How important are human capital, physical capital and total factor productivity for determining state economic growth in the United States: 1840-2000?

Turner, Chad and Tamura, Robert and Mulholland, Sean

Clemson University

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Chad Turner, Robert Tamura, Sean E. Mulholland*

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Abstract

This paper creates a new data set on physical capital at the state level for the United States from 1840 - 2000. Combining these new data with state level human capital and output data enables us to estimate the contribution of aggregate input growth and total factor productivity (TFP) growth to output growth across states from 1840 - 2000, and to decompose the cross-sectional variance of output growth into the component explained by variation in aggregate inputs and the compenent explained by variation in TFP. As our data are across states instead of across countries, one would expect less institutional heterogeneity in this study than in studies using cross-country comparisons. We find that that 65% of average output growth from 1840 - 2000 is accounted for by average input growth. We find a plausible upper bound of output variation explained by TFP growth is 91%, while a plausible upper bound of output variation explained by input growth is 62%. Interestingly, even at the state level where the unit of observation is more homogeneous, TFP continues to be an important determinant of both the growth of and the variation of output per worker.

Total Factor Productivity (TFP) represents the residual portion of output growth not explained by changes in inputs. Though many of the cross-country analyses have increased our knowledge on the importance of TFP and TFP growth in affecting both output level differences, the growth rate of output and its variation, many economists object to the empirical work on growth.[1] One objection is the inability to account for large heterogeneity in social, religious, and institutional characteristics. Another criticism is the small time

*Chad Turner is at Nicholls State University, Sean Mulholland is at Mercer University and Robert Tamura is at Clemson University and the Federal Reserve Bank of Atlanta. We thank the workshop participants at Pepperdine University, Midwest Macroeconomics Meetings at the University of Iowa, Nicholls State University, and Xavier University. We have benefited from discussions with Curtis Simon, Gerald P. Dwyer, Mark Fisher, Paula Tkac, and Kevin M. Murphy. We particularly thank Scott Baier for all his generous suggestions. All ideas and remaining errors are the authors' and do not necessarily represent those of the Atlanta Federal Reserve Bank or the Federal Reserve System.

[1]See those listed in Temple (1999).

frame over which cross-country inputs, output, and TFP are estimated.[2] Our analyses address both of these criticisms by combining state level measures of human capital and output from Turner, Tamura, Mulholland and Baier, (2007), henceforth TTMB, with new measures of state level physical capital. Since we deal with the growth of output across states rather than countries, many of the objections associated with institutional heterogeneity are eliminated. Because our data spans 160 years, errors that can be induced by business cycles are less likely.

We use standard growth accounting methodology to estimate the contribution of aggregate input growth and TFP growth for output growth across states. Assuming constant returns to scale and perfectly competitive factor markets, we decompose output growth into two components. The first component, aggregate input growth, is the portion of output growth that is accounted for by the accumulation of inputs. The second component, TFP, or the "Solow residual," is the fraction of output that cannot be accounted for by aggregate input growth. We find average TFP growth across states from 1840 - 2000 is 0.50% per year, which is approximately 35% of the output growth per worker, leaving 65% of output growth accounted for measured input growth. Clearly, a large portion of output growth is accounted for by input growth, but a significant portion of output growth remains unexplained. We also show that the growth rates of output and TFP vary across states and census regions.

Following Klenow and Rodriguez-Clare (1997) and Easterly and Levine (2002), we explore the possibility that while TFP does not account for an overwhelming fraction of output growth, the *variance* in TFP growth across states may explain a large fraction of the *variance* in output growth across states. While the institutions, legal systems, educational systems, and tax rates of the various states are not homogeneous, it is likely these institutions display less heterogeneity than would be observed across countries.[3] Having mitigated these sources of variation, we would expect to see a larger fraction of the cross-sectional variance in output growth explained by aggregate input growth. Thus, we decompose the cross-sectional variation in output growth across states into two components: the portion explained by differences in aggregate input growth and the portion explained by differences in TFP growth. The variance decomposition measures are sensitive to the treatment of any observed correlation between the growth rates of TFP and aggregate input, but the literature is not settled on how to deal with the covariance term. As a result, we present the data so that the reader may choose (1) to ignore the correlation, using only the relative variances, (2) follow the methodology of Klenow & Rodriquez-Clare (1997), splitting the correlation amongst the two sources equally, or (3) follow the methodology of Baier, Dwyer, and Tamura (2006) and construct upper and lower bounds for each component. For the

[2] Jorgenson (1990) concludes "that the aggregate production model used in analyzing economic growth by Denison, Kendrick, Kuznets, Maddison, Solow, Tinbergen, and a long list of others is appropriate for studying long-term growth trends. However this model is highly inappropriate for analyzing the sources of growth over shorter periods" (Jorgenson 1990, 26).

[3] Clearly slavery from 1840-1860 in the southern states of the United States represented a different insitution than in the rest of the United States. Furthermore the end of Reconstruction in these states produced another differential institutional regime in these states, Jim Crow. For more on the effects of these institutions, see Margo (1990), Canaday (2003), Canaday and Tamura (2007).

entire 1840 - 2000 period, we find that aggregate input growth can explain at most 62% of the cross-sectional variance of output growth, while TFP growth can explain as much as 91%. We also conduct sensitivity analyses to determine how initial conditions and the time frame selected affect the variance decomposition results.

The organization of the remainder of the paper is as follows. The second section outlines the creation of the physical capital data and displays the results of these calculations for census regions. The third section provides a summary of the human capital and output measures created by TTMB and displays these measures for census regions. The fourth section presents the growth accounting framework and presents the analysis of the growth rates for states and for census regions. The following section analyzes the variance of the growth rates across states, for the nation as a whole, and within regions. The final section offers a brief conclusion and outlines future work.

PHYSICAL CAPITAL

In order to complete the analyses described above, we require a time series on measures of inputs for each of the states. To this end, we produce original estimates of physical capital for each of the states of the United States from 1840 – 1920 at a decadal frequency and annually from 1929 – 2000. Primary data sources on physical capital at the state level become available only at the very end of the period we examine. However, information on the amount of physical capital in each industry at the national level is available from the Bureau of Economic Analysis after 1902 and can be derived using information from Gallman (1986) for years prior to 1900.[4] We allocate the national capital to the individual states by assuming the capital-output ratio is identical across states within a given industry, but allow for differing capital-labor ratios across industries.[5] This assumption, while not ideal theoretically, enables us to create an estimate of the fraction of each industry's capital located in each state.[6] By simply adding across industries in each state, we arrive at an estimate of physical capital for that state. First, we describe national data on physical capital in each industry. Due to data availability issues, special attention here is paid to governmental and residential capital. Second we discuss state level data on output each industry. We then outline the method by which we allocate the national level physical capital to the states. Finally, we present the state level physical capital measures.

[4] The BEA does not contain direct measures of the capital stock for each industry until 1947. However, we are able to utilize BEA provided data on investment flows to estimate capital stocks from 1902 – 1947. Details are discussed in the following subsection.

[5] This procedure requires state level data on output for each industry. The details and availability of this data is discussed in the following subsection. Our assumption of a common capital output ratio by industry implies that factor returns are equalized within an industry across states. However our assumption that capital shares are identical across sectors implies that factor returns are not equalized across industries. This issue is detailed in Bernard and Jones (1996b). The effects of assuming non constant capital shares are examined in Bernard and Jones (1996a).

[6] Garofalo and Yamarik (2002) utilize a similar assumption in their work on regional convergence from 1977 to 1996.

National Industry Level Physical Capital

The first step in the construction of state level physical capital estimates is to calculate physical capital stocks at the industry level for the nation as a whole.[7] For 1840 – 1900, we use industry share data provided by Gallman (1986) combined with national output data in TTMB. For each of six industries, Gallman provides an estimate of that industry's share of total value added (a sectoral share), as well as an estimate of the capital-value added ratio for that industry.[8] TTMB provide estimates of aggregate state output over this period.[9] Combining the information from these two data sets allows us to calculate the capital stocks. Letting Y_j denote value added in industry j, it is straightforward to calculate K_j, the amount of physical capital employed in industry j:

$$K_j = \left(\frac{Y_j}{\sum_j Y_j} \right)_{Gallman} \left(\frac{K_j}{Y_j} \right)_{Gallman} \left(\sum_j Y_j \right)_{TTMB} \tag{1}$$

The first term in the expression is Gallman's estimate of the sectoral shares; the second term is Gallman's estimate of the capital-value added ratio in each industry, and the final term is value added for the nation as a whole from TTMB. The result is total physical capital in each industry from 1840-1900.[10]

[7] As our focus is to produce physical capital per worker measures for each state, we chose to use sectoral capital - value added ratios available by sector at the national level. In addition, since we are focusing on the 1840 - 2000 period, we did not use the seminal work of Jorgenson, Gollop and Fraumeni (1987), which produces sectoral capital measures from 1948 to 1979, inclusive.

[8] Gallman's data subdivides the economy into the following industries: Agriculture, Manufacturing, Transportation, Commerce, Government, and Residences.

[9] In the 1840-1920 period TTMB constructs output per worker from principally three sectors, agriculture, manufacturing, and all other sectors. For the 1963-2000 period, gross state product (GSP) for each state for nine sectors is available from the BEA. While the BEA does not provide estimates of GSP from 1929-1962, or from 1998-2000 using identical industry classifictions, the BEA does provide measures of wages and salary disbursements in each industry at the state level. There is a very high correlation between wage and salary disbursements and gross state product, and therefore wage and salary disbursements are used to estimate gross state product for 1929-1962 and 1998-2000. The result of combining this data is state level output measures for 3 sectors from 1840 - 1920 and for 9 sectors from 1920 - 2000.

Gallman (1986) reports national measures of capital output ratios for 1840-1900 at the decadal frequency for six sectors as well as sectoral shares. This enables the amount of (national) capital in each sector to be calculated. For 1902 through 2000, data are provided by the Bureau of Economic Analysis in the Fixed Reproducible Tangible Wealth series. This source provides an estimate of the capital stock at the industry level for 1947 through 2000. While this BEA series does not provide data on physical capital stocks for the period 1902 through 1946, it does provide figures on gross investment flows into all industries (except government and residences) which are used to derive estimates of the capital stock. The results of combining this data is national capital stocks measures for 6 industries prior to 1900 and for 9 industries after 1902.

[10] In the interest of exposition, we have suppressed one detail in the calculation of Equation (1). The final term represents the total amount of output in the US across all industries. Gallman does not report the Y_j, and thus we cannot simply sum across industries, $\sum_j Y_j$. We can, however, arrive at the overall level

For 1902 through 2000, we use data provided by the Bureau of Economic Analysis in the Fixed Reproducible Tangible Wealth series. This source provides an estimate of the capital stock at the industry level for 1947 through 2000.[11] While this BEA series does not provide data on physical capital stocks for the period 1902 through 1946, it does provide figures on gross investment flows into all industries (except government and residences) which we use to derive estimates of the capital stock. Letting K_{jt} denote the capital stock for industry j in period t, I_{jt} denote the gross investment flow into industry j in period t, and defining $\Delta K_{jt} = \ln(K_{jt}) - \ln(K_{jt-1})$, we fit the following equation with ordinary least squares for each industry:

$$\Delta K_{jt} = \beta_0 + \beta_1 * \Delta K_{jt+1} + \beta_2 \left(\frac{I_{jt}}{K_{jt}} \right) \tag{2}$$

We then use the result of this estimation to go backward in time from the 1947 value of the capital stock to derive values of the capital stock going back to 1902.[12,13]

The data for governmental capital is more limited. Capital stock data exist beginning in 1947, but gross investment flows first become available in 1925. We proceed as described above, using our estimation procedure to obtain values back 1925. As we have no data on the stock of capital or investment flows in the government sector prior to 1925, we simply assume the growth rate of government capital in this period is 6% per year. This figure corresponds to the growth rate of government capital observed over the 1925 through 2000 period, and is very similar to the rate observed from 1840 through 1900 in the Gallman data.

Residential capital makes up nearly half of all physical capital throughout the period and thus is quite important. While the Gallman data enables us to calculate an estimate of residential capital from 1840 – 1900 and the BEA data provides an estimate from 1947 – 2000, we have no data from these sources for the period 1900 – 1946. In order to complete the series, we use two additional data series taken from Historical Statistics of the United States (HSUS): annual estimates for 1925 to 1970 of Net Stocks of Residential Structures (Series F213) and Wealth in Residential Nonfarm Structures in 1900, 1912, 1922, and 1929 (Series F425). Unfortunately, the coverage in these sources varies, particularly depending on treatment of farm residences, government-owned housing, and other methodological

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of output via another path. TTMB provides estimates of output for each state i, Y_i^{TTMB}, which implicity includes all industries, $Y_i^{TTMB} = \sum_j Y_{ij}^{TTMB}$. We then simply sum across states to arrive at total output. Thus in equation (1) what we denote by $\sum_j Y_j$ is in fact $\sum_i \sum_j Y_{ij}^{TTMB}$.

[11] The BEA data uses the following industry classifications: Agriculture, Forestry and Fishing, Mining, Construction, Manufacturing, Transportation, Wholesale Trade, Retail Trade, FIRE, and Services.

[12] As the Gallman data and the BEA data use different industry classifications, it is not possible to directly compare the (extended) BEA series in 1902 to the Gallman series in 1900 for each industry. However, the totals (across all industries) differ by less than 2%.

[13] This algorithm generates a capital stock in agriculture that is implausibly high in the early part of the 20th century. We considered several alternatives, ultimately choosing the specification that most closely matched the Gallman figure for agriculture in 1900. We estimate the following equation to predict values of the capital stock in for 1902 – 1946 for agriculture: $\ln(K_{ag,t}) = \beta_0 + \beta_1 * \ln(I_{ag,t})$

considerations. We assume that the growth rates of residential capital are those that are implied by the data in these sources. Thus, we use the BEA data for 1947 - 2000, and use the growth rates implied by the two HSUS series and Gallman's data to go backward in time to create the residential capital series for years prior to 1947.[14] The time paths of residential capital and of non-residential capital, which includes all other industries, are displayed below on a logarithmic scale in Figure 1. Annual estimates are displayed after 1902, though the growth accounting analyses that follows uses only decadal values. These measures, and all subsequent measures throughout this paper, are reported in 2000 dollars.

State Industry Level Output

From 1840 through 1920, we utilize state level data reported in TTMB that contains output for three industries: agriculture, manufacturing, and the non-agricultural non-mining industry.[15] From 1963 through 1997, the BEA provides measures of gross state product in each industry for each state. While the BEA does not provide estimates of GSP from 1929-1962 or from 1998-2000, the BEA does provide measures of wages and salary disbursements in each industry at the state level.[16] We find that gross state product and wages are highly correlated. Therefore, we use overlapping data from 1963-1997 and ordinary least squares to predict gross state product for each industry, j, for each state, i, for 1929-1962 and 1998-2000:

$$\ln(gsp_{ijt}) = \beta_0 + \beta_1 * \ln(wages_{ijt}) + \beta_2 * year + \beta_3 * Z \tag{3}$$

where Z is a vector of dummies for each state. The results of the regressions are reported in Appendix C.[17] With the exception of agriculture, the fit is quite good.

State Level Allocation

We next allocate each industry's capital to the individual states. Recall that we have physical capital data by industry at the national level and output data by industry at the state level. We allocate capital across states assuming a constant capital-output ratio for each industry, utilizing across state variation in the sectoral composition of output and temporal variation in the capital-output ratio in each industry.[18] While ideally we would

[14] We assume constant growth rates between 1900 - 1912, 1912 - 1922, and 1922 – 1929.

[15] Because the Gallman data subdivides capital into six industries, we are forced to combine the capital in Commerce, Transportation, and Government categories and allocate it based on income in the non-agricultural, non-mining industry for years prior to 1900. See Appendix B for additional details.

[16] Wage and salary disbursements by place of work are reported in BEA series SA07.

[17] The BEA also provides a measure of earnings by place of work at the industry level through series SA05. Using this data to predict gross state product produces similar results.

[18] In an earlier version of this work, we considered a constant labor-output ratio for each industry. We rejected this methodology as it assigns implausibly large amounts of capital to southern regions and implausibly small amounts of capital to western states. We also considered allocating capital on the basis of overall income in a state relative to the national average. The results on growth accounting and the variance decomposition of growth are not affected by this assumption.

allow capital-output ratios to vary within each industry, these assumptions are motivated directly by data availability issues.[19] Utilizing this assumption, the fraction of industry j's capital that is located in state i will be identical to the fraction of industry j's output that is produced in state i. Letting Y_{ijt} represent output in state i of industry j, during period t, we have:

$$K_{ijt} = \left(\frac{Y_{ijt}}{\sum\limits_i Y_{ijt}} \right) K_{jt} \tag{4}$$

We sum across all industries for each state to arrive at the state level measure of capital for each year.[20]

$$K_{it} = \sum_j K_{ijt} \tag{5}$$

Physical Capital Estimates

Figure 2 below displays the labor force weighted average of physical capital per worker for the United States as a whole, as well as the values for the states with the highest and lowest values.[21] In addition, the coefficient of variation across states is displayed, utilizing the vertical axis displayed on the right axis.[22] Physical capital falls between 1860 and 1870 and between 1890 and 1900. While new states entering the data tend to increase the coefficient of variation early in the period, there is an uninterrupted decrease in capital inequality from 1910 until 1970, with a particularly sharp decline from 1940 to 1950. This is largely because of rapid capital growth in Southern states, which, up until this period, had been low capital states. The states with the highest values of capital per worker are consistently located in the Mountain, Pacific, Middle Atlantic census regions, and later in the period, the West South Central census region. Those states with the lowest values of capital per worker are typically in the South Atlantic and East South Central regions, however, in the later portion of the data, the South Atlantic region is among the leaders.

While we have estimates of physical capital per worker for each state, it would be cumbersome to display the graphs for each state. Figures 3 - 5 show physical capital per worker, weighted by state labor force, for the nine census regions across time on a logarithmic scale.[23,24] The slopes of the lines are growth rates.[25]

[19] Our approach is identical to Garofalo and Yamarik (2002) in allocating capital across industries. They utilize gross state product data from 1977 – 1997, only.

[20] Residential capital is allocated to states by assuming that residential capital per worker in state i is proportional to output per worker in state i.

[21] We use labor force data from TTMB. Additional details are provided in next next section and in TTMB.

[22] See Table E1 in Appendix E for the values, for each decade, of the mean, min, max, standard deviation and coefficient of variation.

[23] See Appendix A for a listing of the states in each region. We start with the New England census region and move clockwise around the census regions until we arrive at the East North Central.

[24] See Table E2 in Appendix E for the values, for each decade, in each of the census regions.

[25] During the early portions of the dataset, data on capital per worker are not available for all states within

Figure 3 shows the Middle Atlantic census region, not surprisingly, is higher than average throughout the entire period. The South Atlantic census region is well below the national average for much of the period, begins to catch up to the rest of the nation beginning in 1900, and by 1980, this region has surpassed the national average. The New England region begins as a high capital region, follows the national average closely until 1940, and then falls below the national average.

Figure 4 displays the physical capital per worker measures for the East South Central, West South Central, and Mountain census regions. Due to its initial focus on mining, the Mountain census region begins with a very high capital measure, but remains only slightly above the national average throughout the period.[26] The East South Central region is far below the national average, though a dramatic convergence begins in 1940. The West South Central region begins above the national average, falls below from 1870-1950, and then becomes a high capital region thereafter. This region also sees a dramatic change beginning in 1940.

Figure 5 illustrates in 1850, the Pacific region has very high output per worker, fueled by mining output in California. By 1870 the Pacific regions behaves much like the Mountain region. The East North Central and West North Central region follow the national average reasonably closely from 1840 – 2000, with the West North Central trailing the East North Central region slightly.

As much of the literature discussing state output convergence focuses on the role that Southern and Western states have in producing output convergence, we find it useful to aggregate into even broader regions. We thus aggregate into what we call the North, South, and West. We display summary statistics and figures depicting the time paths of variables for these broader regions in Appendix D.[27]

HUMAN CAPITAL, OUTPUT AND LAND

Annual data on income by state is available beginning 1929 from the Bureau of Economic Analysis. Data on income is available from Easterlin (1960a,b) in 1840, 1880, 1900 and 1920. TTMB developed measures of state output in 1850, 1860, 1870, 1890, and 1910. Given information on the size of the labor force, a measure of output per worker can be

a region. This entry of new states into our dataset occassionally results in Figures 3 - 5 giving a slightly misleading impresson of the growth rates within that region. Consider a region where we first observe physical capital data for one state in 1850 and first observe a second state in 1860. If the level of capital of the second state is substantially below the level of the first in 1860, the growth rate in the region calculated from 1850 - 1860 will be larger than the growth rate implied from observing the 1850 value and the mean (of both states) in 1860. These instances are rare, especially outside the western regions and after 1870. See Appendix A for the year in which data is first available for each state.

[26] This high measure of capital may also be reflecting mismeasurement of price levels in the Mountain and Pacific regions. This issue is discussed in greater detail below.

[27] We define the South region as the South Atlantic, East South Central, and West South Central census regions. We define the West as Pacific, Mountain, and West North Central regions. While the other pairings seem natural, we find throughout the entire period, the output and human capital levels of the East North Central region are very similar to those of the other census regions we include in the North category.

calculated.[28] All output data provided by the sources above are nominal figures. TTMB utilized information on both annual national price level variation and less frequent observations of interregional price variation to convert to real output.[29] All subsequent output measures in this work are reported in 2000 dollars. Figure 6 displays the labor force weighted average for the United States, the states with the smallest and largest levels of output, and the coefficient of variation across states in each year. Figures 7 - 9 display the labor force weighted averages for census regions.[30] What is clear is that the Pacific, the Mid Atlantic, to a lesser extent, the East North Central census regions are output leaders throughout the period. The South Atlantic, East South Central and West South Central census regions all follow similar paths and are consistently below the US average, particularly so in the early portion of the data. For additional details, see TTMB.

Human Capital per Worker

The work of Kendrick (1956), Schultz (1960), Griliches (1960), Denison (1962), and Jorgenson and Griliches (1967) developed labor quality measures for the United States as a whole based on educational attainment. Similarly we use information on the level of educational attainment of the labor force and human capital per worker at the state level developed in TTMB. Like the international measures developed in Barro and Lee (1993), and Baier, Dwyer and Tamura (2006), TTMB provide an estimate of the average years of schooling for workers in each state for decadal years from 1840 to 1920, and annually from 1929 – 2000, and a measure of the average age of the population, which we utilize here. To guide our thinking, we consider a Mincerian measure of human capital:

$$h_{it} = \exp\left(\beta E_{it} + \gamma_1 ex_{it} - \gamma_2 ex_{it}^2\right) \tag{6}$$

[28] Data from 1840 - 1920 are measures of output. Data from 1929 - 2000 are measures of income. Throughout this work, we simply refer to both as output. State labor force measurements from TTMB utilizes *Historical Statistics of the United States*, various census issues, and work done by Weiss (1999) to correct 19th century census estimates. Additional details on data sources for the labor force are included in Appendix B in TTMB.

[29] Data on national price level comes from Gordon (1999b) for 1875 – 2000, while data prior to 1875 is from *Historical Statistics of the United States*. By combining data from Mitchener and McLean (1999), Williamson and Linder (1980), and Berry, Fording, and Hanson (2000), TTMB have observations on relative price levels back to 1840 for all census regions except the Mountain and Pacific, which are first observed in 1880. TTMB assumes the relative regional price differences observed in these regions in 1880 persists from 1840 to 1870, and then normalizes regional price levels to the national price level figures given in Gordon. TTMB surmises the relative price level in the Pacific and Mountain regions may have been even higher between 1840 and 1870 than observed in 1880. This supposition is based on the trend observed from 1880 to 1920 and the nominal output figures observed for these regions. Additional details on both national and regional price levels are included in Appendix B in TTMB.

[30] See Table E3 in Appendix E for the values, for each decade, of the mean, min, max, standard deviation and coefficient of variation. See Table E4 in for the values, for each decade, in each of the census regions. The sources and construction of the output series are discussed in greater detail in TTMB.

where E_{it} is the average years of schooling as described above and ex_{it} is experience (per worker) in state i in period t.[31]

The specification above, however, assumes a constant return to a year of schooling. As such, we divide returns to schooling into components for primary schooling, P, intermediate schooling, I, and secondary and higher education, S. The assumption is made that primary schooling must be completed to attend intermediate schooling, and intermediate schooling must be complete to attend secondary and higher education. Primary schooling is assumed to last 4 years, while intermediate schooling is also assumed to last 4 years.[32] Suppressing subscripts for states and years, human capital can be expressed as:

$$h = h_0 \exp\left(\phi_P P + \phi_I I + \phi_S S + \gamma_1 ex + \gamma_2 ex^2\right) \tag{7}$$

where h_0 is the level of human capital with no schooling or experience, ϕ_P, ϕ_I, and ϕ_S are parameters on years of primary, intermediate, and secondary and higher education, $\gamma_1$and γ_2 are parameters on experience, ex, and experience squared. We choose this specification, and generally accepted parameters from the literature, to make our results comparable to existing cross-country studies. We follow Hall and Jones (1999) and assign $\phi_P = 0.134$, $\phi_I = 0.101$, and $\phi_S = 0.068$. We use estimates for the return to experience and experience squared from Klenow and Rodriguez-Clare (1997), assigning $\gamma_1 = 0.0495$ and $\gamma_2 = -0.0007$.[33]

Given parameter values and the human capital production function, we can calculate the measure of human capital for each state. The average for the nation as a whole, the highest and lowest values, and coefficient of variation are displayed in Figure 10.[34] Again, to give a sense of the data, Figures 11 − 13 show human capital per worker for each census region. The New England, the Mid Atlantic, and the East North Central regions are education leaders throughout the period, while the East South Central, West South Central, and South Atlantic regions are educational laggards. The Mountain region follows the national average quite closely.

Land per Worker

In our initial analysis, we had excluded land as input in production, but found that TFP growth was near zero from 1840 - 1940. We interpret this as suggesting, especially in the early portion of our dataset, land is an important input into production. As a result, we proxy land by utilizing a series of land in farms from Historical Statistics of the United

[31] Experience is defined as the average age of those persons in the labor force minus the average years of schooling less 6 years.

[32] If average years of schooling is less than 4, P = E, I = 0, S = 0. If average years of schooling is between 4 and 8, P = 4, I = E – 4, S = 0. Finally, if average years of schooling is greater than 8, P = 4, I = 4, S = E – 8.

[33] This methodology and parameter values are identical to those in Baier, Dwyer, and Tamura (2006).

[34] See Table E5 in Appendix E for the values, for each decade, of the mean, min, max, standard deviation and coefficient of variation. See Table E6 for the values, for each decade, in each of the census regions.

States.[35] Figure 14 displays the average amount of land per worker for the nation as a whole, the states with the highest and lowest values, and the coefficient of variation. For brevity, we do not illustrate the time path of land per worker for census regions.[36]

GROWTH ACCOUNTING AND VARIANCE DECOMPOSITION OF GROWTH

The allocation of growth to its sources is far from a new endeavor. Fabricant (1954), Abramovitz (1956), Solow (1957), and Kendrick (1956) pointed to the possibility that labor quality might be an important component of economic growth. Shultz (1960), Griliches (1960), Kendrick (1961), Denison (1962, 1974, and 1985) and many others empirically analyzed the role that labor quality played in the growth of the United States. Jorgenson and Griliches (1967) then "introduced a framework that treats the problem of composition adjustment in both labor and capital inputs in an elegant and symmetric fashion." (Gordon 1999a, p. 123). Jorgenson, Gollop, and Fraumeni (1987), Jorgenson (1988), and Jorgenson and Stiroh (2000) analyzed the role of intermediate inputs in US economic growth across industries. Many international growth accounting analyses, including Tinbergen (1942), Elias (1992), Young (1995), and Dougherty and Jorgenson (1996), used various inputs measures but only analyzed countries within a certain region or countries with similar levels of advancement. Others, including Maddison (1995) and Jones (1997), analyzed country growth across the world using physical capital stock as the lone input, though recent works have included measures of human capital as an input, including Klenow and Rodriguez-Clare (1997).

Our work builds on this foundation by performing a standard growth accounting analysis on 160 years of state level data on output per worker, human capital per worker, and physical capital per worker that has yet to be analyzed. In addition, we explore the cross-sectional variance in growth rates across states. Analyzing the cross-sectional variation is sensitive to the treatment of the observed correlation between aggregate input growth and TFP growth. We present data that allows the reader to (1) ignore the covariance term, (2) follow Klenow and Rodriguez-Clare (1997) and split the covariance term, or (3) follow Baier, Dwyer, and Tamura (2006) to create an upper and lower bound for each source. As far as we are aware, this is the first empirical analysis of its kind in regard to the scope of the data utilized.

Growth Accounting

We assume an aggregate production function characterizes the relationship between productive resources and output, and further assume TFP is Hicks-neutral:

[35] Data are from HSUS, Series K 17-81. We also searched for a suitable series on the value of land, but could not find data across the entire period.

[36] See Table E7 in Appendix E for the values, for each decade, of the mean, min, max, standard deviation and coefficient of variation. See Table E8 in Appendix E for the values, for each decade, in each of the census regions.

$$Y_t = A_t K_t^{\alpha} H_t^{\beta} \mathcal{L}_t^{1-\alpha-\beta} \tag{8}$$

where Y_t, K_t, H_t, and $\mathcal{L}_t$ are output per worker, physical capital per worker, human capital per worker, and land per worker in period t. A_t denotes the level of technology in period t. We make the twin assumptions that private marginal products are equal to social marginal products and perfect competition characterizes markets. Then, suppressing subscripts for each state and time period, it can be shown that:

$$a = y - \alpha k - \beta h - (1 - \alpha - \beta)\,\ell \tag{9}$$

where lowercase variables represent growth rates of variables, α denotes physical capital's share of output, and β denotes labor's share of output. We assume that physical capital's share of output is 0.283, labor's share of output is 0.667, and land's share of output is 0.05.[37]

TFP per worker is simply the residual portion of the growth rate of output that is not be explained by the growth in measured inputs, and thus should be interpreted cautiously. What is being called TFP may actually be identified as technological progress, or instead could result from mismeasurement of output, human capital, physical capital, or simply a failure of the assumptions of perfect competition and constant returns to scale. There may also be interactions between technological progress and the stocks of human and physical capital.[38] There are certainly other interpretations as well.

Figure 15 display the mean, minimum, and maximum value of TFP as well as the coefficient of variation, while Figures 16 - 18 display TFP for each census region and the nation as a whole.[39] What seems obvious from these figures is that those census regions in the South display dramatic increases in TFP over the period, surely some of which is related to the Civil War, but much of which occurs after 1900. The Pacific and Mountain regions begin with very high levels of TFP that likely reflect transitory mining output that is not captured by physical capital or human capital, while the Middle Atlantic, and to a lesser extent New England region, display high levels of TFP early in the period. One could argue that the Civil War or reaction in the post-war period has had a lasting effect on the East South Central and West South Central census regions.

Returning to rates of growth, Table 1 shows summary statistics for the average growth

[37] In another paper we allow for a time varying land share of output, starting at .136 and ending at .025, see Turner, Tamura, Mulholland (2008). Jones (2001) assumed a constant 10 percent share of output to land, as did Tamura (2006).

[38] We chose not to reformulate the production function as in Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999) as $a = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{k}{y}\right) - h$. The reasoning behind this transformation was that k may endogenously respond to exogenous changes in a or changes in h. However, this implies that h is not influenced by movements in k or a, and a is not influenced by movements in k or h. To us, this seems implausible, and we choose to use the more traditional method to back out TFP. See also Bosworth and Collins (2003) for more on this issue.

[39] As we have normalized the value of human capital associated with no experience and no years of schooling, and as land is measured in units other than dollars, there is implicitly a normalization with calculation of TFP.

rates of real output per worker, human capital per worker, and TFP per worker.[40] The data is reported on an annualized basis, and is calculated using the entire period for each state in which we have human capital, physical capital, land, and output measures. The number of years from which this figure is calculated varies from region to region, depending on data availability.[41] These figures are not weighted by labor force, nor weighted by the number of years included.[42]

For the period 1840 - 2000, the annualized rate of growth of output per worker is 1.45% for the United States as a whole. Of this 1.45% annual growth in output per worker, 0.95% (65%) is accounted for by input growth, while 0.50% (35%) is attributed to TFP growth. We observe variation in growth rates across regions. The East South Central and South Atlantic census regions have the highest growth rates of output, while the Pacific and Mountain census regions have the lowest.[43] Ignoring the Pacific and Mountain census regions for a moment, the New England census region has the highest fraction of growth explained by TFP (44%), while the West North Central census region has the lowest fraction of growth explained by TFP (31%). When considering broader regions, the South displays faster output, physical capital, and human capital growth rate than the North, fueling output convergence. The fraction of output growth explained by TFP ranges from 22% in the west to roughly 40% in the North and South. Overall, the input measures explain a significant fraction of output growth, but a meaningful fraction remains.

Given the values observed in the Pacific and Mountain regions, Table 2 duplicates the methodology of the previous table, but chooses 1880 as an initial condition, rather than 1840. For the United States as a whole from 1880 - 2000, the growth rate of output per worker is slightly higher, 1.58% per year, and now 56% of output growth is accounted for by input growth, leaving 44% attributed to TFP growth. Census regions included in the South display the fastest growth, while the Mid Atlantic and East North Central census regions display slower growth. The regions with the highest and lowest fraction of growth accounted for by TFP growth are the New England and Mountain regions respectively, while the fraction accounted for by TFP varies only from 37% in the West to 50% in the north. The growth rate of physical capital, human capital, and TFP are still highest in the South. Overall, using either starting condition, it would be correct to say that input measures explain slightly more than half of output growth.

[40] These results, and all subsequent results, are reported excluding the District of Columbia. The reason for omitting District of Columbia is discussed below.

[41] For instance, for the New England census region, we have data on all inputs and output beginning in 1840. The growth rate reported for output would be: $[log(output_{2000}) - log(output_{1840})]/160$. However, we do not observe output and human capital for the Pacific census region until 1850. Hence, the growth rate reported there would be: $[log(output_{2000}) - log(output_{1850})]/150$.

[42] As a result, the average value reported for the United States is not necessarily the growth rate of output in the United States as a whole. A state with a small labor force receives the same weight as a state with a large labor force in the calculation reported in Table 1. Similarly, a state for which we have data beginning in 1840 will receive the same weight as a state for which we have data beginning in 1870.

[43] As these calculations utilize information only in 2000 and the year in which output, human capital, physical capital are first observed, they are very sensitive to this initial condition. This issue is explored further in a later portion of this paper. Thus, the high estimate of output per worker in 1850 for the Pacific census region has a large impact on the annualized growth rate calculated from 1850 – 2000.

Estimates of Variability Across States

Although the basic growth accounting techniques we use are standard, the literature on explaining the cross-sectional variance in growth rates is less settled. Looking at international data, Klenow and Rodriguez-Clare (1997) and Easterly and Levine (2000) suggest that while the growth rate of TFP does not account for the majority of the growth rate of output, the variance of the growth rate of TFP across countries may explain the vast majority of the cross-sectional variance of the growth rate of output. In this section, we decompose the state level variance of output growth into the component explained by the variance of aggregate input growth and the component explained by the variance of TFP growth.

We continue with the production relationship specified above, with lower case letters denoting growth rates, and y, k, ℓ, and h denoting the growth rates of output per worker, capital per worker, land per worker, and human capital per worker, respectively:

$$y = a + \alpha k + \beta h + (1 - \alpha - \beta)\,\ell \tag{10}$$

We define x as the growth rate of aggregate input per worker:

$$x = \alpha k + \beta h + (1 - \alpha - \beta)\,\ell \tag{11}$$

which allows us to express the output growth as a function of aggregate input growth and TFP growth:

$$y = x + a \tag{12}$$

By the definition of variance, we have:

$$\sigma_Y^2 = \sigma_X^2 + 2\sigma_{X,A} + \sigma_A^2 \tag{13}$$

Dividing by σ_Y^2 and using the definition of covariance, produces:

$$1 = \frac{\sigma_X^2}{\sigma_Y^2} + \frac{\sigma_A^2}{\sigma_Y^2} + \frac{2\sigma_X\sigma_A}{\sigma_Y^2}\rho_{x,a} \tag{14}$$

where $\rho_{x,a}$ is the correlation between the growth rate of inputs, x, and the growth rate of TFP, a. If TFP growth and aggregate input growth are uncorrelated, the first term is the fraction of the variance of output growth caused by the variance of aggregate input growth, while the second term is fraction of output growth variance explained by TFP growth variance. However, this correlation is not zero empirically.

There are several methods to deal with the covariance term. First, ignore the covariance term entirely. If so, the relative variances will necessarily not sum to unity unless the covariance is in fact zero. A negative covariance term would result in the relative variances summing to a figure in excess of unity. Alternatively, we could follow Klenow and Rodriguez-Clare (1997) and allocate half of the covariance term to relative variance of the inputs and half to the relative variance of TFP. We do not pursue either of these methods. Instead, we follow the methodology of Baier, Dwyer, and Tamura (2006), and make two alternative estimates of the relative variances, and in doing so, we create an upper and lower bound on each source of variance.[44] We alternately assign all of the correlation between aggregate input growth and TFP growth to either aggregate input growth, or to TFP growth. This implies that each estimate will have a complement that adds to unity.

The first alternative, consistent with Romer (1986), Lucas (1988), and Tamura (1992, 2002, 2006), assumes that all changes in output growth that are predictable by aggregate input growth are due to aggregate input growth, or stated differently, that the correlation between input growth and TFP reflects unmeasured effects of input growth. All of these models assume that input growth induces TFP growth. Assuming a positive correlation, this assumption creates an upper bound on the fraction of the variance of output growth that can be explained by variance of input growth, and thus creates a lower bound on the fraction of the variance of output growth that can be explained by variation in TFP growth.[45]

$$\frac{\left(\sigma_X + \sigma_A * \rho_{x,a}\right)^2}{\sigma_Y^2} + \frac{\left(1 - \rho_{x,a}^2\right)\sigma_A^2}{\sigma_Y^2} = 1 \tag{15}$$

The second alternative, consistent with Solow (1956) and Romer (1990), assumes that all changes in output growth that are could be predicted by TFP growth are due to TFP growth, or, assumes the correlation reflects unmeasured effects of TFP growth. These models assume that TFP growth induces factor accumulation, i.e., input growth. This assumption then creates the upper bound on the fraction of the variance of output growth that can be explained by TFP growth, and therefore creates a lower bound on the fraction of the variance that can be explained by variation in aggregate input growth.[46]

$$\frac{\left(1 - \rho_{x,a}^2\right)\sigma_X^2}{\sigma_Y^2} + \frac{\left(\sigma_A + \sigma_X * \rho_{x,a}\right)^2}{\sigma_Y^2} = 1 \tag{16}$$

Variance Decomposition Results for the Entire United States

Because the decomposition of the covariance is not unique and remains unsettled in the literature, we provide information in Table 3 that enables the three common methods used in the literature to be calculated. Table 3 displays information on the results of the variance decomposition using data from 1840 through 2000 and using data from 1880 to 2000. For

[44] However, as we note below, we report our information so all three methods commonly used in the literature can be examined.

[45] In the case of negative correlation between TFP growth and aggregate input growth, this assumption will in fact create a lower bound on the fraction of the output variance that can be explained by aggregate input and an upper bound on the fraction of the output variance that can be explained with TFP. These cases are rare. In the tables that display the results, we always report the actual lower and upper bound, regardless of from which assumption it is derived.

[46] See footnote above. In the case of negative correlation between TFP growth and aggregate input growth, this assumption creates an upper bound on the fraction explained by variation in inputs, and a lower bound on the fraction explained by variation in TFP.

the 1840 through 2000 period, the variance of the growth rate of TFP is 13% of the variance of output growth, while the variance of the growth rate of TFP is 56% of the variance of output growth. The lower and upper bounds, respectively, suggest that between 9% and 62% of the variance of output growth can be explained by the variance of aggregate input growth, leaving between 38% and 91% to be explained by the variation of TFP growth. The wide range is influenced heavily by an observed correlation coefficient of approximately 0.56 between the growth rate of aggregate input and the growth rate of TFP.

We also report the variance decomposition for the broader regions in Table 3. We are hesitant to infer too much from the regional analysis. The results are quite sensitive to the correlation between aggregate input growth and TFP growth. In addition, after subdividing the nation into regions, this correlation is based on as few as 14 observations. That caveat aside, the results are reasonably similar for the South and West. Within the South and West regions, variation in TFP growth is capable of explaining the vast majority of the variance of output growth, while input growth variations can explain at most between half and two-thirds of the variance of output growth. Because the correlation between aggregate input growth and TFP growth is very near zero in the North, the upper and lower bounds are quite tight. Variation in input growth can explain roughly 30% of the variance in output growth, while variation in TFP growth can explain roughly 70% of the variance in output growth.

As noted above, the growth rates are sensitive to the initial conditions; therefore, we repeat the analysis using data from 1880 through 2000. The results of this decomposition are also reported in the Table 3. For the US as a whole, the results are fairly similar to the result using the 1840 initial condition. We find that the variance of the growth rate of aggregate inputs can explain between 24% and 65% of the variance of output growth, leaving TFP to explain between 35% and 76%. The results show that the variance decomposition is clearly dependent on the treatment of the observed correlation of aggregate input growth and TFP growth. Depending on how this correlation is allocated, either aggregate input or TFP could be responsible for explaining the lion's share of the variance in output growth.

We find this result surprising. The upper bounds on the relative importance of the variance of the growth rate of TFP is 90% of the variation in output growth rates from 1840 - 2000, and 76% from 1880 - 2000. While the cross country data examined in Baier, Dwyer and Tamura (2006) has many unmeasured features, such as different monetary regimes, different tax regimes, different trade policies, different education regimes, differential private property regimes, etc., the cross state differences in these unmeasured features should be much smaller. A priori we thought that this greater homogeneity across the states would have been more inputs more informative about the causes of differential economic growth outcomes. The unique feature of slavery and the Post Reconstruction period in the former slave southern states may be a contributing feature. This is beyond the scope of this paper, and is examined in Turner, Tamura and Mulholland (2008). However, as in Baier, Dwyer and Tamura (2006), the data allow an individual with strong priors as to which theory of growth is relevant, TFP induced by input growth, or input growth induced by TFP growth, to be confirmed. However, we note that in each period and region, the upper bound that can be explained by TFP growth is always larger than the upper bound that can be explained by input growth, and occasionally considerably so.

Results for Subperiods

Table 4 reports the growth accounting and variance decompositions for various subperiods: The Civil War Reconstruction Era (1870-1910), the Interwar Era (1910-1950), the Post War Era (1950-1973), Post Bretton-Woods Era (1973-2000).[47,48] In the period from 1870-1910, the data indicate that effectively all output growth is accounted for by the growth of aggregate inputs. However, the growth of inputs must have been relatively uniform across states over this time period, as the variation in input growth is roughly 8 percent of the variation in output growth. Taking into account the correlation of inputs and TFP, we find that the plausible upper bound on aggregate input growth accounts for just over half of the variation in output growth. During the Interwar Era, the growth rate of output per worker nearly doubled from the previous era. The growth of output was almost equally accounted for by the growth of aggregate inputs and the growth of TFP. The variation of aggregate input growth is 23% of the variance in output per worker growth while the variation in TFP growth is 36% of output growth variation. Taking into account the correlation of input growth and TFP growth, we find the plausible upper and lowers bounds for TFP growth are quite similar to the upper and lower bounds for aggregate input growth, with only a slight skew towards TFP. The Post War Era looks is similar to the Interwar Era in regard to the growth rates of human and physical capital. However, TFP growth accounts for nearly two-thirds of the growth rate in output per worker. As in the Interwar Era, the relative variances of TFP and aggregate input growth are the of the same magnitude in the Post War Era. While the upper and lower bounds are tighter for each source in this subperiod, the upper and lower bounds explained by TFP are again similar to the upper and lower bounds explained by inputs, again with a slight skew towards TFP. In the Post Bretton-Woods Era, growth of aggregate inputs accounts for 61% of the growth in output per worker. However in this period the variation in TFP accounts for a larger fraction of the variation of output per worker.

In sum, the subperiods are more or less consistent with the findings over the larger sample, but there are a few exceptions. First, in the Reconstruction period, TFP growth was much lower than in all other subperiods. Second, and not surprisingly, because it is consistent with almost all growth accounting exercises over similar time horizon, TFP growth was fastest during the Post War Era (1950-1973). Third, variations in aggregate input growth explain a smaller fraction of the variation in output per worker in the Reconstruction and the Post War era. These exceptions aside, the inferences drawn from the subperiods

[47] The choice of subperiods roughly corresponds to the growth accounting exercise in Maddison. His periods are 1870-1913, 1913-1950, 1950-1973, 1973-1992. Because we only have decadal data until 1929, we could not use the period 1870-1913 as in Maddison. We extend the 1973 - 1992 period to 2000.

[48] In the 1973-2000 and 1950-1973 subperiods, we include all 50 states and exclude D.C. D.C. appears to behave much differently than the other states; including D.C. results in a meaningully different observed correlation between aggregate input growth and TFP growth. As we move backward to the 1910-1950 period, data for Oklahoma becomes unavailable. As we continue to the 1870-1910 period, data for both North Dakota and South Dakota become unavailable.

should be similar to inferences drawn from the growth accounting exercises and variance decompositions for the entire sub-period: aggregate inputs account for a little more than 50% of the growth in output per worker. For those who have a strong prior as to what factors account for the variation in output per worker across countries, the data does not provide enough support to reject the reader's priors.

CONCLUSION

This paper creates and utilizes a new state level physical capital measures to conduct a growth accounting for the United States from 1840 – 2000. We find that our measure of aggregate input is able to account for 65% of average output growth per worker, leaving 35% to TFP growth. The measure of aggregate input growth explains a large fraction of output growth, but a significant fraction remains. TFP growth rates are different across census regions.

By analyzing state-level data, rather the country-level data, and thus reducing the expected heterogeneity of policies and institutions, we expected the fraction of output growth explained by accounted for by inputs to be higher than those found in cross country analyses. One possibility that may be playing a large role is the exclusion of African-Americans from formal education. This large observed variation of human capital across regions may be a result of this institution difference and hence explain a significant portion of output variation.[49]

We find that conclusions concerning the fraction of the cross sectional variance of output growth that is explained by TFP growth and aggregate input growth depend on the treatment of the observed correlation between TFP growth and aggregate input growth, and are somewhat sensitive to time periods considered. For longer periods, the upper and lower bounds created suggest that either variance in aggregate input growth or variance in TFP growth is able to account for the vast bulk of the variance in output growth. Our results also suggest that growth analysis covering the last forty years, from 1960 – 2000 will reach somewhat different conclusions than those looking back to 1840 or 1880.

[49] In Turner, Tamura, Mulholland (2008) we do a development accounting exercise and again find that the variance of log output per worker is generally explained by variation in log TFP, rather than log inputs. We examined whether differential schooling availability to African Americans can better capture the true human capital input. We find some evidence that unequal treatment of African Americans in education provision directly lowers state TFP.

REFERENCES

Abramovitz, Moses. 1956. "Resource and Output Trends in the United States since 1870", *American Economic Review Papers and Proceedings*, 46,. 5-23.

Barro, Robert J., and Jong-Wha Lee. 1993. "International Comparisons of Educational Attainment", *Journal of Monetary Economics*, 32, 363-94.

Baier, Scott, Gerald Dwyer, and Robert Tamura. 2006. "How Important are Capital and Total Factor Productivity for Economic Growth?", *Economic Inquiry*, 44, 23-49.

Bernard, Andrew, and Charles I. Jones. 1996a. "Productivity and Convergence across U.S. States and Industries," *Empirical Economics*, 21, 113-135.

Bernard, Andrew, and Charles I. Jones. 1996b. "Comparing Apples to Oranges: Productivity Convergence and Measurement Across Industries and Countries," *American Economic Review*, 86, 1216-1238.

Berry, William D., Richard C. Fording, and Russell L. Hanson. 2000. "An Annual Cost of Living Index for the American States, 1960-95", *Journal of Politics*, 60, 550-67.

Bosworth, Barry P. and Susan M. Collins. 2003. "The Empirics of Growth: An Update", *Brookings Papers on Economic Activity*, 2, 113-206.

Canaday, Neil. 2003. "Taxation and the Determinants of Public Spending on the Education of African Americans Under Segregation: Evidence from South Carolina, 1895-1960. Unpublished Clemson University Ph.D. dissertation.

Canaday, Neil, and Robert Tamura. 2007. "White Discrimination in Provision of Black Education: Plantations and Towns", Clemson University working paper.

Denison, Edward F., 1962. "The Sources of Economic Growth in the United States and the Alternatives Before Us", New York: Committee for Economic Development: Supplementary Paper: 13.

Denison, Edward F. 1974. *Accounting for Economic Growth*, 1929-1969, Washington D.C.: Brookings Institution.

Denison, Edward F. 1985. *Trends in Economic Growth*, 1929-1982, Washington D.C.: Brookings Institution.

Department of Commerce. 1975. *Historical Statistics of the United States: Colonial Times to 1970*, Washington, D.C.: U.S. Government Printing Office.

Dougherty, Chrys. and Dale W. Jorgenson. 1996. "International Comparisons of the Sources of Economic Growth", *The American Economic Review*, 86: 2, Papers and Proceedings of the Hundredth and Eighth Annual Meeting of the American Economic Association. 25-29.

Easterlin, Richard. 1960a. "Regional Growth of Output: Long Term Tendencies, 1880 – 1950", in *Population and Redistribution and Economic Growth, United States, 1870-1950*, Vol. 1, Analyses of Economic Change, eds. Simon Kuznets, Ann Ratner Miller, and Richard Easterlin, Philadelphia: American Philosophical Society.

Easterlin, Richard. 1960b. "Interregional Differences in Per Capita output, Population, and Total output, 1840-1950", in *Trends in the American Economy in the Nineteenth Century*, ed. William N. Parker, Princeton: Princeton University Press.

Easterly, William and Ross Levine. 2002. "It's Not Factor Accumulation: Stylized Facts and Growth Models", Unpublished paper, World Bank.

Elias, Victor. 1992. *Sources of Growth: A Study of Seven Latin American Countries.* San Francisco, California: ICS Press.

Fabricant, Solomon. 1954. *Economic Progress and Economic Change.* In 34th Annual Report. New York: National Bureau of Economic Research.

Gallman, Robert E. 1986. "The United States Capital Stock in the Nineteenth Century", in *Long-Term Factors in American Economic Growth*, Stanley L. Engerman and Robert Gallman, editors, Chicago: University of Chicago Press.

Garofalo, Gasper A. and Steven Yamarik. 2002. "Regional Convergence: Evidence From A New State-By-State Capital Stock Series", *The Review of Economics and Statistics*, 84, 316-323.

Gordon, Robert J.1999a. "U.S. Economic Growth since 1870: One Big Wave?," *American Economic Review*, 89(2), 123-128.

Gordon, Robert. 1999b. *Macroeconomics.* New York: Addison-Wesley.

Griliches, Zvi. 1960. "Measuring Inputs in Agriculture: A Critical Survey" *Journal of Farm Economics, Proceedings of the Annual Meeting of the American Farm Economic Association.* 42: 1411-1427.

Hall, Robert, and Charles I. Jones. 1999. "Why Do Some Countries Produce So Much More Output Per Worker Than Others?" *Quarterly Journal of Economics*, 114: 83-116.

Jones, Charles I. 1997. "On the Evolution of the World Output Distribution", *Journal of Economic Perspectives*, 11, 19-36.

Jones, Charles I. 2001. "Was An Industrial Revolution Inevitable? Economic Growth Over the Very Long Run" *Advances in Macroeconomics*, Article 1.

Jorgenson, Dale W. 1988."Productivity and Postwar U.S. Economic Growth", *The Journal of Economic Perspectives*, 2(4). 23-41.

Jorgenson, Dale W. 1990. "Productivity and Economic Growth," in Berndt, E. and J. Triplett, (eds) *Fifty Years of Economic Measurement*, NBER Studies in Income and Wealth Volume 54, Chicago: The University of Chicago Press.

Jorgenson, Dale W., Frank Gollop, Barbara Fraumeni. 1987. *Productivity and U.S. Economic Growth* Cambridge, MA, Harvard University Press.

Jorgenson, Dale W., Zvi Griliches. 1967. "The Explanation of Productivity Changes", The Review of Economic Studies, 34: 249-283.

Jorgenson, Dale W.; Kevin J. Stiroh. 2000. "U.S. Economic Growth at the Industry Level", *The American Economic Review*, 90: 2, *Papers and Proceedings of the One Hundred Twelfth Annual Meeting of the American Economic Association*. 161-167.

Kendrick, John W. 1956. *Productivity Trends: Capital and Labor*. New York: National Bureau of Economic Research.

Kendrick, John W. 1961. *Productivity Trends in the United States*. Princeton NJ: Princeton University Press.

Klenow, Peter J., and Andres Rodriguez-Clare. 1997. "The Neoclassical Revival in Growth Economics: Has it Gone Too Far?", in *NBER Macroeconomics Annual* 1997, eds. Ben S. Bernanke and Julio J. Rotemberg, 73-103.

Lucas, Robert E., Jr. 1988. "On the Mechanics of Economic Development", *Journal of Monetary Economics*, 22, 3-42.

Maddison, Angus. 1995. *Monitoring the World Economy, 1820-1992*, Paris: Development Centre of the Organization for Economic Cooperation and Development.

Maddison, Angus. 2001. *The World Economy: A Millennial Perspective*, Paris: Development Center of the Organization for Economic Cooperation and Development.

Mankiw, N. Gregory, David Romer and David N. Weil. 1992. "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, 107, 407-37.

Margo, Robert A. 1990. *Race and Schooling in the South, 1880-1950*, Chicago: University of Chicago Press.

Mitchener, Kris J. and Ian W. McLean. 1999. "U.S. Regional Growth and Convergence 1880 –1980", *The Journal of Economic History*, 59, 1016-42.

Romer, Paul. 1986. "Increasing Returns and Long-Run Growth", *Journal of Political Economy*, 94, 1002-1037.

Romer, Paul. 1990. "Endogenous Technological Change", *Journal of Political Economy*, 98, S71-S102.

Schultz, Theodore W. 1960. "Capital Formation By Education", *Journal of Political Economy*, 68, 571-583.

Solow, Robert M. 1956. "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, 70, 65-94.

Solow, Robert M. 1957. "Technical Change and the Aggregate Production Function", *Review of Economics and Statistics*, 39, 312-320.

Tamura, Robert, 1992. "Efficient Equilibrium Convergence: Heterogeneity and Growth", *Journal of Economic Theory,* 58, 355-376.

Tamura, Robert, 2002. "Human Capital and the Switch From Agriculture to Industry", *Journal of Economic Dynamics and Control*, 27, 207-242.

Tamura, Robert, 2006. "Human Capital and Economic Development", *Journal of Development Economics*, 79, 26-72.

Temple, Jonathan. 1999. "The New Growth Evidence", *Journal of Economic Literature*, 37, 112-156.

Tinbergen, Jan. 1942. "Zur Theorie de Langfristigen Wirtschaftsentwicklung", *Weltwirtschaftliches Archiv*. 55:1. 511-549.

Turner, Chad, Robert Tamura, Sean E. Mulholland and Scott Baier. 2007. "Education and output of the States of the United States: 1840 – 2000", *Journal of Economic Growth*, 12, 101-158

Turner, Chad, Robert Tamura, Sean E. Mulholland. 2008. "Productivity Differences: The Importance of Intra-State Black - White Schooling Differences Across the United States, 1840 - 2000," Unpublished Clemson University working paper.

U.S. Census Bureau. *Statistical Abstracts of the United States*, various issues, Washington, D.C.: U.S. Government Printing Office.

U.S. Census Bureau. *Census of Population*, various issues, Washington, D.C.: U.S. Government Printing Office.

Weiss, Thomas. 1999. “Estimates of White and Nonwhite Gainful Workers in the United States by Age Group and Sex, 1800 to 1900”, *Historical Methods*, 32, 21-36.

Williamson, Jeffrey G. and Peter H. Linder. 1980. *American Inequality*, Academic Press.

Young, Alwyn. 1995. The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Experience. *Quarterly Journal of Economics* 110(3): 641-680.

TABLES / FIGURES

Table 1: Growth Accounting: 1840 (or when data becomes available) to 2000

	y	k	h	ℓ	x	a	a / y
All Regions	1.45%	1.67%	0.79%	-1.15%	0.95%	0.50%	0.347
NE	1.46%	1.70%	0.62%	-2.21%	0.78%	0.68%	0.463
MATL	1.52%	1.76%	0.75%	-2.18%	0.89%	0.63%	0.414
SATL	1.92%	2.15%	0.86%	-1.93%	1.09%	0.83%	0.432
ESC	1.66%	1.89%	0.88%	-1.29%	1.05%	0.61%	0.365
WSC	1.58%	1.72%	0.85%	-1.08%	1.01%	0.57%	0.365
MTN	1.26%	1.55%	0.74%	0.88%	1.05%	0.21%	0.165
PAC	0.93%	1.21%	0.78%	-2.09%	0.76%	0.17%	0.180
WNC	1.33%	1.40%	0.83%	-0.51%	0.92%	0.41%	0.306
ENC	1.44%	1.68%	0.80%	-1.52%	0.94%	0.50%	0.351
North	1.46%	1.70%	0.71%	-1.96%	0.86%	0.60%	0.413
South	1.77%	1.98%	0.86%	-1.56%	1.06%	0.71%	0.401
West	1.20%	1.42%	0.78%	-0.29%	0.93%	0.27%	0.222

Table 2: Growth Accounting: 1880 (or when data becomes available) to 2000

	y	k	h	ℓ	a	x	a / y
All Regions	1.58%	1.64%	0.75%	-1.56%	0.69%	0.89%	0.438
NE	1.41%	1.49%	0.58%	-2.67%	0.73%	0.68%	0.520
MATL	1.34%	1.46%	0.62%	-2.43%	0.64%	0.70%	0.474
SATL	2.04%	2.07%	0.90%	-2.39%	0.97%	1.07%	0.478
ESC	1.92%	1.87%	0.90%	-1.67%	0.88%	1.04%	0.457
WSC	1.87%	1.88%	0.92%	-1.27%	0.79%	1.08%	0.424
MTN	1.37%	1.57%	0.72%	0.29%	0.42%	0.98%	0.311
PAC	1.45%	1.65%	0.74%	-2.22%	0.60%	0.85%	0.413
WNC	1.41%	1.35%	0.75%	-0.63%	0.56%	0.85%	0.395
ENC	1.33%	1.31%	0.62%	-1.78%	0.64%	0.69%	0.480
North	1.37%	1.42%	0.60%	-2.30%	0.68%	0.69%	0.496
South	1.97%	1.97%	0.90%	-1.93%	0.91%	1.06%	0.460
West	1.41%	1.51%	0.74%	-0.71%	0.52%	0.89%	0.370

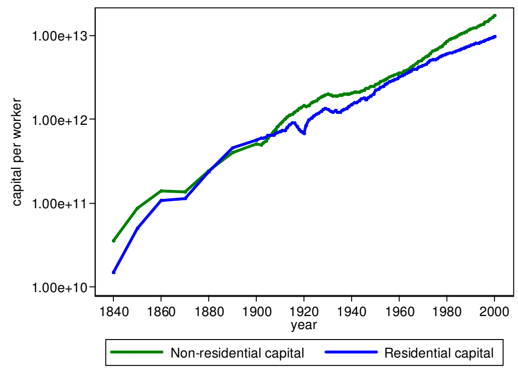
Table 3: Variance Decomposition Results

Time Period:	1840 (or when available) to 2000				1880 (or when available) to 2000			
Region:	All	North	South	West	All	North	South	West
Standard deviations:								
σ_Y	0.45%	0.19%	0.22%	0.53%	0.34%	0.08%	0.24%	0.24%
σ_X	0.16%	0.10%	0.06%	0.20%	0.18%	0.03%	0.10%	0.15%
σ_A	0.34%	0.16%	0.18%	0.38%	0.22%	0.10%	0.17%	0.17%
Relative variances:								
σ_X^2 / σ_Y^2	0.132	0.262	0.079	0.141	0.288	0.164	0.162	0.405
σ_A^2 / σ_Y^2	0.563	0.704	0.654	0.523	0.424	1.571	0.491	0.514
$\sigma_{X,A}$ / σ_Y^2	0.335	0.255	0.260	0.368	0.453	0.257	0.392	0.447
$\rho_{X,A}$	0.562	0.040	0.585	0.618	0.413	-0.725	0.617	0.089
Fraction σ_Y^2 explained by:								
σ_X^2 - lower bound	0.090	0.262	0.052	0.087	0.238	0.078	0.100	0.402
σ_X^2 - upper bound	0.615	0.297	0.570	0.677	0.649	0.254	0.696	0.490
σ_A^2 - lower bound	0.385	0.703	0.430	0.323	0.351	0.746	0.304	0.510
σ_A^2 - upper bound	0.910	0.738	0.948	0.913	0.762	0.922	0.900	0.598

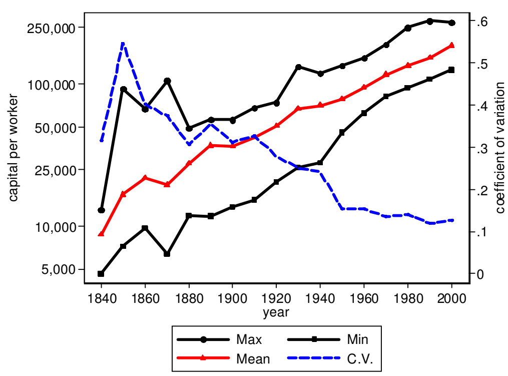
Table 4: Growth Accounting / Variance Decomposition in Subperiods

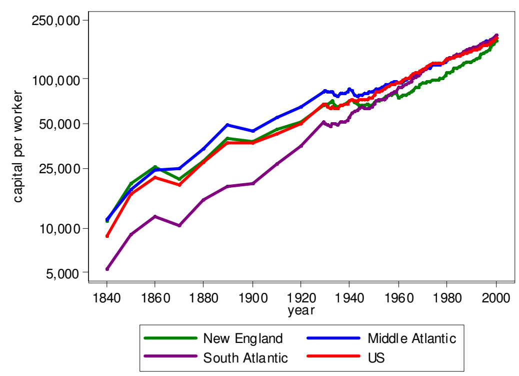
	1870-1910	1910-1950	1950-1973	1973-2000
Average Growth Rates:				
y	0.97%	1.86%	2.42%	1.14%
h	0.88%	0.90%	0.62%	0.60%
k	1.65%	1.79%	2.01%	0.77%
ℓ	-0.50%	-0.48%	-2.96%	-2.39%
x	1.03%	1.08%	0.84%	0.70%
a	-0.06%	0.77%	1.58%	0.44%
Standard Deviations:				
σ_Y	1.13%	0.63%	0.58%	0.49%
σ_X	0.32%	0.33%	0.29%	0.18%
σ_A	0.92%	0.39%	0.33%	0.40%
Relative Variances:				
σ_X^2 / σ_Y^2	0.08	0.27	0.25	0.14
σ_A^2 / σ_Y^2	0.66	0.38	0.33	0.66
$\sigma_{X,A}$ / σ_Y^2	0.26	0.36	0.12	0.20
$\rho_{X,A}$	0.56	0.56	0.21	0.32
Fraction σ_Y^2 explained by:				
σ_X^2 - lower bound	0.06	0.18	0.39	0.07
σ_X^2 - upper bound	0.55	0.74	0.54	0.66
σ_A^2 - lower bound	0.45	0.26	0.46	0.34
σ_A^2 - upper bound	0.94	0.82	0.61	0.93
States	44	47	50	50
Includes DC	no	no	no	no

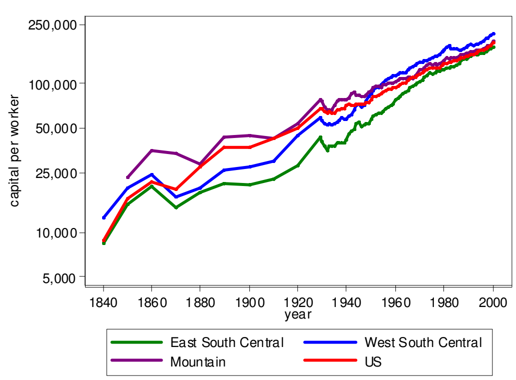
Figure 1

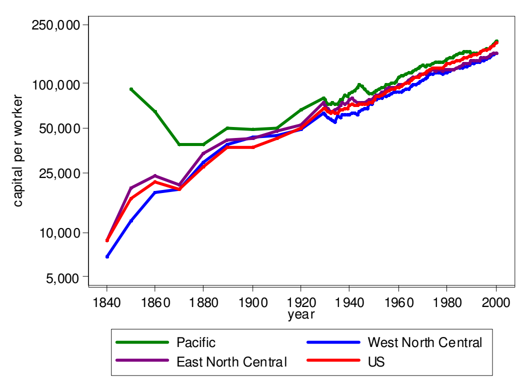


Figures 2 - 5

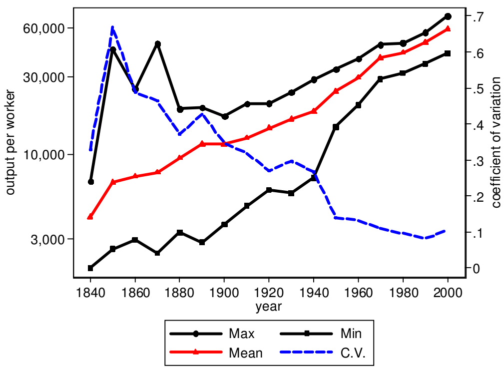








Figures 6 - 9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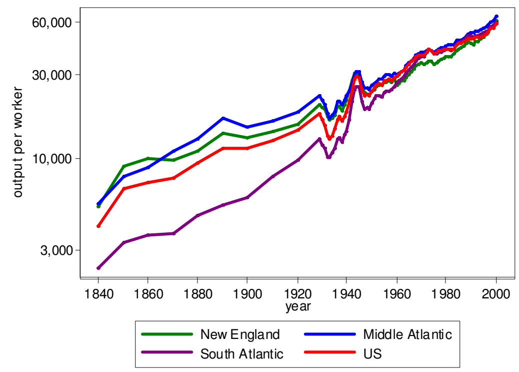
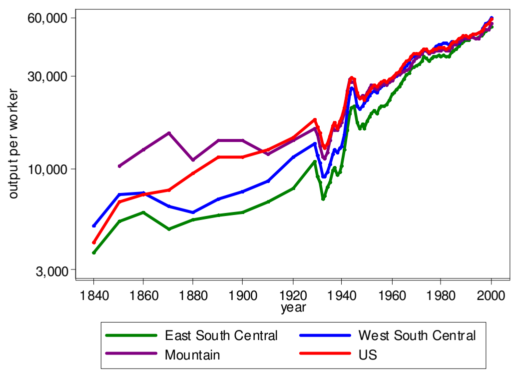
60,000
30,000
10,000
3,000
coefficient of variation
.7
.6
.5
.4
.3
.2
.1
0
1840 1860 1880 1900 1920 1940 1960 1980 2000
year
Max
Min
Mean
C.V.


output per worker
60,000
30,000
10,000
3,000
1840 1860 1880 1900 1920 1940 1960 1980 2000
year
New England
Middle Atlantic
South Atlantic
US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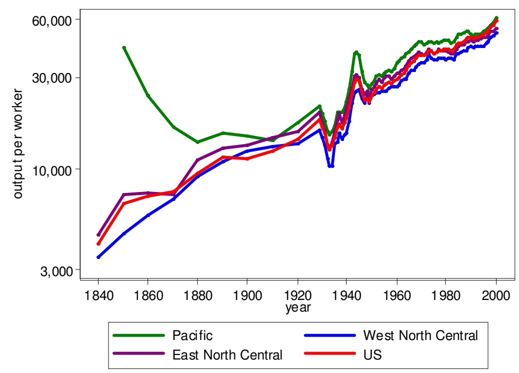
30,000
10,000
3,000
1840 1860 1880 1900 1920 1940 1960 1980 2000
year
East South Central
West South Central
Mountain
US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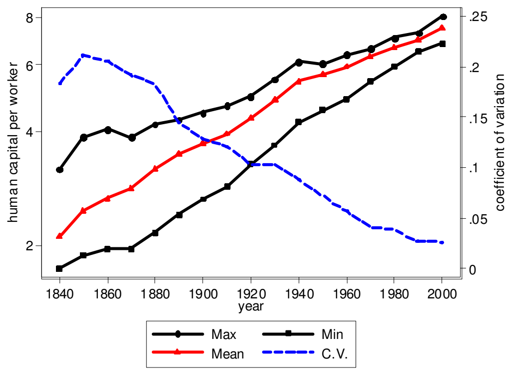
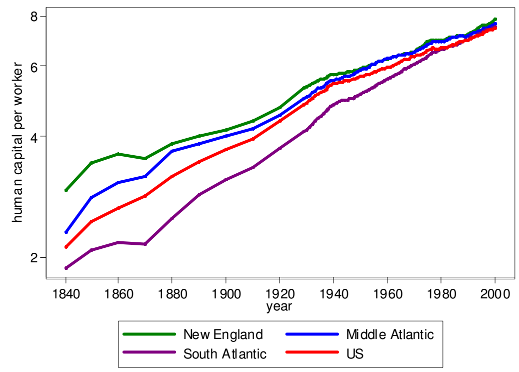
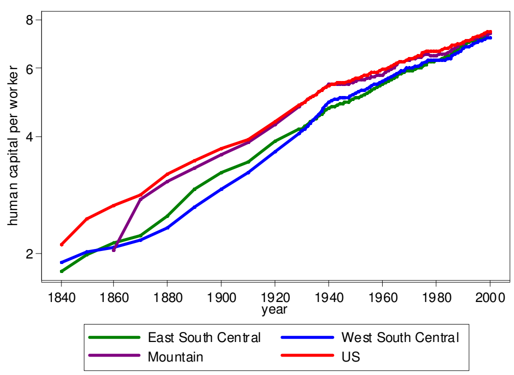
30,000
10,000
3,000
1840 1860 1880 1900 1920 1940 1960 1980 2000
year
Pacific
West North Central
East North Central
US

Figures 10 - 13







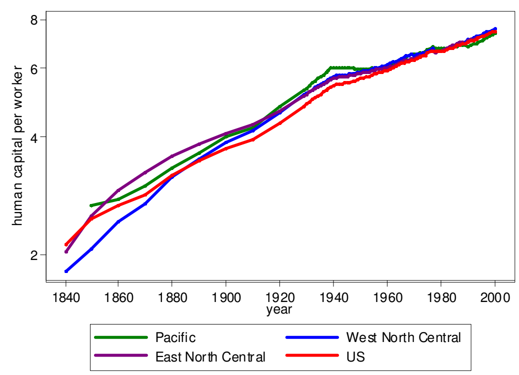
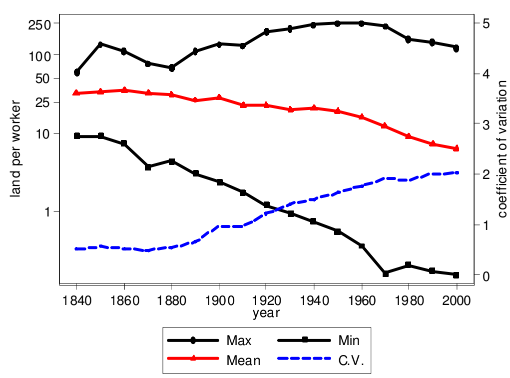
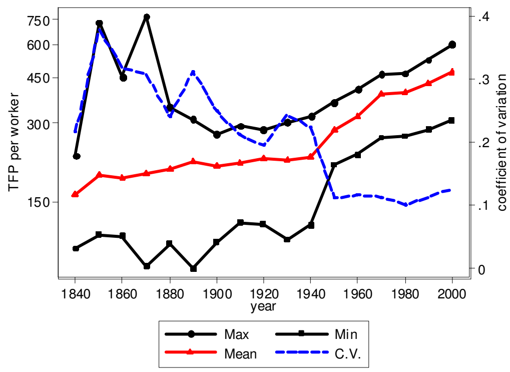
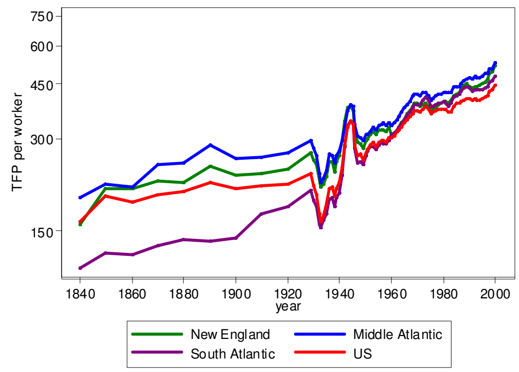


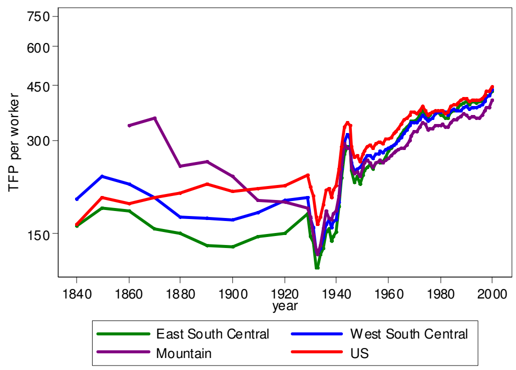
Figure 14

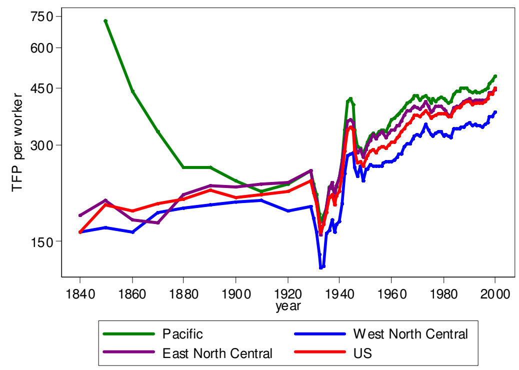


Figures 15 - 18









APPENDIX A

Regional Divisions:

New England	*Middle Atlantic*	*South Atlantic*	*E. South Central*	*W. South Central*
Connecticut	New Jersey	Delaware	Alabama	Arkansas
Maine	New York	D.C.	Kentucky	Louisiana
Massachusetts	Pennsylvania	Florida	Mississippi	Oklahoma
New Hampshire		Georgia	Tennessee	Texas
Rhode Island		Maryland		
Vermont		North Carolina		
		South Carolina		
		Virginia		
		West Virginia		
Mountain	*Pacific*	W. North Central	*E. North Central*	
Arizona	Alaska	Iowa	Illinois	
Colorado	California	Kansas	Indiana	
Idaho	Hawaii	Minnesota	Michigan	
Montana	Oregon	Missouri	Ohio	
Nevada	Washington	Nebraska	Wisconsin	
New Mexico		North Dakota		
Utah		South Dakota		
Wyoming				

Year in which data is available:

1840: Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia

1850: California, New Mexico, Oregon, Texas, Utah, Wisconsin

1860: Kansas, Minnesota, Nebraska, Washington, New Mexico*, Utah*

1870: Colorado, Montana, Nevada, West Virginia

1880: Arizona, Idaho

1900: North Dakota, South Dakota, Wyoming

1920: Oklahoma

1930: District of Columbia

1950: Alaska

*output and physical capital data available in 1850, but human capital data not available until 1860.

APPENDIX B

Capital Mapping

Gallman Capital, 1840 - 1900

Industry:	Allocated to states using:
Agriculture	TTMB agricultural output
Manufacturing	TTMB manufacturing output
Transportation	TTMB non-agricultural non-manufacturing output
Commerce	TTMB non-agricultural non-manufacturing output
Government	TTMB non-agricultural non-manufacturing output
Residential	TTMB real output per worker

BEA Capital, 1902 - 1920

Industry:	Allocated to states using:
Agriculture, Forestry, Fishing	TTMB agricultural output
Mining	TTMB non-agricultural non-manufacturing output
Construction	TTMB non-agricultural non-manufacturing output
Manufacturing – Durable	TTMB manufacturing output
Manufacturing – Non-durables	TTMB manufacturing output
Transportation	TTMB non-agricultural non-manufacturing output
Wholesale Trade	TTMB non-agricultural non-manufacturing output
Retail Trade	TTMB non-agricultural non-manufacturing output
Fire	TTMB non-agricultural non-manufacturing output
Services	TTMB non-agricultural non-manufacturing output
Government	TTMB non-agricultural non-manufacturing output
Residential	TTMB real output per worker

BEA Capital, 1929 - 1962, 1998 - 2000

Industry:	Allocated to states using:
Agriculture, Forestry, Fishing	Estimated agriculture gross state product
Mining	Estimated mining gross state product
Construction	Estimated agriculture gross state product
Manufacturing – Durable	Estimated durable goods gross state product
Manufacturing – Non-durables	Estimated non-durable goods gross state product
Transportation	Estimated transportation gross state product
Wholesale Trade	Estimated Trade gross state product
Retail Trade	Estimated Trade gross state product
Fire	Estimated FIRE gross state product
Services	Estimated Services gross state product
Government	Estimated Government gross state product
Residential	Real output per worker

BEA Capital, 1963 - 1997

Industry:	Allocated to states using:
Agriculture, Forestry, Fishing	Agriculture gross state product
Mining	Mining gross state product
Construction	Agriculture gross state product
Manufacturing – Durable	Durable goods gross state product
Manufacturing – Non-durables	Non-durable goods gross state product
Transportation	Transportation gross state product
Wholesale Trade	Wholesale trade gross state product
Retail Trade	Retail trade gross state product
Fire	FIRE gross state product
Services	Services gross state product
Government	Government gross state product
Residential	Real output per worker

APPENDIX C

Regression results for predicting GSP for 1929-1962 and 1998 - 2000

$$\ln(gsp_{ijt}) = \beta_0 + \beta_1 * \ln(wages_{ijt}) + \beta_2 * year + \beta_3 * Z \quad (17)$$

Industry	Constant	SE	Wages	SE	Year	SE	R^2	N	State Dummies
	10.02	0.299	0.579	0.017			0.400	1785	N
Agriculture	21.206	6.693	0.606	0.023	-0.006	0.004	0.401	1785	N
	-1.497	0.067	0.212	0.028	0.035	0.003	0.971	1785	Y
	-0.564	0.110	1.084	0.006			0.948	1779	N
Mining	-3.944	2.349	1.081	0.006	0.002	0.001	0.948	1779	N
	1.071	0.062	0.969	0.016	0.009	0.001	0.986	1779	Y
	0.384	0.043	1.007	0.002			0.992	1785	N
Construction	-12.552	0.486	0.976	0.002	0.007	0.000	0.995	1785	N
	0.024	0.017	0.963	0.007	0.008	0.000	0.997	1785	Y
	0.762	0.048	0.989	0.002			0.991	1785	N
Manuf. Durable	-14.549	0.748	0.971	0.002	0.008	0.000	0.993	1785	N
	0.148	0.052	1.021	0.012	0.004	0.001	0.995	1785	Y
	0.056	0.058	1.028	0.003			0.987	1785	N
Manuf. Nondurable	-14.915	0.809	1.005	0.003	0.008	0.000	0.989	1785	N
	-0.054	0.045	0.982	0.014	0.009	0.001	0.996	1785	Y
	0.943	0.060	1.000	0.003			0.985	1785	N
Trans. & Utilities	-22.014	0.673	0.946	0.003	0.012	0.000	0.991	1785	N
	0.121	0.025	0.927	0.012	0.014	0.001	0.996	1785	Y
	1.362	0.078	0.964	0.004			0.973	1693	N
Transportation	-16.827	1.046	0.924	0.004	0.01	0.001	0.977	1693	N
	0.687	0.031	0.954	0.016	0.008	0.001	0.992	1693	Y
	0.507	0.066	1.046	0.003			0.982	1715	N
Utilities	-11.279	1.073	1.016	0.004	0.006	0.001	0.983	1715	N
	-0.770	0.042	0.873	0.015	0.018	0.001	0.992	1715	Y
	0.955	0.053	1.007	0.003			0.987	1763	N
Communication	-20.484	0.696	0.960	0.003	0.011	0.000	0.992	1763	N
	-0.647	0.020	0.744	0.007	0.028	0.001	0.997	1763	Y
	0.791	0.026	0.995	0.001			0.997	1785	N
Trade	-1.670	0.373	0.989	0.001	0.001	0.000	0.997	1785	N
	-0.230	0.010	0.940	0.004	0.005	0.000	1.000	1785	Y
	2.866	0.044	0.943	0.002			0.991	1785	N
FIRE	-1.375	0.799	0.934	0.003	0.002	0.000	0.991	1785	N
	0.437	0.029	1.070	0.011	-0.011	0.001	0.997	1785	Y
	1.043	0.020	0.976	0.001			0.998	1785	N
Services	1.280	0.374	0.977	0.001	0.000	0.000	0.998	1785	N
	0.001	0.013	0.972	0.006	0.000	0.001	1.000	1785	Y
	-0.339	0.034	1.031	0.002			0.996	1785	N
Government	-14.732	0.289	0.993	0.001	0.008	0.000	0.998	1785	N
	-0.089	0.010	0.996	0.006	0.007	0.000	0.999	1785	Y

APPENDIX D

Regional Convergence

To facilitate examination of convergence at the state level and census regional levels, Figure D1 displays the time path of physical capital per worker in the North, South, and West, along with the nation as a whole. Table D1 reports these measures, while Table D2 reports the gap between the states (or regions) with the highest and lowest value of physical capital per worker. The measure of the gap reported is the difference between the logarithms of the state (or region) with the largest value and the state (or region) with the lowest value. The row marked Regions presents gaps between census regions, and the row marked States represents gaps between states. We also present the gap between states excluding the District of Columbia in the row marked States'. The gap between regions decreases consistently from 1890 to 1970, while the gap between states is sensitive to the inclusion of new states.

Figure D1

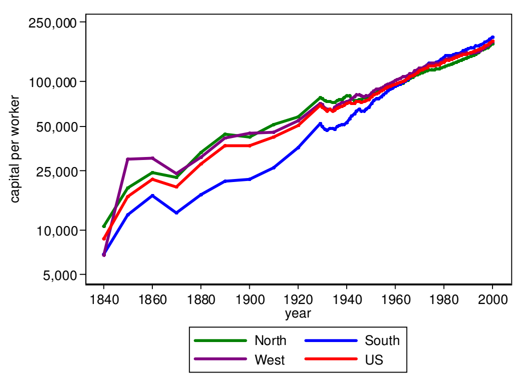


Table D1: Physical Capital per Worker, Labor Force Weighted

Year	North	South	West	US	SD	CV	Gap
1840	10,593	6,897	6,822	8,735	2,242	0.26	3,771
1850	19,151	12,603	29,935	16,737	5,755	0.34	17,331
1860	24,505	17,002	30,650	21,910	5,696	0.26	13,649
1870	22,692	13,061	24,047	19,570	5,405	0.28	10,985
1880	33,146	17,334	31,191	27,681	8,094	0.29	15,812
1890	44,493	21,460	41,673	36,860	11,737	0.32	23,032
1900	42,612	21,982	44,964	36,712	11,288	0.31	22,982
1910	51,029	26,236	45,718	42,319	12,613	0.30	24,793
1920	57,922	36,014	54,729	50,862	10,908	0.21	21,908
1930	76,292	49,991	70,012	67,295	12,692	0.19	26,301
1940	80,506	52,950	73,307	70,770	13,065	0.18	27,556
1950	81,526	71,276	83,953	79,076	5,782	0.07	12,677
1960	93,148	93,365	101,399	95,229	4,941	0.05	8,252
1970	112,831	119,408	122,607	117,295	5,300	0.05	9,776
1980	125,639	145,023	138,882	135,532	9,009	0.07	19,384
1990	145,940	164,877	154,398	154,776	8,187	0.05	18,937
2000	178,793	200,183	184,658	187,992	9,836	0.05	21,390

Table D2: Physical Capital per Worker, Gaps

	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Regions	0.93	0.96	0.89	0.89	0.87	0.71	0.71	0.44	0.42	0.40	0.44	0.32	0.30
States	1.42	1.57	1.41	1.49	1.29	1.63	1.45	1.09	0.94	0.95	1.55	1.40	1.69
States'	1.42	1.57	1.41	1.49	1.29	1.63	1.45	1.09	0.94	0.95	1.55	1.27	0.98

Table D3 shows human capital levels for the North, South, and West while Figure D2 displays these measures graphically. Clearly, the South is the laggard for the entire period, while the North region is a clear leader early. Interestingly, the West region overtakes the North region by 1920, only to fall behind the North region again by 1980. Looking at the gap between the region with the highest human capital (usually the North) and lowest human capital (always the South) for the same period, we see decreases throughout, with the exception of 1920 – 1930. Table D4 reports the gap between the states (and regions) with the highest and lowest value of physical capital per worker.

Figure D2

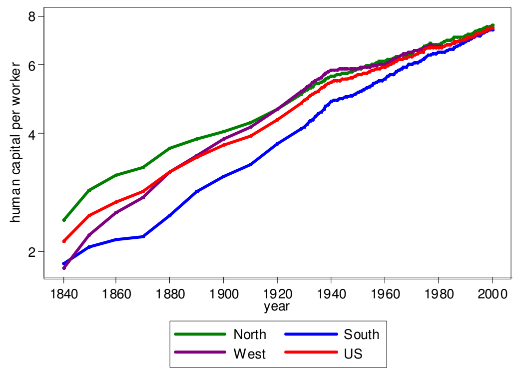


Table D3: Human Capital per Worker, Labor Force Weighted

Year	North	South	West	US	SD	CV	Gap
1840	2.40	1.85	1.80	2.12	0.334	0.158	0.594
1850	2.86	2.04	2.20	2.46	0.485	0.197	0.820
1860	3.12	2.14	2.50	2.66	0.549	0.206	0.980
1870	3.27	2.18	2.75	2.83	0.560	0.197	1.090
1880	3.66	2.46	3.19	3.19	0.605	0.190	1.204
1890	3.87	2.83	3.52	3.48	0.516	0.148	1.035
1900	4.06	3.11	3.86	3.72	0.474	0.127	0.945
1910	4.26	3.34	4.15	3.94	0.474	0.120	0.921
1920	4.61	3.76	4.62	4.36	0.439	0.101	0.857
1930	5.12	4.16	5.18	4.85	0.497	0.102	1.019
1940	5.62	4.83	5.81	5.42	0.444	0.082	0.979
1950	5.85	5.10	5.89	5.64	0.382	0.068	0.787
1960	6.16	5.53	6.04	5.95	0.283	0.048	0.625
1970	6.44	6.03	6.48	6.32	0.214	0.034	0.448
1980	6.79	6.45	6.70	6.66	0.152	0.023	0.335
1990	7.12	6.90	6.93	6.99	0.103	0.015	0.213
2000	7.59	7.41	7.43	7.48	0.090	0.012	0.183

Table D4: Human Capital per Worker, Gaps

	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Regions	0.51	0.42	0.35	0.30	0.27	0.25	0.24	0.17	0.14	0.10	0.10	0.07	0.09
States	0.66	0.57	0.53	0.49	0.41	0.40	0.37	0.28	0.27	0.20	0.17	0.12	0.20
States'	0.66	0.57	0.53	0.49	0.41	0.40	0.37	0.28	0.27	0.20	0.17	0.11	0.17

Moving our attention to output figures, Figure D3 shows visually that there has been regional output convergence during the period, and Table D5 details the output levels. What is noticeable in Figure D3 is the convergence brought on by the South beginning in

1900 and continuing throughout the period. The gap between the region with the highest output (most often the North) and the region with the lowest output per worker (usually the South) narrows between 1890 and 1990, with the exception of the period from 1920 to 1930. Table D6 reports the gap between the states (and regions) with the highest and lowest value of output per worker. Both show evidence of broad convergence for states and census regions until at least 1970.

Figure D3

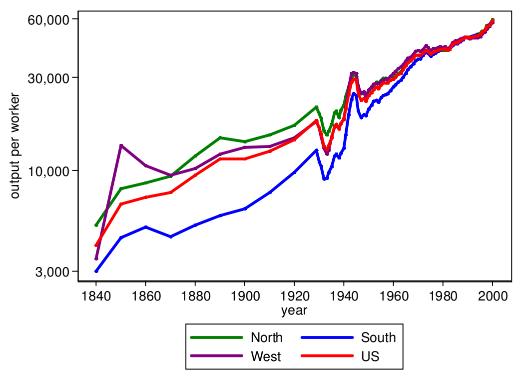


Table D5: Output per Worker, Labor Force Weighted

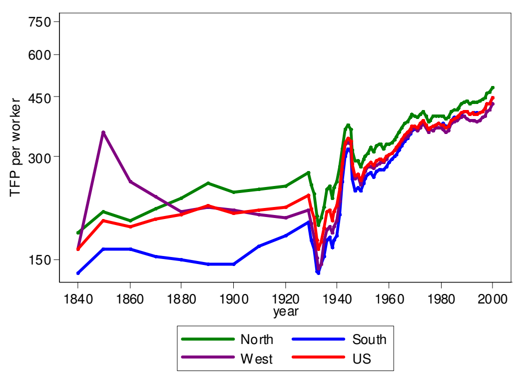
Year	North	South	West	US	SD	CV	Gap
1840	5,195	3,020	3,503	4,114	1,305	0.32	2,174
1850	7,996	4,502	13,385	6,691	2,983	0.45	8,883
1860	8,573	5,090	10,565	7,297	2,399	0.33	5,474
1870	9,306	4,564	9,443	7,704	2,558	0.33	4,880
1880	11,878	5,231	10,220	9,449	3,342	0.35	6,646
1890	14,723	5,836	12,193	11,514	4,434	0.39	8,887
1900	14,026	6,318	13,073	11,477	3,923	0.34	7,707
1910	15,304	7,737	13,227	12,554	3,831	0.31	7,566
1920	16,977	9,806	14,742	14,429	3,527	0.24	7,171
1930	19,587	11,070	16,426	16,442	4,115	0.25	8,517
1940	21,612	12,882	18,359	18,328	4,147	0.23	8,730
1950	25,716	20,656	25,944	24,286	2,567	0.11	5,288
1960	30,124	26,848	31,540	29,514	2,116	0.07	4,692
1970	39,170	37,238	41,339	39,139	1,960	0.05	4,101
1980	41,621	41,841	43,046	42,083	817	0.02	1,425
1990	48,758	48,791	48,000	48,552	475	0.01	792
2000	59,284	59,073	57,881	58,791	796	0.01	1,403

Table D6: Output per Worker, Gaps

	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Regions	1.07	1.13	0.93	0.87	0.84	0.87	0.79	0.45	0.39	0.3	0.24	0.16	0.23
States	1.75	1.91	1.54	1.44	1.23	1.57	1.40	0.82	0.65	0.55	0.68	0.59	0.68
States'	1.75	1.91	1.54	1.44	1.23	1.43	1.40	0.82	0.65	0.55	0.68	0.45	0.53

Figure D4 displays TFP for the North, South, and West. There is evidence for convergence in TFP. This appears to be primarily driven by the South, and seems to have occurred quite rapidly between 1940 and 1970 after a long period of little convergence. We seem to see an acceleration of TFP growth after 1940 in both the South and the West, and arguably the North. However, given the business cycle fluctuations, it is diffiicult to determine when this break occurs.

Figure D4



APPENDIX E

Physical Capital per Worker

Table E1: Physical Capital per Worker, Labor Force Weighted

Year	N	Mean	SD	CV	Min	Max
1840	28	8,735	2,753	0.32	4,627	13,025
1850	34	16,737	9,144	0.55	7,239	93,101
1860	38	21,910	8,824	0.40	9,728	66,773
1870	45	19,570	7,333	0.37	6,387	106,069
1880	45	27,681	8,490	0.31	11,862	49,087
1890	45	36,860	13,069	0.35	11,740	56,585
1900	47	36,712	11,473	0.31	13,640	56,093
1910	47	42,319	13,851	0.33	15,367	68,256
1920	48	50,862	14,194	0.28	20,527	74,305
1930	49	67,295	16,837	0.25	25,902	132,689
1940	49	70,770	17,061	0.24	27,875	119,162
1950	51	79,076	12,321	0.16	45,847	136,187
1960	51	95,229	14,900	0.16	62,756	160,417
1970	51	117,295	17,076	0.15	82,261	212,015
1980	51	135,532	25,701	0.19	94,490	446,669
1990	51	154,776	26,035	0.17	109,143	440,486
2000	51	187,992	33,246	0.18	126,196	682,780

Table E2: Physical Capital per Worker, Labor Force Weighted

Year	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
1840	11,078	11,413	5,248	8,347	12,556	.	.	6,822	8,696	8,735
1850	19,934	18,268	9,047	15,521	19,703	23,641	91,162	11,971	19,871	16,737
1860	25,899	24,299	11,953	20,476	24,251	35,900	64,753	18,675	24,000	21,910
1870	21,318	25,311	10,398	14,618	17,404	34,242	38,657	19,327	20,642	19,570
1880	28,288	34,269	15,248	18,718	19,822	28,630	38,774	29,721	34,099	27,681
1890	39,715	49,214	19,137	21,431	26,183	43,397	49,735	39,054	41,597	36,860
1900	38,023	44,240	19,964	20,907	27,298	45,097	48,641	43,905	42,749	36,712
1910	46,154	55,078	26,618	22,650	30,012	42,405	50,455	44,483	48,407	42,319
1920	51,570	64,667	35,142	27,906	44,434	54,003	66,366	48,804	53,015	50,862
1930	67,395	83,642	50,525	41,073	56,650	76,007	78,057	62,666	71,344	67,295
1940	71,662	85,122	55,391	41,914	58,369	79,066	85,279	62,042	78,388	70,770
1950	70,345	84,918	68,205	58,209	85,936	90,639	87,663	77,472	81,582	79,076
1960	74,990	93,617	86,882	78,551	113,949	104,425	110,107	87,424	98,252	95,229
1970	93,481	116,576	113,415	104,430	139,152	122,870	131,981	106,661	115,310	117,295
1980	110,036	133,408	136,570	125,086	170,203	143,877	147,826	119,256	123,833	135,532
1990	131,639	156,372	160,647	148,829	180,929	160,119	159,955	137,984	141,579	154,776
2000	180,011	198,041	196,498	175,629	219,668	192,082	191,901	162,149	162,722	187,992

Output per Worker

Table E3: Real Output per Worker, Labor Force Weighted

Year	N	Mean	SD	CV	Min	Max
1840	28	4,114	1,355	0.33	1,990	6,820
1850	34	6,691	4,480	0.67	2,602	44,171
1860	38	7,297	3,567	0.49	2,984	25,185
1870	45	7,704	3,571	0.46	2,455	47,727
1880	45	9,449	3,509	0.37	3,297	18,991
1890	45	11,514	4,936	0.43	2,870	19,330
1900	47	11,477	3,983	0.35	3,678	17,088
1910	47	12,554	4,011	0.32	4,800	20,353
1920	48	14,429	3,907	0.27	6,019	20,492
1930	49	16,442	4,929	0.3	5,751	27,766
1940	49	18,328	4,934	0.27	7,135	28,797
1950	51	24,286	3,401	0.14	14,689	33,215
1960	51	29,514	3,895	0.13	20,032	38,531
1970	51	39,139	4,361	0.11	28,871	50,002
1980	51	42,083	4,177	0.1	31,558	62,117
1990	51	48,552	4,096	0.08	35,897	64,700
2000	51	58,791	6,260	0.11	41,653	82,438

Table E4: Real Output per Worker, Labor Force Weighted

Year	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
1840	5,267	**5,528**	2,342	3,683	5,042	.	.	3,503	4,540	4,114
1850	9,077	7,901	3,302	5,344	7,346	10,250	**43,207**	4,641	7,343	6,691
1860	9,999	8,840	3,647	5,928	7,503	12,606	**24,257**	5,760	7,484	7,297
1870	9,717	10,910	3,728	4,869	6,312	15,299	**16,500**	7,056	7,452	7,704
1880	10,998	12,954	4,752	5,447	5,971	10,951	**13,786**	9,248	11,147	9,449
1890	13,818	**16,786**	5,400	5,695	6,923	13,840	15,438	10,972	12,965	11,514
1900	13,073	14,947	5,929	5,900	7,641	13,838	**14,992**	12,395	13,440	11,477
1910	14,230	**16,234**	7,909	6,774	8,633	11,789	14,188	13,167	14,682	12,554
1920	15,706	**18,469**	9,770	7,947	11,512	13,823	17,606	13,486	15,842	14,429
1930	19,454	**21,564**	11,961	9,035	11,559	14,884	19,447	14,714	17,489	16,442
1940	21,518	**22,639**	14,278	10,240	12,993	17,247	22,302	15,515	20,512	18,328
1950	24,224	26,168	20,811	17,624	22,718	24,877	**27,758**	24,256	25,725	24,286
1960	26,042	29,854	26,982	24,092	28,521	28,272	**35,638**	26,991	31,641	29,514
1970	34,919	40,110	37,781	33,949	38,449	37,353	**45,806**	35,770	39,605	39,139
1980	38,074	43,667	42,058	37,899	43,845	40,690	**47,185**	36,952	40,972	42,083
1990	45,424	**51,713**	49,986	46,050	48,273	46,959	50,172	44,039	47,283	48,552
2000	61,426	**64,758**	60,216	54,134	59,833	56,277	61,374	51,527	54,162	58,791

Human Capital per Worker

Table E5: Human Capital per Worker, Labor Force Weighted

Year	N	Mean	SD	CV	Min	Max
1840	28	2.12	0.390	0.184	1.74	3.18
1850	33	2.46	0.518	0.210	1.89	3.87
1860	39	2.66	0.547	0.205	1.96	4.06
1870	45	2.83	0.542	0.191	1.96	3.87
1880	46	3.19	0.581	0.182	2.17	4.18
1890	49	3.48	0.503	0.144	2.42	4.30
1900	49	3.72	0.476	0.128	2.65	4.49
1910	49	3.94	0.477	0.121	2.86	4.68
1920	49	4.36	0.450	0.103	3.28	4.95
1930	49	4.85	0.502	0.103	3.68	5.49
1940	51	5.42	0.475	0.088	4.24	6.12
1950	51	5.64	0.409	0.072	4.56	6.05
1960	51	5.95	0.336	0.056	4.87	6.39
1970	51	6.32	0.262	0.041	5.42	6.61
1980	51	6.66	0.255	0.038	5.94	7.07
1990	51	6.99	0.186	0.027	6.50	7.35
2000	51	7.48	0.200	0.027	6.83	8.35

Table E6: Human Capital per Worker, Labor Force Weighted

Year	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
1840	**2.94**	2.32	1.87	1.79	1.90	.	.	1.80	2.02	2.12
1850	**3.45**	2.81	2.08	1.99	2.02	.	2.67	2.06	2.50	2.46
1860	**3.63**	3.06	2.17	2.14	2.07	2.04	2.77	2.43	2.92	2.66
1870	**3.53**	3.19	2.15	2.23	2.17	2.76	2.99	2.69	3.23	2.83
1880	**3.85**	3.66	2.49	2.50	2.32	3.08	3.35	3.16	3.58	3.19
1890	**4.00**	3.85	2.86	2.93	2.64	3.32	3.64	3.52	3.84	3.48
1900	**4.15**	4.01	3.13	3.24	2.93	3.60	4.01	3.86	4.07	3.72
1910	**4.38**	4.19	3.34	3.45	3.23	3.87	4.24	4.17	4.30	3.94
1920	4.72	4.54	3.74	3.89	3.66	4.30	**4.80**	4.61	4.64	4.36
1930	**5.33**	5.03	4.16	4.20	4.13	4.86	5.32	5.17	5.15	4.85
1940	5.73	5.54	4.82	4.74	4.93	5.45	**6.02**	5.73	5.67	5.42
1950	5.93	5.85	5.09	5.03	5.17	5.57	**5.98**	5.89	5.83	5.64
1960	6.25	**6.27**	5.55	5.46	5.56	5.78	6.06	6.11	6.02	5.95
1970	**6.53**	6.49	6.07	5.91	6.03	6.31	6.52	6.50	6.35	6.32
1980	**6.97**	6.89	6.61	6.29	6.31	6.49	6.78	6.67	6.64	6.66
1990	**7.20**	7.16	7.00	6.89	6.74	6.97	6.84	7.11	7.05	6.99
2000	**7.85**	7.65	7.55	7.35	7.20	7.35	7.39	7.56	7.47	7.48

Land per Worker

Table E7: Land per Worker, Labor Force Weighted

Year	N	Mean	SD	CV	Min	Max
1840	30	32.27	16.23	0.50	0.00	60.35
1850	36	33.65	19.16	0.57	0.00	138.17
1860	40	35.27	18.54	0.53	0.00	111.41
1870	46	31.88	15.81	0.50	0.00	78.07
1880	46	30.71	16.82	0.55	0.00	69.50
1890	49	26.47	17.67	0.67	0.00	112.98
1900	49	28.84	28.38	0.98	0.00	183.41
1910	49	23.02	22.29	0.97	0.00	130.76
1920	49	22.97	28.27	1.23	0.00	200.08
1930	49	20.21	29.72	1.47	0.00	254.60
1940	51	21.37	33.65	1.57	0.00	295.32
1950	51	19.25	32.92	1.71	0.00	287.93
1960	51	16.05	29.74	1.85	0.00	281.48
1970	51	12.66	25.60	2.02	0.00	254.29
1980	51	9.40	18.23	1.94	0.00	160.45
1990	51	7.53	15.71	2.09	0.00	144.53
2000	51	6.64	13.99	2.11	0.00	128.41

Table E8: Land per Worker, Labor Force Weighted

Year	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
1840	19.90	19.31	38.66	**44.94**	21.89	.	.	44.73	38.26	32.27
1850	19.30	19.34	39.26	44.52	45.91	14.89	**52.20**	45.12	38.60	33.65
1860	18.09	16.53	42.81	45.05	**58.35**	37.61	48.76	52.71	35.26	35.27
1870	15.06	15.38	42.30	43.15	45.44	13.23	**51.85**	44.75	32.21	31.88
1880	13.67	12.44	37.87	40.97	**49.41**	14.03	46.87	**49.91**	29.25	30.71
1890	9.84	8.63	30.13	33.49	47.78	29.14	38.83	**48.75**	21.98	26.47
1900	8.65	7.23	26.07	28.13	**76.03**	69.90	45.61	54.43	19.76	28.84
1910	6.76	5.26	20.00	22.65	48.23	**53.74**	26.53	52.29	16.25	23.02
1920	5.25	4.39	18.31	23.83	46.67	**93.50**	23.26	56.01	13.83	22.97
1930	4.16	3.20	14.26	19.49	40.70	**112.88**	16.93	52.54	10.97	20.21
1940	3.95	3.03	13.95	20.86	44.21	**136.55**	16.41	56.20	11.28	21.37
1950	3.22	2.52	12.37	19.62	39.56	**132.22**	12.32	51.35	9.01	19.25
1960	2.06	1.88	8.22	15.81	33.12	**104.41**	9.33	47.65	7.25	16.05
1970	1.07	1.30	5.28	12.19	26.70	**77.23**	6.66	41.82	5.74	12.66
1980	0.78	1.11	3.40	7.90	17.44	**46.28**	4.60	32.06	4.54	9.40
1990	0.58	0.88	2.26	6.14	13.94	**34.91**	3.35	28.15	3.95	7.53
2000	0.55	0.83	1.94	5.39	12.22	25.37	2.73	**25.59**	3.51	6.64