workforce to remain when the returns to education are low at home, but large in other parts of the world.

References

[1] Abowd, John M., et. al. (2007). "Technology and the Demand for Skill: An Analysis of Within and Between Firm Differences." NBER Working Paper No. 13043.

[2] Acemoglu, Daron (1998). "Why do New Technologies Complement Skills? Directed Technical Change and Wage Inequality." *Quarterly Journal of Economics* 113 (4): 1055-1089.

[3] Autor, David, Frank Levy and Richard J. Murname (2003). "The Skill Content of Recent Technological Change: An Empirical Exploration." *Quarterly Journal of Economics* 118 (4): 1279-1333.

[4] Beaudry, Paul, Mark Doms and Ethan Lewis (2006). "Endogenous Skill Bias in Technology Adoption: City-Level Evidence from the IT Revolution." NBER Working Paper No. 12521.

[5] Bleakley, Hoyt (2007). "Disease and Development: Evidence from Hookworm Eradication in the American South." *Quarterly Journal of Economics* 122 (1) 73-117.

[6] Bodenhorn, Howard (1996). "A More Perfect Union: Regional Interest Rates in the Twentieth Century United States." In *Anglo-American Financial Systems: Institutions and Markets in the Twentieth Century*, Eds. Michael Bordo and Richard Sylla. Burr Ridge, Illinois: Irwin, pp. 415-453.

[7] Carlson, Leonard (1981). "Labor Supply, the Acquisition of Skills and the Location of Southern Textile Mills, 1880-1900," *Journal of Economic History* 41 (1): 65-71.

[8] Carter, Susan and Elizabeth Savoca (1988). "Labor Mobility and Lengthy Jobs in 19th Century America." *Journal of Economic History* 50 (1): 1-16.

[9] Carter, Susan and Elizabeth Savoca (1991). "Gender Differences in Learning and Earning in Nineteenth Century America: The Role of Expected Job and Career Attachment." *Explorations in Economic History* 28 (3): 323-343.

[10] Caselli, Francesco and Wilbur John Coleman (2006). "The World Technology Frontier." *American Economic Review* 96: 499-522.

[11] Collins, William J. (1997). "When the Tide Turned: Immigration and the Delay of the Great Black Migration." *Journal of Economic History* 57 (3): 607-632.

[12] Comin, Diego A., Bart Hobijn and Emilie Rovito (2007). "World Technology Usage Lags." NBER Working Paper No. 12677.

[13] Davis, Lance (1965). "The Investment Market, 1870-1914: The Evolution of a National Market." *Journal of Economic History* 25 (3): 355-393.

[14] Eichengreen, Barry (1984). "Mortgage Interest Rates in the Populist Era." *American Economic Review* 74 (5): 995-1015.

[15] Eichengreen, Barry (1987). "Agricultural Mortgages in the Populist Era: Reply to Snowden." *Journal of Economic History* 47 (3): 757-760.

[16] Ehrlich, Isaac (2007) "The Mystery of Human Capital as Engine of Growth, or Why the US Became the Economic Superpower in the 20th Century", NBER Working Paper No. 12868

[17] Fishback, Price (1998). "“Operations of ‘Unfettered’ Labor Markets: Exit and Voice in American Labor Markets at the Turn of the Century.” *Journal of Economic Literature* 36 (2): 722-765.

[18] Goldin, Claudia D. (1999). "A Brief History of Education in the United States." NBER Working Paper No. h119.

[19] Goldin, Claudia D. and Lawrence F. Katz (1995). "The Decline of Non-Competing Groups: Changes in the Premium to Education, 1890 to 1940." NBER Working Paper No. 5202.

[20] Goldin, Claudia D. and Lawrence F. Katz (1998). "The Origins of the Technology-Skill Complementarity." *The Quarterly Journal of Economics* 113 (3): 693-732.

[21] Goldin, Claudia D. and Lawrence F. Katz (1999). "The Returns to Skill in the United States across the Twentieth Century." NBER Working Paper No. 7126.

[22] Goldin, Claudia D. and Lawrence F. Katz (2000). "Education and Income in the Early Twentieth Century: Evidence from the Prairies." *Journal of Economic History* 60 (3): 782-818.

[23] Goldin, Claudia D. and Lawrence F. Katz (2003). "Mass Schooling and the State." NBER Working Paper No. 10075.

[24] Goldin, Claudia D. and Lawrence F. Katz (2008). *The Race Between Education and Technology.* Cambridge, MA: Harvard University Press.

[25] Goldin, Claudia D. and Robert A. Margo (1992). "The Great Compression: The Wage Structure in the United States at Mid-Century." *The Quarterly Journal of Economics* 107 (1): 1-34.

[26] Goldin, Claudia D. and Kenneth Sokoloff (1984). "The Relative Productivity Hypothesis of Industrialization: The American Case 1820 to 1850." *The Quarterly Journal of Economics* 99 (3): 461-488.

[27] Lamoreaux, Naomi R. and Kenneth L. Sokoloff (2000). "Location and Technological Change in the American Glass Industry During the Late Nineteenth and Early Twentieth Centuries." *Journal of Economic History* 60 (3): 700-729.

[28] Law, Marc T. and Mindy S. Marks (2007). "Effects of Occupational Licensing Laws on Minroities: Evidence from the Progressive Era." Working Paper, University of California.

[29] Margo, Robert A. (1990). *Race and Schooling in the South, 1880-1950: An Economic History.* Chicago: University of Chicago Press.

[30] Mitchener, Kris J. and Ian W. McLean (1999). "U.S. Regional Growth and Convergence." *Journal of Economic History* 59 (4): 1016-1042.

[31] Mitchener, Kris J. and Ian W. McLean (2003). "The Productivity of U.S. States Since 1880." *Journal of Economic Growth* 8 (1): 73-114.

[32] Nelson, Richard R. and Gavin Wright (1992). “The Rise and Fall of American Technological Leadership: The Postwar Era in Historical Perspective,” *Journal of Economic Literature*, 30 (4):1931-1964.

[33] North, Douglass C. (1961). *The Economic Growth of the United States, 1790-1860.* New York: Prentice Hall.

[34] Ransom, Roger L. and Richard Sutch (2001). *One Kind of Freedom: The Economic Consequences of Emancipation.* New York: Cambridge.

[35] Rosenbloom, Joshua L. (1990). "One Market or Many? Labor Market Integration in the Late Nineteenth-Century United States." *Journal of Economic History* 50 (1): 85-108.

[36] Rosenbloom, Joshua L. (1996). "Was there a National Labor Market at the End of the Nineteenth Century? New Evidence on Earnings in Manufacturing." *Journal of Economic History* 56 (3): 626-656.

[37] Rosenbloom, Joshua L. (2002). *Looking for Work, Searching for Workers: Labor Markets during American Industrialization.* New York: Cambridge.

[38] Ruggles, Steven and Matthew Sobek, Trent Alexander, Catherine A. Fitch, Ronald Goeken, Patricia Kelly Hall, Miriam King, and Chad Ronnander. Integrated Public Use Microdata Series: Version 3.0 [Machine-readable database]. Minneapolis, MN: Minnesota Population Center [producer and distributor], 2004.

[39] Snowden, Kenneth (1987). "Mortgage Rates and Capital Market Development in the Late Nineteenth Century." *Journal of Economic History* 47 (3): 671-691.

[40] Sylla, Richard (1969). "Federal Policy, Banking Market Structure, and Capital Mobilization in the United States, 1863-1913." *Journal of Economic History* 39 (4): 657-86.

[41] Thorndike, Edward L. (1909). "The Teaching Staff of Secondary Schools in the United States" United States Bureau of Education Bulletin No. 4. Washington, D.C.: Government Printing Office.

[42] Thorndike, Edward L. (1922). "Changes in the Quality of the Pupils Entering High School." *The School Review: A Journal of Secondary Education* 30 (5): 355-359.

[43] Thorndike, Edward L. (1923). "The Interests of Teachers in Studies During their High-School Course." *School and Society* 17 (443): 419-420.

[44] Thorndike, Edward L. and Eleanor Robinson (1923). "The Diversity of High School Students' Programs." *Teachers College Record* 24 (2): 111-121.

[45] Thorndike, Edward L. and P.M. Symonds (1922). "The Occupations of High School Graduates and Non-Graduates." *The School Review: A Journal of Secondary Education* 30 (6): 443-451.

[46] United States Department of Commerce, Bureau of the Census. *Statistical Abstract of the United States.* Washington, D.C.: Government Printing Office. Various Years.

[47] United States Department of Commerce, Bureau of the Census. *Census of Manufactures.* Washington, D.C.: Government Printing Office. Various Years.

[48] Uwaifo, Ruth (2006). "Africa's Education Enigma? The Nigerian Story." Working Paper, Georgia Tech.

[49] Wright, Gavin (1981). "Cheap Labor and Southern Textiles, 1880-1930." *Quarterly Journal of Economics* 96 (4): 605-629.

[50] Wright, Gavin (1987). "The Economic Revolution in the American South." *Journal of Economic Perspectives* 1 (1): 161-178.

[51] Wright, Gavin (1990). "The Origins of American Industrial Success." *American Economic Review* 80 (4): 651-668.

7 Appendix

7.1 Further Evidence on the Heterogeneity of Endowments

Here we provide more detailed evidence of the heterogeneity in the educational and technology endowments at the beginning of the twentieth century. While the labor productivity estimates presented in Table 1 establish regional heterogeneity in labor productivity, they do not tell us about regional heterogeneity in factor endowments themselves.[21] We must turn to more direct measures to gauge the extent of heterogeneity in educational and non-labor endowments in the American past. Ideally, we would like to take the approach of Acemoglu (1998), who argued that historical levels of human and physical capital may induce invention and adoption of new, skill-intensive technologies. If measures of the relative quantities of educated workers and capital at the turn of the last century were available, relative wages and relative quantities could estimate the implied demand for skill by region or state. We could see if the measure of implied demand for skill is correlated with a measure of the pre-existing factor endowment. If the factor endowment plays a key role, we would expect the correlation to be positive. The problem with such an approach is that it does not separate or distinguish capital and technology. Since at this time it was still possible to substitute raw materials, unskilled labor, and physical capital for skill, measures of capital will hide as much as they will show. Given these limitations, we search the historical record for measures of technology – electric motors, combustible engines, horsepower, and other measures – that will capture the nature of skill-biased technical change at this time. We concentrate on measures of technology and skill that reflect the changing environment– allowing us to distinguish locations that were at the technological and educational frontier and those that were not.

Appendix Tables 1 and 2 summarize these educational and non-labor factors. Appendix Table 1 lists measures associated with both the level and growth of education, listing the literacy rate, school expenditures, and school enrollment for the high school aged population in the early twentieth century. California, Illinois, Iowa, Ohio, and Wisconsin all have high literacy rates, each above 95% by 1910 and all but California above 95% in 1900, suggesting a large endowment of relatively skilled workers. Both Georgia and Texas have relatively low literacy rates, suggesting a smaller endowment of skilled workers. The second panel shows school expenditures, both per capita and per capita of the school aged population. Although all states saw significant growth in school expenditures per capita from 1900 to 1920, Georgia was spending less than one quarter of what the midwestern states were, and Texas only slightly more than half. California, by contrast, was spending more than 150% of what the midwestern states were. The last panel of Appendix Table 1 shows school attendance rates for high school age students. In 1910, Georgia is the only state in which less than three quarters of 14 or 15 year olds are not attending school. Texas' attendance rates were approaching the rates for the midwestern states and show a particularly high attendance rate for 16 to 17 year olds. By 1930, California has the highest attendance figures for 1910 to 1930 for 14 and 15 year olds, and very high rates for 16 to 20 year olds.

Appendix Table 2A presents some growth in factors associated with the spread of skill-intensive production methods. The manufacturing share of the labor force in Illinois, Ohio, and Wisconsin

[21] For example, states with a significant percentage of the labor force in mining have a higher level of labor productivity. A priori, returns to education in the West may have been particularly low due to the high wages commanded by unskilled workers, or they could be high because of the technology used to extract these resources. Similarly, these trends in labor productivity tell us little about how labor productivity (price-adjusted income per worker) varied with changes in the educational, capital and resource endowments. While the estimates in Table 1 are broad measures of labor productivity, more microeconomic estimates, such as the regional price-adjusted manufacturing annual earnings estimates by Rosenbloom (2002), largey agree with the income per worker estimates here.

grows by an average of 95% from 1900 to 1910. In Iowa the manufacturing share of the labor force grows by 124% between 1900 and 1910, and in Texas the percentage employed in manufacturing nearly doubles between 1900 and 1910, increasing by 99%. Similarly, the value of machinery per the agricultural workforce increases substantially between 1900 and 1910 in Texas. The growth of Georgia's labor force in manufacturing was relatively modest (only 68%), suggesting a relatively less influential spread of skill-intensive technologies in Georgia, and the manufacturing sector grows the least in California between 1900 and 1910 (only 64%). There were differences in capital deepening – the level of capital per establishment in 1905 was much greater than in 1900 for all states, partly driven by a decrease in the number of establishments, but an outlier in this factor is Texas, which sees a significant increase in the amount of capital per establishment.

As we noted earlier, the story of skill-biased technical change supposes a displacement of the old technology for the new, skill complementing technology, and Appendix Table 2B presents evidence of the prevalence of capital-intensive technologies by state in the beginning of the twentieth century. The number of technological firms and the value added by manufacturing varied considerably. There were many more technological firms in the midwestern states than in the South or the West. California and Texas, states with significant natural resource endowments, have relatively low levels of value added in manufacturing. This carries over into more direct measures of technology, such as the number of internal combustion engines and electric motors, which were much more prominent in the Midwest than in the South or West. California and Texas do increase the number of electric motors by the beginning of the twentieth century, but Georgia still lags well behind the other states in the use of this new technology.

Appendix Table 2C shows that these differences carried over into the early twentieth century. Internal combustion horsepower shows the marked variation in how intensively these technologies were used. Both Georgia and Texas have less than 1,000 internal combustion horsepower in 1900, although they do increase horsepower significantly by 1910. Further inferences can be drawn from the number of internal combustion engines and electric motors per establishment in 1919 and the amount of horsepower from both sources in 1929. While Texas leads in internal combustion power in 1929 and has relatively high amounts of electric power, California, and Georgia lag behind the other states both in the number of electric motors and in horsepower generated by them. Even with the gains made by California, Georgia, and Texas, they continue to lag behind the midwestern states in the number of electric motors per establishment in 1919, and in the amount of electric horsepower per establishment in 1929.

All told, the evidence in Appendix Tables 1 and 2 show that there were marked differences in the factors related to the returns to education in the early twentieth century. We do not argue here that every measure should agree with our general assertions about the regional differences in the supply and demand for skill, and we would be surprised if they did.[22] All of the evidence presented here, however, is more consistent with the proposition of regional heterogeneity than homogeneity, and agrees with our general point about significant regional variation in the educational and technological endowments. While some regions fall easily into a set that would yield predictions about the returns to education, direct estimates of the returns to education are necessary for regions with indeterminate predictions for the returns to education based on their endowments.[23]

A movement towards new capital and skill-intensive processing technologies would not have the same effect on the relatively unindustrialized South as it would on the Midwest. Similarly, one

[22] For example, Lamoreaux and Sokoloff (2000) show that during the late nineteenth century there began to be a divide geographic divide between the centers of invention and the centers of production in some respects.

[23] We also note that, generally, supply of skill is slow to adjust to technology-based demand for skill. As such, levels of skill at a point in time will be exogenous, and returns in the short run would reflect primarily technological factors while long run returns would reflect the endogenous nature of the supply and demand for skill.

would predict that, given differences in their educational endowments, skill-biased technological change would have a different impact in California as opposed to Texas.[24] Given these regional differences in factor endowments at the beginning of the twentieth century, we would expect skill-biased technical change to produce regional differences in returns to education in the early twentieth century. Appendix Table 3 shows the convergence of the technological endowment over the twentieth century. We concentrate here on time-consistent measures such as electric capacity and the value added per manufacturing establishment. Both show marked convergence from 1935 to 1970, in keeping with our assertion that as the endowment converged the returns the education did likewise.

7.2 Theoretical Appendix

7.2.1 A Model of skill-biased Technical Change with Heterogeneous Endowments

Assume initially that there are two sectors of production, a land-dependent sector, t (for traditional agriculture) and a capital-dependent sector o (for old capital-dependent sector).[25] The two sectors use skilled and unskilled labor together with either capital K or land T to produce output

$$\begin{aligned} Y_i &= K_o^{\alpha} H_o^{\beta} L_o^{1-\alpha-\beta} \\ Y_t &= T^{\alpha} H_t^{\beta} L_t^{1-\alpha-\beta} \\ H_t + H_o &= H \\ L_t + L_o &= L \\ K_o &= K. \end{aligned}$$

We model each region as a small open economy that takes the relative price of output in each sector as given, but has its own factor markets. We normalize this relative price of output to one. High- and low-skilled labor are mobile across sectors, and so in equilibrium they each get paid their marginal product and these wages are equalized across sectors. Solving the equilibrium labor allocation and wages is straightforward: in equilibrium, the fraction of high-skilled workers employed in the capital-dependent sector is increasing in the capital/land ratio, and equal to the fraction of low-skilled workers employed

$$\begin{aligned} \frac{K}{K+T} &= \frac{\tilde{H}_o}{H} = \frac{\tilde{L}_o}{L} \\ \frac{\tilde{w}_H}{\tilde{w}_L} &= \frac{\beta}{1-\alpha-\beta}\left(\frac{H}{L}\right)^{-1}. \end{aligned}$$

The expressions show that the fraction of workers employed in industry is increasing in the capital/land ratio, and the relative wage of high-skilled workers is decreasing in their relative abundance. (The tildas signify the initial equilibrium.) Assumption (A1) assures that high-skilled workers are scarce enough to earn a premium over low-skilled workers

$$\frac{H}{L} < \frac{\beta}{1-\alpha-\beta}. \tag{A1}$$

[24] Although we can form predictions about the returns to education in California versus Texas, it is more difficult to predict what the returns would be relative to returns in the Midwest or South.

[25] Here t could represent any sector that is natural resource intensive, but not capital intensive. T would then represent all natural resources.

Now consider the introduction of a new capital-dependent sector (n)

$$Y_i = AK_n^{\alpha} H_n^{\gamma} L_n^{1-\alpha-\gamma}.$$

Since capital is now mobile across the two capital-dependent sectors, the capital constraint becomes:

$$K_o + K_n = K.$$

The new capital intensive sector differs from the old sector in that it is more skilled labor-intensive. Mathematically, this assumption is expressed:

$$\gamma > \beta. \tag{A2}$$

This assumption captures the skill-biased nature of the new technology.

We show that if the new capital-intensive technology is a large enough improvement over the old technology, the new equilibrium has the following characteristics.

Proposition 1 *Given (A1)-(A2), if the productivity of the new technology is sufficiently large, the new capital-intensive sector displaces the old capital-intensive sector, and the new capital-intensive technology sector employs a higher fraction of high-skilled workers than low-skilled workers. That is,*

$$\begin{aligned} \exists A^* \textit{ s.t. for } A &> A^* \\ K_n &= K \\ \frac{H_n}{H} &> \frac{L_n}{L}. \end{aligned}$$

Proposition 2 *Given (A1)-(A2), given the same level of productivity, the number of high-skilled employed in the new capital-intensive technology exceeds the number of high skilled previously employed in the old capital-intensive technology. The relative wage of high-skilled workers also exceeds the previous relative wage. That is,*

$$\begin{aligned} \textit{for } A &> A^* \\ H_n &> \tilde{H}_o \\ \frac{w_H}{w_L} &> \frac{\tilde{w}_H}{\tilde{w}_L}. \end{aligned}$$

Furthermore, if the productivity is even larger, the number of low-skilled workers in the new capital-intensive technology exceeds the number employed in the old capital-intensive technology. In particular,

$$\begin{aligned} \exists \hat{A} &> A^* \textit{ s.t. for } A > \hat{A} \\ L_n &> \tilde{L}_o. \end{aligned}$$

Proposition 3 *Given (A1)-(A2), the higher the capital/land ratio, the higher the fraction of high-skilled* and *low-skilled workers employed in the new capital-intensive technology and the higher the* *relative wage of high-skilled workers. That is,*

$$\begin{aligned} \text{for } A &> A^* \\ \frac{dH_n}{d(K/T)} &> 0 \\ \frac{dL_n}{d(K/T)} &> 0 \\ \frac{d(w_H/w_L)}{d(K/T)} &> 0. \end{aligned}$$

Proposition 4 *Given (A1)-(A2), the introduction of the new technology raises the return to capital relative to land. Furthermore, the higher the high-skilled/low-skilled labor ratio, the larger is this increase in the relative rental rate of capital.*

$$\begin{aligned} \text{for } A &> A^* \\ \frac{R_K}{R_T} &> \frac{\tilde{R}_K}{\tilde{R}_T} \\ \frac{d(R_K/R_T)}{d(H/L)} &> 0. \end{aligned}$$

Together Propositions 1 and 2 show that the model replicates the story of Goldin and Katz (1998). That is, the new capital-dependent sector expands, increasing the relative demand for skilled workers and also their relative wage. If the new technology is a dramatic enough advance it furthers industrialization– displacing the old technology and even employing more unskilled workers than the old technology.[26] This is the standard skill-biased technical change story.

Proposition 3 has strong implications that predict higher returns and more labor employed in the new technology in areas with high relative endowments of capital. Thus, there will be variation in the returns to education that go hand-in-hand with the nature and extent of industrialization before the technological change. The result is entirely intuitive– the region that is technologically backward sees little increase in the returns to education because the technological change is skill intensive, but the backwards region has little of either the old or new capital-intensive technologies. In order for batch processing and electrification to induce high returns to education, there had to be industries that could implement and successfully take advantage of the new technologies. In other words, displacement of old technology will not result in increased returns to education if there is not a significant amount of old technology to be replaced. Proposition 3 highlights the role that the technological endowment has with the return to education. If a region did not have the infrastructure or extensive industry before the diffusion of skill intensive technologies, it would not lead to large returns to education in that region. Proposition 3 therefore provides us with the central test of the theory in Section 3 of the paper.

Finally, Proposition 4 shows how the new technologies increased the incentives to invest in physical capital, especially in areas with high levels of human capital. The new technology increases the return to capital, and the increases will be larger the larger the educational endowment. The model therefore offers an explanation for increased levels of industrialization experienced in the first half of the century, but faster industrialization in the Northeast, Midwest and West (where schooling levels were high) than in the South, where they were lower.

[26] Given the static nature of the problem, Proposition 1 implies extreme displacement. In the real world, the changeover of capital from the old to new technology is clearly a slower process.

7.2.2 Derived Demand and Teachers' Relative Wages

Ideally, we would like to test these implications directly using economy wide wage data. Unfortunately, such data is not readily available. We show that reasonable assumptions translate the relative wages of workers overall into relative wages of high- and low-skilled teachers through the derived demand for education and ultimately teachers. We model a schooling sector, and allow students to decide whether to become high- or low-skilled. Let h and l denote the number who become high- and low-skilled, respectively, which are produced using high- and low-skilled workers:

$$\begin{aligned} h &= F_h(H_h, L_h) \\ l &= F_l(H_l, L_l) \\ H_h + H_l &= H_s \\ L_h + L_l &= L_s. \end{aligned}$$

The following proposition delineates three assumptions for the above predictions regarding relative wages in the economy overall to also hold for relative wages in the schooling sector.

Proposition 5 *Assume:*
(i) the relative supply of high-skilled teachers is increasing in the relative supply of high-skilled workers in the overall labor force, i.e., $\frac{\partial(H_s/L_s)}{\partial(H/L)} > 0$*; (ii) the relative student demand for high- vs. low-skilled educations is increasing in the relative wage to high-skilled workers, i.e.,* $\frac{\partial(h/l)}{\partial(w_h/w_l)} > 0$*; (iii) the production of high-skilled education is more intensive in high-skilled teachers than the low-skilled education, i.e.,* $H_h/L_h > H_l/L_l$*. Then the relative wage of high-skilled teachers increases, and increases more the higher the capital to land ratio:*

$$\begin{aligned} \frac{w_h}{w_l} &> \frac{\tilde{w}_h}{\tilde{w}l} \\ \frac{d\,(w_h/w_l)}{d\,(K/T)} &> 0. \end{aligned}$$

Given the assumptions in Proposition 5, the predictions for relative wage overall in Propositions 2 and 3 also hold for the relative wage of teachers. Intuitively, increasing returns to skill (which are a function of the factor endowments) lead to increasing demand for education. Since the type of education demanded is intensive in high-skilled individuals, the returns to education for teachers of high level skills will mirror the returns to skill more generally.

7.2.3 Proofs

Proof of Proposition 1: *A) Proving* $K_n = K$

Since the land-intensive technology and the old capital-intensive technologies have the same factor shares, it can be readily shown that they will always employ the same ratio of inputs. It is also trivial to show that K_n, H_n and L_n are increasing in A. Thus, A^* can be derived as the level that equates the marginal return to capital in the new capital-intensive technology when all capital is employed in that sector (i.e., $K_n = K$) to the marginal return to land in the land-intensive sector (which equals the potential marginal return to capital in the old capital-intensive sector):

$$\begin{aligned} R_{K,n}(A^*) &= R_{K,o}(A^*) \\ A^* \alpha K^{\alpha-1} (f_H H)^{\gamma} (f_L L)^{1-\alpha-\gamma} &= \alpha T^{\alpha-1} \left((1-f_H)\,H\right)^{\beta} \left((1-f_L)\,L\right)^{1-\alpha-\beta}. \end{aligned}$$

Solving for

$$A^* = \frac{(1-\alpha-\beta)^{1-\alpha-\beta}\,\beta^\beta}{(1-\alpha-\gamma)^{1-\alpha-\gamma}\,\gamma^\gamma}\left(\frac{H}{L}\right)^{\beta-\gamma}\left[\frac{(1-\alpha)\,(T+K)}{(\beta T+\gamma K)}-1\right]^{\beta-\gamma}.$$

For all levels higher than A^*, $R_{K,n}(A^*) = \tilde{R}_{K,o}(A^*)$ and so $K_n = K$.

B. Proving $\frac{H_n}{H} > \frac{L_n}{L}$

We prove by contradiction. Defining $f_H \equiv \frac{H_n}{H}$ and $f_L \equiv \frac{L_n}{L}$ we assume $\frac{H_n}{H} \leq \frac{L_n}{L}$, which is $f_H < f_L$.Optimality again requires

$$\begin{aligned} w_H &= \gamma A\left(\frac{K}{f_L L}\right)^\alpha\left(\frac{f_H H}{f_L L}\right)^{\gamma-1} \\ &= \beta\left[\frac{T}{(1-f_L)\,L}\right]^\alpha\left[\frac{(1-f_H)\,H}{(1-f_L)\,L}\right]^{\beta-1} \qquad (1) \\ w_L &= (1-\alpha-\gamma)\,A\left(\frac{K}{f_L L}\right)^\alpha\left(\frac{f_H H}{f_L L}\right)^\gamma \\ &= (1-\alpha-\beta)\left[\frac{T}{(1-f_L)\,L}\right]^\alpha\left[\frac{(1-f_H)\,H}{(1-f_L)\,L}\right]^\beta. \qquad (2) \end{aligned}$$

Dividing the two equations by each other yields:

$$\begin{aligned} \frac{\gamma}{(1-\alpha-\gamma)}\frac{(1-f_H)}{(1-f_L)} &= \left(\frac{f_H}{f_L}\right)\frac{\beta}{(1-\alpha-\beta)} \\ \frac{\gamma}{(1-\alpha-\gamma)} &\leq \frac{\beta}{(1-\alpha-\beta)} \\ \gamma &\leq \beta. \end{aligned}$$

But $\gamma > \beta$, by assumption.

Proof of Proposition 2 *A) Proof of* $H_n > H_o$

Again, one can trivially show that H_n is increasing in A, so it suffices to show that at $A = A^*$, $H_n > H_o$. We prove equivalently that $f_H > \tilde{f}_H$. Consider the first order conditions above. Dividing the top by the bottom yields and expression for which we define an implicit function:

$$g_1(f_H, f_L) = \left[\begin{array}{c} \frac{\gamma}{(1-\alpha-\gamma)}\frac{(1-f_H)}{f_H} - \\ \frac{(1-f_L)}{f_L}\frac{\beta}{(1-\alpha-\beta)} \end{array}\right] = 0$$

It is trivial to show that $\partial g_1/\partial f_H < 0$ and $\partial g_1/\partial f_L < 0$. Since $f_L < f_H$, it suffices to show that $g_1(\tilde{f}_H,\tilde{f}_L) > 0$. Substituting in $\tilde{f}_H = \tilde{f}_L = K/(T+K)$ yields

$$g_1(\tilde{f}_H, \tilde{f}_L) = \frac{T}{K}\left(\frac{\beta}{(1-\alpha-\beta)} - \frac{\gamma}{(1-\alpha-\gamma)}\right) < 0$$

since $\gamma > \beta$.

B) Proof of $\frac{w_H}{w_L} > \frac{\tilde{w}_H}{\tilde{w}_L}$

We prove by contradiction assume:

$$
\begin{aligned}
\frac{w_H}{w_L} &< \frac{\tilde{w}_H}{\tilde{w}_L} \\
\frac{\beta}{(1-\alpha-\beta)}\left(\frac{(1-f_H)\,H}{(1-f_L)\,L}\right)^{-1} &< \frac{\beta}{(1-\alpha-\beta)}\left(\frac{\tilde{f}_H H}{\tilde{f}_L L}\right)^{-1} \\
\left(\frac{1-f_H}{1-f_L}\right)^{-1} &< 1 \\
f_H &< f_L
\end{aligned}
$$

which contradicts Proposition 1.

C) Proof of $L_n > \tilde{L}_o$ for $\forall A$ for $\hat{A} > A^*$

It is trivial to show that both H_n and L_n are increasing in A. We show that $H_n + L_n < \tilde{H}_o + \tilde{L}_o$ for $A = A^*$ and then derive $\hat{A}$.

Assume $A = A^*$ and $L_n > \tilde{L}_o$. By construction at A^*, the marginal product of capital and land are equated, as are the marginal product of low skilled workers:

$$
\begin{aligned}
\alpha A^* K^{\alpha-1}\left(f_H H\right)^{\gamma}\left(f_L L\right)^{1-\alpha-\gamma} &= \\
\alpha T^{\alpha-1}\left(\left(1-f_H\right)H\right)^{\beta}\left(\left(1-f_L\right)L\right)^{1-\alpha-\beta} &
\end{aligned}
$$

$$
\begin{aligned}
(1-\alpha-\gamma)\,A^* K^{\alpha-1}\left(f_H H\right)^{\gamma}\left(f_L L\right)^{-\alpha-\gamma} &= \\
(1-\alpha-\gamma)\,T^{\alpha-1}\left(\left(1-f_H\right)H\right)^{\beta}\left(\left(1-f_L\right)L\right)^{-\alpha-\beta} & \qquad .
\end{aligned}
$$

Dividing these two expressions by each other yields:

$$
\begin{aligned}
\frac{1}{(1-\alpha-\gamma)}\left[\frac{f_L L}{K}\right] &= \frac{1}{(1-\alpha-\beta)}\left[\frac{(1-f_L)\,L}{T}\right] \\
\frac{T}{(1-\alpha-\gamma)}\left(1-f_L\right) &= \frac{K}{(1-\alpha-\beta)} f_L \\
\frac{(1-\alpha-\gamma)\,K}{(1-\alpha-\gamma)\,K+(1-\alpha-\beta)\,T} &= f_L.
\end{aligned}
$$

The expressions can be solved for f_L and $f_{H:}$. Now we start with the assumption:

$$
\begin{aligned}
\frac{(1-\alpha-\gamma)\,K}{(1-\alpha-\gamma)\,K+(1-\alpha-\beta)\,T} &> \frac{K}{T+K} \\
\gamma &< \beta
\end{aligned}
$$

which contradicts (A2)

We now derive $\hat{A}$ by assuming:

$$
\hat{f}_L = \tilde{f}_L = \frac{K}{T+K} \tag{3}
$$

and solving for the implied $\hat{A}$. The first order conditions for high and low skilled labor again yield the following expression:

$$\begin{aligned}
\left(\frac{1-\alpha-\gamma}{\gamma}\right)\frac{\left(1-\hat{f}_L\right)}{\hat{f}_L} &= \left(\frac{1-\alpha-\beta}{\beta}\right)\frac{\left(1-\hat{f}_H\right)}{\hat{f}_H} \\
\left(\frac{1-\alpha-\gamma}{\gamma}\right)\frac{T}{K}\hat{f}_H &= \left(\frac{1-\alpha-\beta}{\beta}\right)(1-f_H) \\
\hat{f}_H &= \frac{\gamma(1-\alpha-\beta)K}{[\gamma(1-\alpha-\beta)K+\beta(1-\alpha-\gamma)T]}.
\end{aligned}$$

Substituting $\hat{f}_L$ and $\hat{f}_H$ into the first order condition on high-skilled labor, we solve for $\hat{A}$:

$$\hat{A} = \frac{\beta}{\gamma}\left[\frac{\beta(1-\alpha-\gamma)(T+K)}{[\gamma(1-\alpha-\beta)K+\beta(1-\alpha-\gamma)T]}\frac{H}{L}\right]^{\beta-\gamma}$$

Proof of Proposition 3 The relative wage equals the ratio of the marginal products in agriculture, which can be simplified to:

$$\begin{aligned}
w_H/w_L &= \frac{\beta}{1-\alpha-\beta}\left(\frac{L_a}{L_a}/\frac{L}{H}\right) \\
\frac{d\log(w_H/w_L)}{d\log(K/T)} &= \frac{d\log(1-f_L)}{d\log(K/T)} - \frac{d\log(1-f_H)}{d\log(K/T)}.
\end{aligned}$$

So we proceed by showing that $\frac{d\log(1-f_H)}{d\log(K/T)} < \frac{d\log(1-f_L)}{d\log(K/T)} < 0$, which implies $\frac{dH_n}{d(K/T)} > 0$ and $\frac{dL_n}{d(K/T)} > 0$, and, by the above equation, $\frac{d(w_H/w_L)}{d(K/T)} > 0$. To simplify presentation, we change notation to work directly with the fractions of labor in agriculture, ${}^a f_L \equiv 1-f_L$ and ${}^a f_H \equiv 1-f_H$, and use the implicit function defined by the log of the first-order conditions for comparative statics

$$\begin{aligned}
\log\left(\frac{\gamma}{\beta}\right) + \log A + (\alpha+\beta-1)\log^a f_L + & \\
(1-\alpha-\gamma)\log(1-^a f_L) + (1-\beta)\log^a f_H + & \\
(\gamma-1)\log(1-^a f_H) + \alpha\log\left(\frac{K}{T}\right) + (\gamma-\beta)\log\left(\frac{H}{L}\right) &= 0 \\
\log\left(\frac{1-\alpha-\gamma}{1-\alpha-\beta}\right) + \log A + (\alpha+\beta)\log^a f_L + & \\
(-\alpha-\gamma)\log(1-^a f_L) - \beta\log^a f_H + & \\
\gamma\log(1-^a f_H) + \alpha\log\left(\frac{K}{T}\right) + (\gamma-\beta)\log\left(\frac{H}{L}\right) &= 0.
\end{aligned}$$

Now solving the first order conditions for the change $d\log^a f_H$ and $d\log^a f_L$ as $\log(K/T)$ yields the following system of equations:

$$\begin{bmatrix} \begin{bmatrix} (1-\beta)+ \\ (1-\gamma)\left(\frac{^a f_H}{1-^a f_H}\right) \end{bmatrix} & \begin{bmatrix} (\alpha+\beta-1)- \\ (1-\alpha-\gamma)\left(\frac{^a f_L}{1-^a f_L}\right) \end{bmatrix} \\ \begin{bmatrix} -\beta- \\ \gamma\left(\frac{^a f_H}{1-^a f_H}\right) \end{bmatrix} & \begin{bmatrix} (\alpha+\beta)+ \\ (\alpha+\gamma)\left(\frac{^a f_L}{1-^a f_L}\right) \end{bmatrix} \end{bmatrix} \begin{matrix} \frac{d\log^a f_H}{d\log(K/T)} \\ \frac{d\log^a f_L}{d\log(K/T)} \end{matrix} = \begin{matrix} -\alpha \\ -\alpha \end{matrix}$$

Defining the 2 by 2 matrix as M. Given ${}^a f_L >^a f_H$ (which follows immediately from Proposition 1), we show after algebraic simplification that that the determinant of M is positive:

$$
\begin{aligned}
|M| &= \alpha + \alpha \left(\frac{{}^a f_H}{1 -^a f_H} + \frac{{}^a f_L}{1 -^a f_L} \right) + \\
& \quad \alpha \left(\frac{{}^a f_H}{1 -^a f_H} \right) \left(\frac{{}^a f_L}{1 -^a f_L} \right) + \\
& \quad \alpha (\gamma - \beta) \left(\frac{{}^a f_L}{1 -^a f_L} - \frac{{}^a f_H}{1 -^a f_H} \right) > 0.
\end{aligned}
$$

Applying Cramer's rule, we show that the resulting solutions are therefore negative:

$$
\begin{aligned}
\frac{d \log^a f_H}{d \log (K/T)} &= \frac{-\alpha \left[1 + \left(\frac{{}^a f_L}{1 -^a f_L} \right) \right]}{|M|} < 0 \\
\frac{d \log^a f_L}{d \log (K/T)} &= \frac{-\alpha \left[1 + \left(\frac{{}^a f_H}{1 -^a f_H} \right) \right]}{|M|} < 0
\end{aligned}
$$

and the difference between the first exceeds the second:

$$
\begin{aligned}
\frac{d \log^a f_L}{d \log (K/T)} - \frac{d \log^a f_H}{d \log (K/T)} &= \frac{\alpha \left(\frac{{}^a f_L}{1 -^a f_L} - \frac{{}^a f_H}{1 -^a f_H} \right)}{\left[\begin{array}{c} \alpha + \alpha \left(\frac{{}^a f_L}{1 -^a f_L} + \frac{{}^a f_H}{1 -^a f_H} \right) \\ +\alpha \left(\frac{{}^a f_L}{1 -^a f_L} \right) \left(\frac{{}^a f_H}{1 -^a f_H} \right) + \\ \alpha((\gamma - \beta) \left(\frac{{}^a f_L}{1 -^a f_L} - \frac{{}^a f_H}{1 -^a f_H} \right) \end{array} \right]} \\
&> 0.
\end{aligned}
$$

Proof of Proposition 4 The fact that $\frac{R_K}{R_T} > \frac{\tilde{R}_K}{\tilde{R}_T}$ follows directly from Proposition 1. We know that $\frac{\tilde{R}_K}{\tilde{R}_T} = 1$, and from the proof in Proposition 1, we show that $R_K > R_T$. We show now that the relative return to capital and labor is increasing in H/L:

$$
\begin{aligned}
\frac{R_K}{R_T} &= \frac{\alpha A K^{\alpha-1} (f_H H)^{\gamma} (f_L L)^{1-\alpha-\gamma}}{\alpha T^{\alpha-1} ((1 - f_H) H)^{\beta} ((1 - f_L) L)^{1-\alpha-\beta}} \\
&= A \left(\frac{K}{T} \right)^{\alpha-1} \left(\frac{f_H}{f_L} \right)^{\gamma} \left(\frac{1 - f_L}{1 - f_H} \right)^{\beta} \left(\frac{H}{L} \right)^{\gamma-\beta}
\end{aligned}
$$

$$
\frac{1 - \alpha - \gamma}{\gamma} \left(\frac{f_H}{f_L} \right) = \frac{1 - \alpha - \beta}{\beta} \left(\frac{1 - f_H}{1 - f_L} \right)
$$

$$
\begin{aligned}
\frac{R_K}{R_T} &= A \frac{\beta (1 - \alpha - \gamma)}{\gamma (1 - \alpha - \beta)} \left(\frac{K}{T} \right)^{\alpha-1} \left(\frac{f_H H}{f_L L} \right)^{\gamma-\beta} \\
\frac{d (R_K/R_T)}{d (K/L)} &= C \left(\frac{K}{T} \right)^{\alpha-1} \left(\frac{H_n}{L_n} \right)^{\gamma-\beta-1} \frac{d (H_n/L_n)}{d (K/L)} > 0
\end{aligned}
$$

where

$$C = A(\gamma - \beta) \frac{\beta(1 - \alpha - \gamma)}{\gamma(1 - \alpha - \beta)}.$$

Proof of Proposition 5 Given condition (iii), the effect of (h/l) on w_h/w_l follows from the Stolper-Samuelson Theorem. Condition 1 connects the effects on $w_{h,s}/w_{l,s}$ to w_H/w_L. Similarly, given condition (iii), the effect of H_s/L_s on w_h/w_l follows from the Rybcynski Theorem, while Condition (ii) connects these effects on $w_{h,s}/w_{l,s}$ to w_H/w_L.

Table 1

Summary of Productivity Estimates by Region and State, 1880-1920

Region	Price Adjusted Income per Worker Relative to US Average 1900	1920
West	126	117
Midwest	114	102
South	56	67
Northeast	128	125

State	Price Adjusted Income per Worker 1900	1920
California	754.9	2223.0
Georgia	206.8	857.2
Illinois	729.2	2042.1
Iowa	625.4	1585.7
Ohio	624.8	1842.0
Texas	389.6	1371.3
Wisconsin	523.7	1537.4

Sources:

Regional Estimates (Top Panel) come from Mitchener and McLean (1999) Table 1 (p. 1019). State Estimates (Bottom Panel) come from Mitchener and McLean (2003) Appendix Table 1. The relative income estimates are population weighted and take the US average as 100 (e.g. a region estimate of 50 implies that region had income per worker that was 50% of the US average).

Table 2
Heterogeneity in Technology and Educational Endowments in 1910

	Industrial Technology Measures					Agricultural Technology Measures		
	Percent Labor in Manufacturing	Establishments/ 1000 Persons	Horsepower/ 1000 Persons	Capital/ 1000 Persons	Value Added/ 1000 Persons	Percent Labor in Agriculture	Value of Livestock/ Farm worker	Value of Capital/ Farm Worker
California	13.7	3.2	138.4	225.9	86.0	22.5	239	68
Georgia	9.7	1.8	114.3	77.7	32.9	59.6	52	13
Illinois	23.9	3.2	179.7	274.6	134.5	19.8	276	70
Iowa	11.2	2.5	69.8	77.0	39.8	40.5	436	106
Ohio	27.8	3.2	332.1	272.9	128.7	22.5	184	48
Texas	6.4	1.2	72.5	55.7	24.3	55.6	147	26
Wisconsin	25.3	4.2	237.5	259.5	104.5	33.0	206	69

	Education Measures		
	Literacy Rate	Public Spending per Person Aged 5-17	Percent Enrolled Aged 14-20
California	95.5	39.4	43.5
Georgia	76.7	5.3	33.6
Illinois	95.7	24.5	36.1
Iowa	98.0	21.9	45.1
Ohio	96.5	22.6	39.7
Texas	87.8	9.7	43.3
Wisconsin	96.3	16.8	37.8

Notes: Public spending includes only primary and secondary school spending. Data on establishments, horse power, capital and value added are for the year 1909.
Sources: Statistical Abstract of the United States, 1916, Abstract of the 14th Census of the United States

Table 3
Summary Statistics from Thorndike Report

	California	Georgia	Ohio, Illinois, & Wisconsin	Texas
Mean Annual Salary (Overall)	1142	828	848	733
	(316)	(377)	(379)	(278)
Mean Annual Salary (Men)	1375	1001	918	823
	(344)	(331)	(403)	(290)
Mean Annual Salary (Women)	1020	474	757	575
	(219)	(145)	(323)	(159)
Mean Years Schooling (Overall)	13.8	12.6	12.6	12.6
	(1.4)	(1.7)	(1.9)	(1.9)
Mean Years Schooling (Men)	13.9	12.9	12.4	12.8
	(1.6)	(1.6)	(2.1)	(2.0)
Mean Years Schooling (Women)	13.7	11.9	12.9	12.2
	(1.4)	(1.6)	(1.6)	(1.6)
Mean Years Experience (Overall)	8.3	8.2	9.1	9.6
	(7.0)	(5.8)	(7.2)	(7.1)
Mean Years Experience (Men)	10.6	9.2	10.0	10.3
	(7.3)	(6.1)	(7.1)	(7.3)
Mean Years Experience (Women)	7.1	6.2	8.0	8.3
	(6.5)	(4.6)	(7.1)	(6.6)
Fraction Male	0.34	0.67	0.57	0.64
Number of Observations	658	137	3141	381

Source: Authors' Calculations from Thorndike Report
Standard errors are listed in parentheses.

Table 4
Mincerian Regressions for the Returns to Education by State, 1909

	California	Georgia	Ohio, Illinois, & Wisconsin	Texas
Schooling	0.005	0.033	0.070	0.071
	(0.006)	(0.016)	(0.003)	(0.009)
Experience	0.034	0.012	0.048	0.034
	(0.004)	(0.013)	(0.004)	(0.007)
Exper. Squared	-0.0007	0.0004	-0.0008	-0.0009
	(0.0001)	(0.0006)	(0.0001)	(0.0003)
Male Dummy	0.22	0.64	0.16	0.27
	(0.02)	(0.06)	(0.01)	(0.03)
Intercept	6.67	5.63	5.35	5.26
	(0.08)	(0.20)	(0.04)	(0.10)
R^2	0.45	0.61	0.39	0.42
N	658	137	3141	381

Source: Authors' Calculations from Thorndike Report
Dependent variable is the log of the wage in all regressions.
Robust Standard errors are listed in parentheses.

Table 5
Comparing Mincerian Regression Estimates From Individual- and Median-Level Regressions

State	Schooling Coefficient		Male Coefficient		Intercept	
	Individual Data	Median Data	Individual Data	Median Data	Individual Data	Median Data
California	0.005	0.013	0.22	0.22	6.67	6.59
Georgia	0.033	0.026	0.64	0.64	5.63	5.70
Ohio, Illinois, & Wisconsin	0.070	0.058	0.17	0.17	5.35	5.52
Texas	0.071	0.071	0.27	0.28	5.26	5.24

Source: Author's Calculations from Thorndike Report.
Dependent variable is the log of the wage in all regressions.

Table 6
Median Mincerian Regression Results for Illinois, Ohio, and Wisconsin, 1909

	Illinois	Ohio	Wisconsin
Schooling	0.073	0.080	0.034
	(0.009)	(0.009)	(0.010)
Experience	0.026	0.030	0.042
	(0.009)	(0.009)	(0.010)
Exper. Squared	0.0001	-0.0003	-0.0006
	(0.0003)	(0.0003)	(0.0003)
Male Dummy	0.192	0.079	0.274
	(0.048)	(0.047)	(0.051)
Intercept	5.819	5.766	6.029
	(0.078)	(0.104)	(0.085)
N	122	133	99
R^2	0.69	0.59	55.00

Source: Authors' calculations from Thorndike Report
Dependent variable is the log of the wage in all regressions.
Robust standard errors listed in parentheses.

Table 7

Actual vs. Predicted Relative Wage of High-skilled Efficiency Units in 1909

	Actual	Predicted	Mincerian Return
California	0.73	0.00	0.005
Georgia	0.83	0.38	0.033
Illinois-Wisconsin-Ohio	0.56	0.46	0.070
Texas	0.87	0.45	0.071

Table 8
Mincerian Regressions for Men, Women, and Less Experienced Teachers, 1909

	Individual Data				Median Data		
	California	Georgia	OH, WI, IL	Texas	Illinois	Ohio	Wisconsin
				Men Only			
Schooling	0.004	0.020	0.075	0.085	0.084	0.088	0.044
	(0.010)	(0.021)	(0.004)	(0.009)	(0.013)	(0.011)	(0.015)
Experience	0.041	0.006	0.048	0.035	0.020	0.033	0.040
	(0.007)	(0.017)	(0.004)	(0.009)	(0.013)	(0.124)	(0.014)
Exper. Squared	-0.001	0.001	-0.001	-0.001	0.000	-0.001	0.000
	(0.0002)	(0.0007)	(0.0001)	(0.0003)	(0.0004)	(0.0004)	(0.0005)
Intercept	6.890	6.470	5.480	5.360	5.979	5.816	6.221
	(0.13)	(0.26)	(0.05)	(0.13)	(0.114)	(0.104)	(0.124)
N	226	92	1776	243	60	67	47
R^2	0.22	0.15	0.33	0.34	0.69	0.61	0.58
				Women Only			
Schooling	0.007	0.067	0.063	0.035	0.064	0.072	0.023
	(0.007)	(0.026)	(0.005)	(0.013)	(0.012)	(0.013)	(0.014)
Experience	0.028	0.014	0.046	0.029	0.033	0.027	0.047
	(0.004)	(0.030)	(0.004)	(0.011)	(0.014)	(0.013)	(0.014)
Exper. Squared	0.000	0.001	-0.001	-0.001	0.000	0.000	-0.001
	(-0.0002)	(0.0019)	(0.0001)	(0.0005)	(0.0005)	(0.0004)	(0.0005)
Intercept	6.640	5.190	5.420	5.730	5.834	5.798	6.111
	(0.10)	(0.32)	(0.07)	(0.18)	(0.104)	(0.109)	(0.109)
N	432	45	1365	138	62	66	52
R^2	0.30	0.29	0.41	0.14	0.62	0.57	0.43
				Less Experienced Teachers Only			
Schooling	0.020	0.012	0.052	0.071	0.047	0.059	0.032
	(0.010)	(0.030)	(0.04)	(0.010)	(0.011)	(0.010)	(0.010)
Male Dummy	0.231	0.769	0.201	0.280	0.224	0.152	0.254
	(0.027)	(0.091)	(0.014)	(0.037)	(0.063)	(0.053)	(0.052)
Intercept	6.538	5.884	5.690	5.355	5.799	5.602	6.013
	(0.134)	(0.362)	(0.053)	(0.130)	(0.137)	(0.119)	(0.123)
N	298	54	1278	155	51	54	50
R^2	0.20	0.59	0.20	0.43	0.42	0.48	0.43

Source: Authors' calculations from Thorndike Report.
Dependent variable is log of the wage in each regression.
Robust standard errors listed in parentheses.
Less experienced teachers are those with less than five years of experience

Table 9
Comparing Mincerian Regression Estimates from 1909 and 1940

Variable	Weighted Teachers, Sample States, OLS (1909)	Teachers Only, Sample States, OLS (1940)	Teachers Only, Sample States, Robust Regression (1940)	All Workers, Sample States, OLS (1940)	All Workers, All States, OLS (1940)
Schooling	0.083	0.091	0.089	0.096	0.090
	(0.003)	(0.010)	(0.008)	(0.001)	(0.000)
Female	-0.145	-0.162	-0.125	-0.452	-0.459
	(0.010)	(.056)	(0.044)	(0.007)	(0.004)
Experience	0.034	0.035	0.039	0.047	0.516
	(0.002)	(0.007)	(0.005)	(0.001)	(0.005)
Exper. Squared	-0.001	-0.001	-0.001	-0.001	-0.058
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)

Source: Author's calculation from IPUMS (1940) and Thorndike Report (1909)
Dependent variable is the log of the wage in each regression.
Robust standard errors are listed in parentheses.

Table 10
Mincerian Regressions for the Returns to Education by State, 1940-2000

Year	CA	GA	IL	OH	TX	WI	Relative Variance
1940	0.057	0.124	0.067	0.064	0.109	0.088	1
	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]	[0.003]	
1950	0.037	0.088	0.034	0.03	0.061	0.043	0.67
	[0.002]	[0.004]	[0.002]	[0.003]	[0.003]	[0.005]	
1960	0.048	0.078	0.043	0.043	0.069	0.043	0.33
	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]	[0.002]	
1970	0.0575	0.074	0.056	0.054	0.066	0.05	0.11
	[0.001]	[0.003]	[0.001]	[0.001]	[0.001]	[0.002]	
1980	0.0647	0.068	0.055	0.054	0.064	0.044	0.11
	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]	[0.002]	
1990	0.0869	0.094	0.082	0.083	0.094	0.079	0.06
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	
2000	0.0976	0.098	0.097	0.095	0.096	0.082	0.05
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	

Source: Author's calculation from IPUMS (1940-2000).
Each cell represents the Mincerian return to education among all workers for that state and Census year, controlling for sex, experience, and experience squared.
Relative Variance is the variance across states in a given Census year divided by the variance across states in 1940.
Dependent variable is the log of the wage in each regression.
Standard errors are listed in parentheses.

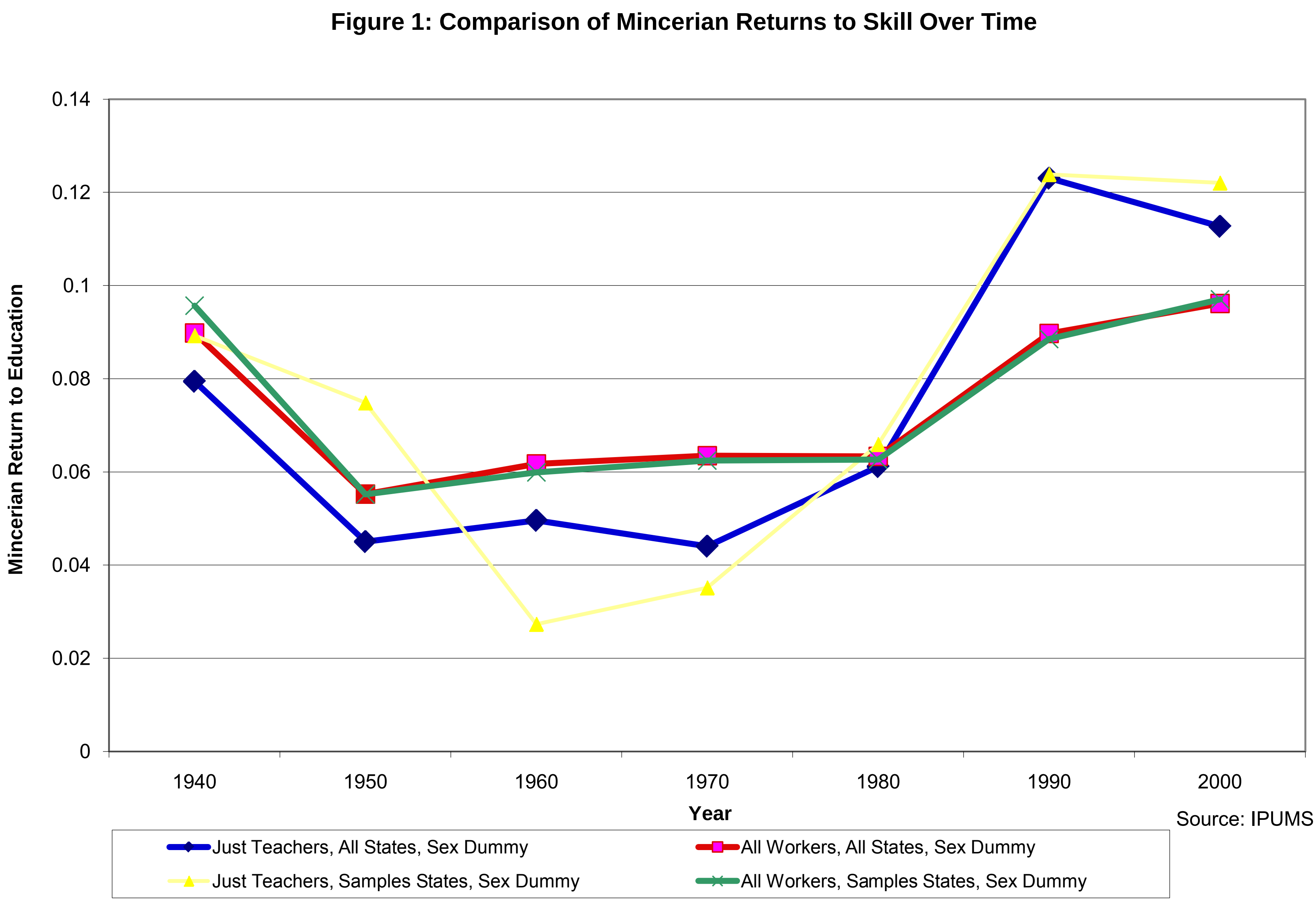
Figure 1: Comparison of Mincerian Returns to Skill Over Time
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Minncerian Return to Education
1940
1950
1960
1970
1980
1990
2000
Year
Source: IPUMS
Just Teachers, All States, Sex Dummy
All Workers, All States, Sex Dummy
Just Teachers, Samples States, Sex Dummy
All Workers, Samples States, Sex Dummy

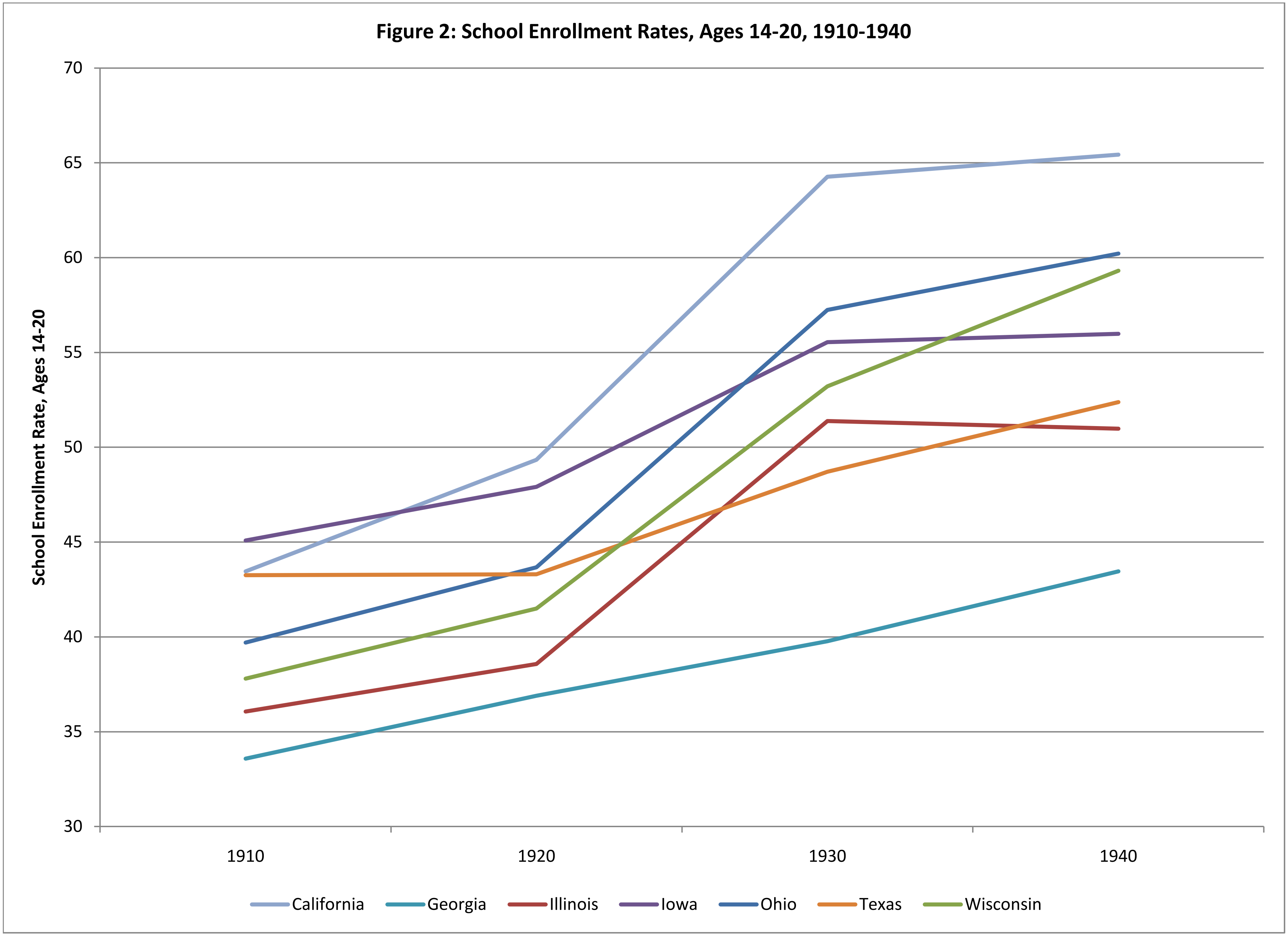
Figure 2: School Enrollment Rates, Ages 14-20, 1910-1940
School Enrollment Rate, Ages 14-20
70
65
60
55
50
45
40
35
30
1910
1920
1930
1940
California
Georgia
Illinois
Iowa
Ohio
Texas
Wisconsin

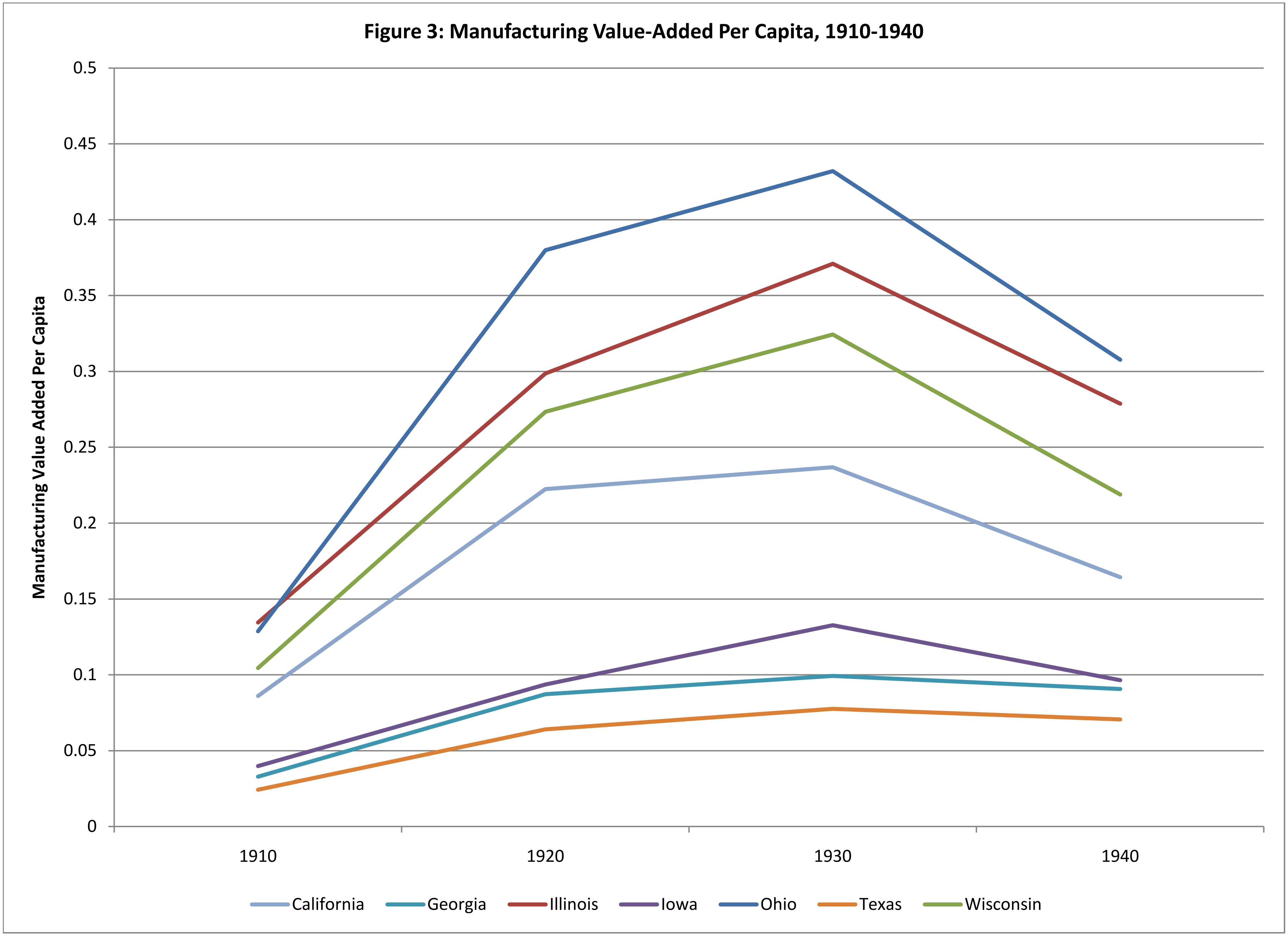
Figure 3: Manufacturing Value-Added Per Capita, 1910-1940
Manufacturing Value Added Per Capita
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1910
1920
1930
1940
California
Georgia
Illinois
Iowa
Ohio
Texas
Wisconsin

Appendix Table 1

Summary of Educational Endowment Factors for the Returns to Education, 1900-1930

State	1900 Literacy Rate	1910 Literacy Rate
California	94.47	95.48
Georgia	66.94	76.74
Illinois	95.9	95.73
Iowa	97.59	97.98
Ohio	95.84	96.46
Texas	83.95	87.77
Wisconsin	95.12	96.34

Literacy Rate Calculated for those above the age of 10 based on IPUMS 1900 and 1910 5% samples.

Public Elementary and Secondary School Expenditures 1900-1930

State	Total Expenditures (thousands of Dollars)				Per capita of state population (in Dollars)				Per capita of population 5-17, (in Dollars)			
	1900	*1910*	*1920*	*1930*	*1900*	*1910*	*1920*	*1930*	*1900*	*1910*	*1920*	*1930*
California	6,909	18,211	48,980	146,943	4.65	7.66	14.29	25.88	19.61	39.40	72.12	128.99
Georgia	1,980	4,420	9,076	18,677	0.89	1.70	3.13	6.42	2.52	5.30	9.72	20.87
Illinois	17,757	34,036	69,358	154,142	8.08	6.04	10.69	20.20	13.03	24.53	44.32	87.07
Iowa	8,496	12,767	37,334	50,737	3.81	5.76	15.53	20.53	12.04	21.85	62.44	82.53
Ohio	13,335	25,500	67,427	145,910	3.21	5.35	11.71	21.95	11.30	22.63	50.63	91.22
Texas	4,465	11,777	33,606	78,150	1.46	3.02	7.21	13.42	4.18	9.65	23.81	48.01
Wisconsin	5,493	10,789	27,255	54,088	2.65	4.64	10.36	18.40	8.88	16.84	39.93	72.71

Sources: 1900: Statistical Abstract of the United States, 1925, 1910-1930: Statistical Abstract of the United States, 1935

School Attendance as Percentage of Eligible Population 14-20 Years of Age 1910-1930

State	14 to 15 Year Olds			16 to 17 Year Olds			18 to 20 Year Olds		
	1910	*1920*	*1930*	*1910*	*1920*	*1930*	*1910*	*1920*	*1930*
California	83.6	89.1	97.2	50.1	54.7	82.1	17.3	21.9	32.7
Georgia	59.3	67.7	73.7	37.3	39.7	43.6	12.1	11.7	14.3
Illinois	75.4	79.0	92.4	36.8	37.1	57.1	11.7	12.3	19.9
Iowa	81.8	85.8	89.8	50.5	51.4	63.9	17.9	19.4	25.1
Ohio	79.0	87.8	96.6	42.4	44.4	67.7	14.1	14.4	22.8
Texas	76.7	79.1	84.6	51.0	48.8	57.2	15.2	14.2	19.8
Wisconsin	75.4	77.8	86.3	36.2	42.2	63.4	13.1	14.6	21.5

Sources: 1910-1920:Abstract of the 14th Census of the United States, 1930: Abstract of the 15th Census of the United States

Appendix Table 2A
Summary of Technological Endowment Factors for the Returns to Education, 1890-1910

Early Snapshot

State	Percent of Labor Force in Manufacturing 1900	Number of Tech. Industry Firms per 1000 people, 1890	Internal Combustion Engines per 1000 people 1904	Electric Motors per 1000 people 1899
California	14.73	1.3	--	0.2
Georgia	7.62	0.9	0.06	0.0
Illinois	20.49	1.4	0.60	0.4
Iowa	7.87	1.4	0.18	0.1
Ohio	25.28	2.2	0.90	0.4
Texas	4.86	1.1	0.09	0.0
Wisconsin	19.42	2.7	0.30	0.3

Later Snapshot

State	Percent of Labor Force in Manufacturing 1910	Number of Tech. Industry Firms per 1000 people 1900	Internal Combustion Engines per 1000 people 1909	Electric Motors per 1000 people 1909	Capital per Estab. 1905/ Capital per Estab.1900
California	24.13	1.5	0.32	0.7	2.5
Georgia	12.79	1.5	0.16	0.3	3.5
Illinois	39.05	1.7	0.31	3.1	3.2
Iowa	17.69	1.7	0.60	0.7	3.4
Ohio	47.05	2.3	0.70	4.5	3.3
Texas	9.69	1.9	0.21	0.3	5.0
Wisconsin	39.61	2.2	0.68	3.2	2.4

Sources:
Value of Machinery and Value of Livestock: 1916 Statistical Abstract of the United States
Percent of the Labor force in Manufacturing: Percent of labor force in Broad, Large and Speical Manufacturing and Electrification Industries as given by the 1924 Statistical Abstract of the United States.
Population Size, and Agricultural Workforce Size: 1924 Statistical Abstract of the United States
Tech Industry Firms: 12th, 13th, and 14th Census of Manufactures, General Report and Analytical Tables (various Tables).
Technical Industry firms are defined as the following: Aluminum Manufactures, Automobile bodies and parts, Automobile repairing, Automobiles, brick, tile, and fire-clay products, bronze and brass products, Copper products, Shop construction and repairs, chemicals, Coke, Electrical

machinery, Electroplating, Steam gas and water engines, Explosives, Foundry products, glass, iron and steel, Lithographing, Patent medicines and compounds, Rubber, Steam fittings, Stoves and furnaces, Structural ironwork, Sulfuric, Nitric and mixed Acids, Wire and Wirework. Oil and Petroleum firms are not listed until 1919, and therefore are not included here.
Internal Combustion and Electric Motors per Establishment: Abstract of the 14th Census of the United States
Capital per Establishment in 1900: 1905 Statistical Abstract of the United States
Capital per Establishment in 1905: 1910 Statistical Abstract of the United States

Appendix Table 2B
Summary of Technological Endowment Factors for the Returns to Education, 1890 - 1910

State	Number of Tech. Industry Firms, 1890	Value Added per Man. Establishment, 1904	Internal Combustion Engines, 1904	Electric Motors 1899	Horsepower per Establishment, 1899
California	1,540	20.67	--	281	25.41
Georgia	1,673	49.20	118	45	45.27
Illinois	5,459	53.01	1,447	1,839	38.91
Iowa	2,613	30.35	922	211	22.09
Ohio	7,997	46.12	2,004	1,721	56.51
Texas	2,503	25.68	403	54	37.39
Wisconsin	4,512	45.21	1,037	551	46.47

State	Number of Tech Industry Firms, 1900	Value Added per Man. Establishment, 1909	Internal Combustion Engines, 1909	Electric Motors 1909	Horsepower per Establishment, 1904
California	2,184	22.78	765	1,591	30.76
Georgia	3,301	48.20	418	829	68.47
Illinois	8,209	58.93	1,755	17,432	49.70
Iowa	3,821	38.25	1,336	1,448	24.67
Ohio	9,557	64.78	3,354	21,279	81.03
Texas	5,793	29.88	802	1,011	52.13
Wisconsin	4,512	57.97	1,578	7,501	51.44

Sources:
12th, 13th, and 14th Census of Manufactures, General Report and Analytical Tables (various Tables).
Technical Industry firms are defined as the following: Aluminum Manufactures, Automobile bodies and parts, Automobile repairing, Automobiles, brick, tile, and fire-clay products, bronze and brass products, Copper products, Shop construction and repairs, chemicals, Coke, Electrical machinery, Electroplating, Steam gas and water engines, Explosives, Foundry products, glass, iron and steel, Lithographing, Patent medicines and compounds, Rubber, Steam fittings, Stoves and furnaces, Structural ironwork, Sulfuric, Nitric and mixed Acids, Wire and Wirework. Oil and Petroleum firms are not listed until 1919, and therefore are not included here.

Appendix Table 2C

Summary of Technological Endowment Factors for the Returns to Education, 1900-1930

State	Internal Combustion Horsepower, 1900	Horsepower Per Establishment 1904	Internal Combustion Engines per Establishment, 1919	Electric Motors per Establishment, 1919
California	3744	30.76	0.09	0.33
Georgia	365	68.47	0.13	0.42
Illinois	8758	49.70	0.06	2.34
Iowa	4524	24.67	0.14	0.69
Ohio	14230	81.03	0.17	2.87
Texas	968	52.13	0.19	0.54
Wisconsin	4358	51.44	0.16	2.08

State	Internal Combustion Horsepower, 1910	Horsepower Per Establishment 1914	Internal Combustion Engines per Establishment, 1929	Electric Horsepower per Establishment, 1929
California	10115	48.82	2.7	14.1
Georgia	3780	77.04	2.5	12.2
Illinois	37025	71.02	6.9	55.7
Iowa	8025	34.04	1.6	33.5
Ohio	103801	127.91	10.1	127.1
Texas	15745	66.05	11.7	32.2
Wisconsin	19531	74.95	1.3	57.6

Sources:

Establishment counts from the 1925 Statistical Abstract of the United States

Internal Combustion Horsepower: Abstract of the 14th Census of the United States

Horsepower per Establishment: 1916 Statistical Abstract of the United States

Internal Combustion and Electric Motors per Establishment: Abstract of the 14th Census of the United States

Internal Combustion and Electric Motors Horsepower per Establishment: Abstract of the 15th Census of the United States

Appendix Table 3
Summary of Technological Endowment Factors for the Returns to Education, 1935-1970

State	Capacity of Electric Power, 1937	Capacity of Electric Power, 1948	Capacity of Electric Power, 1958	Capacity of Electric Power, 1968
California	2808	4392	11714	26675
Georgia	481	952	2365	5052
Illinois	2504	4220	8465	15570
Ohio	2486	4417	10587	14383
Texas	1105	2483	9765	21873
Wisconsin	993	1712	3335	5032

State	Value Added per Man. Establishment, 1937	Value Added per Man. Establishment, 1947	Value Added per Man. Establishment, 1958	Value Added per Man. Establishment, 1968
California	100.5	226.3	419.3	532.9
Georgia	93.6	213.5	358.7	520.7
Illinois	197.1	417.8	631.6	787.4
Ohio	252.5	516.9	754.7	1001.5
Texas	99.3	242.3	480.2	614.8
Wisconsin	112.2	323.8	501.9	675.6

Sources:
Capacity of Electric Power is in thousands of kilowatts for all years.
Value Added per Manufacturing Establishment is in millions of dollars.
Capacity of Electric Power, 1937, 1948, 1958, 1968: 1940, 1950, 1960, 1970 Statistical Abstract of the United States
Value Added per Manufacturing Establishment, 1937, 1948, 1958, 1968: 1940, 1950, 1960, 1970 Statistical Abstract of the United States