NBER WORKING PAPER SERIES

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Working Paper 9923
http://www.nber.org/papers/w9923

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
August 2003

Comments from workshop participants at the NBER 2003 Summer Institute are gratefully acknowledged. The views expressed herein are those of the authors and not necessarily those of the National Bureau of Economic Research.

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NBER Working Paper No. 9923
August 2003
JEL No. N61

ABSTRACT

We use establishment-level data to study capital deepening -- increases in the capital-output ratio -- in American manufacturing from 1850 to 1880. In nominal terms, the aggregate capital-output ratio in our samples rose by 30 percent from 1850 to 1880. Growth in real terms was considerably greater -- 70 percent -- because prices of capital goods declined relative to output prices. Cross-sectional regressions suggest that capital deepening was especially importnat in the larger firms and was positively associated with the diffusion of steam-powered machinery. However, even after accounting for shifts over time in such factors, much of the capital deepening remains to be explained.

Although capital deepening implies a fall in the average product of capital it does not necessarily imply that rates of return were declining. However, we find strong evidence that returns did decline. We also show that returns were decreasing in firm size, although the data are not sufficiently informative to tell us why it was so.

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1. Introduction

In the early nineteenth century most manufacturing in the United States was undertaken in artisan shops. These typically employed the owner-operator and perhaps one or more additional workers. Workers in the artisan shop were, on average, highly skilled. Capital, however, was relatively modest, and non-specific – a building, general-purpose hand tools, and credit extended to customers or tied up in goods sold on consignment.

Over the course of the century, the American manufacturing sector steadily expanded its share of total output and its use of productive resources. This growth was associated with a shift in production from artisan shops to factories. The typical factory was larger in terms of employment and less skill intensive than the typical artisan shop. Initially, many factories relied on hand power just like artisan shops, although some relied on water. However, over time, the use of steam-powered machinery increased substantially (Brown and Philips 1986; Atack, Bateman and Weiss 1990; Goldin and Katz 1998).

By century's end, American manufacturing had begun yet a third transformation--"continuous processing"--that embodied a vastly higher level of capital and energy use, notably, electricity (Chandler 1977; Wright 1990). Although the artisan shop never disappeared completely (and has not even to this day), its role in manufacturing at the end of the nineteenth century was far smaller than it was at the beginning.

American economic historians agree that the various changes in the internal organization of firms, capital intensity, and energy use were associated with significant gains in real output per worker. There is also broad agreement that the productivity gains from the continuous processing phase of industrialization can mostly be attributed to increased capital intensity and energy usage. Further, a significant portion of the increase in productivity during the initial shift away from the artisan shop up to the Civil War can be attributed to the increasing division of labor rather than increased use of capital (Chandler 1977; Sokoloff 1984a; Engerman and Sokoloff 2000). What is less clear, however, is the role that capital played during the second half of the century as manufacturing establishments became larger in size and much more reliant on powered machinery.

In this paper we use establishment level data from the original schedules of the 1850-1880 censuses of manufacturing to study "capital deepening" in mid-nineteenth century manufacturing. By capital deepening we mean changes over time, as well as differences across establishments, in the ratio of capital to output. We focus on the 1850-80 period in part because it encompasses much of the growth of manufacturing prior to continuous processing; that is, the period when the factory increased its share of total value added in manufacturing and steam power displaced hand and waterpower. In nominal terms – that is, not adjusting for changes over time in prices of capital goods and of output – the aggregate capital-output ratio was about thirty percent higher in 1880 than in 1850. Most of this increase occurred in the 1870s. In real terms, however, the increase was even greater because the price of capital goods relative to output appears to have declined over the period. Adjusting for this decline in relative price, real capital per (constant dollar) of output was between seventy and one hundred percent higher on average in 1880 than in 1850. It is also the only period in our history for which these data are available nationwide.

Unlike data from the published census, which are aggregated, the data in this paper shed light on the correlates of the capital-output ratio at the establishment level, such as the size of the establishment and its use of steam power. Drawing on the work of Goldin and Katz (1998) we present a simple model relating the capital-output ratio to establishment characteristics, such as size and use of steam power.

In 1850 the capital-output ratio followed a modest U-shaped pattern with respect to establishment size, once other characteristics were controlled for. However, by 1880, the relationship between the capital-output ratio and size had turned positive, and the larger establishments had higher capital-output ratios, controlling for other factors. The implication of this "twist" in the gradient is that capital deepening occurred primarily in the larger establishments.

Some, but not all, of the twisting may be explained by the diffusion of steam power. Establishments that used steam power had higher capital-output ratios, and steam power use was positively correlated with size, but rising establishment size *per se* appears to matter. However, even after taking account of the diffusion of steam and rising establishment size, much of the capital deepening remains to be explained.

Our estimates of capital-output ratios imply that capital productivity –ouput per unit of capital -- was declining between 1850 and 1880. This does not necessarily mean that the return to capital – its marginal product – was falling over time, because the share of income going to capital might have been rising. Despite this possibility, our estimates suggest that, in both nominal and real terms, the rate of return to capital invested in manufacturing was significantly lower in 1880 than in 1850. Cross-sectional regressions reveal that returns were decreasing in establishment size, although the data are not sufficiently informative to tell us why it this was so.

2. Data and Estimation: Aggregate Results

Our empirical analysis is based on random samples drawn from the surviving manuscripts of the 1850-1880 federal censuses of manufactures (Atack and Bateman 1999). These samples are nationally representative of the surviving manuscripts for each census year.

The censuses reported the value of capital "invested" in the establishment, along with information about each plant's outputs and inputs. The specifics of what was reported, however, varied somewhat from census to census. Although all of the censuses reported the value of outputs and raw materials, only the pre-1880 censuses reported physical quantities of outputs and inputs. In 1850 and 1860 the number of male and female employees was reported; in 1870 and 1880, the number of adult males, adult females, and children were given. Information was also reported on the use of inanimate sources of power, such as water or steam (1850-70); and, in 1880, on horsepower, where water or steam was used.[1]

There is no question that the inquiries about manufacturing capital were among the most vexing and problematic of all such inquiries in the nineteenth century censuses both at the time and since. The questions themselves were vague and it is unclear if census enumerators were given much guidance in eliciting proper responses.

[1] Occasionally, information was reported on horsepower in steam or water powered establishments prior to 1880 but this information is too scattered to be of much use.

Consequently, it is not surprising that there is some disagreement as to what exactly "value" was supposed to mean and what types of "capital" were to be reported.

As for what was meant by "value", there are several possibilities: "book value", net reproduction cost, or market value. The manuscripts schedules themselves offer essentially no clues as to which of these definitions applied in any specific case. The leading authority on the subject, Robert Gallman (1986, p. 174; 1987, pp. 220-222), has argued, however, that book value was uncommon in the nineteenth century and that the capital figures refer typically to market value or net reproduction cost.

Although the samples analyzed in this paper are nationally representative of the surviving manuscript schedules, this does not necessarily mean they are nationally representative of manufacturing establishments that were (at risk) of enumeration by the census. We can do nothing about establishments that were missed completely by a careless enumerators. Likewise, some schedules did not survive to be sampled by us. However, with one exception, we may assume that such failures were random and, hence, do not bias our results.

The one exception occurs in 1880. In that year, certain industries were designated to be enumerated by so-called "special agents" who were, allegedly, more knowledgeable about the industry than the average census enumerator. For example, James Swank, Secretary of the American Iron and Steel Association, was appointed to collect the data on steel producers. However, despite an assiduous search of relevant archives, no schedules enumerated by special agents have ever been found (Delle Donne 1973).

But, as it happens, many establishments in these industries were, in fact, enumerated by regular census agents in the course of their daily tasks and, therefore, were at risk of inclusion in our samples, although there is no question that special agent establishments are under-represented in the 1880 sample. We have dealt with this problem as follows: All statistics for 1880 in this paper have been re-weighted to take account of the under-representation. The precise details of the re-weighting vary depending on the variable being considered but, in general, the assumption is that, when re-weighted, the proportion of special agent establishments in 1880 equals the average share observed in the 1850-70 samples.[2]

We impose a number of selection criteria on the data before estimation. In particular, we require that establishments had (1) positive employment, defined to be the sum of male, female, and (in 1870 and 1880) child workers (2) positive reported value of capital (3) positive value added (value of outputs – value of raw materials) (4) positive value of raw materials. We also excluded observations were extremely low or extremely high rates of return to capital, as estimated by an accounting procedure described in the appendix (see also section 4) Panel A of Table 1 shows the sample sizes for each census year used in our estimations.

We present two series of aggregate capital/output ratios in index number form (1850 = 100) in Panel A of Table 1. "Aggregate" means that the ratios are weighted averages of estimates made at the establishment level, with the weight for each equal to

[2] This re-weighting scheme assumes that special agent establishments that were included in the regular schedules were a random sample of the underlying population of such establishments. It is possible, however, that the extent of under-enumeration was relatively greater for the largest special establishments which, on the basis of our regression results (sections 4 and 5), suggests that our estimates of capital deepening between 1850 and 1880 (Table 1), and of the downward trend in the mean returns to capital (Table 4) may be biased downwards. In this regard, it is important to note that omitting the special agent establishments does not alter our substantive finding with regard to the long-term trend. For instance, if we exclude special agent industries, our estimates of aggregate capital deepening between 1850 and 1880 (see the notes to Table 1) are virtually unchanged, as is our estimate of absolute decline in the mean rate of return to capital (see Table 4).

the establishment's share of total value added.[3] These ratios are labeled "nominal" because they are not (as yet) adjusted for changes over time in the price of capital goods relative to the price of output. Index A follows Sokoloff (1986) by assuming that the census data refer to both fixed and working capital. Index B assumes that the census only reported the value of fixed capital and, therefore, it is necessary to estimate the value of working capital and add the estimated values to the census figures.[4] The estimation procedure assumes that working capital was used in fixed proportion to the gross value of output. The ratios of working capital to gross output are estimated from the 1890 census (which did collect data on working capital). Separate ratios were estimated at approximately the three or four-digit standard industrial classification (SIC) level in each state. These are applied to the establishments in the samples, using the appropriate ratio given the industry and location of the establishment.[5] Index B should be viewed with

[3] Also shown in Table 1 are index numbers for 1880 associated with the geometric means of the establishment level capital-output ratios, weighting each establishment by value added.

[4] Like today, manufacturing capital in the nineteenth century was of two fundamental types – "fixed" reproducible capital-- equipment and structures--and "working capital" (for instance, inventories, financial assets). Until recently, the consensus view has been that working capital was under-reported, or even omitted entirely, in the 1850-1880 manufacturing censuses. The 1890 census specifically requested information on working capital, and it is this information that we use to adjust the pre-1890 data; see the text. The argument that working capital was under-reported prior to 1890 was based on the belief that the growth in the capital stock in manufacturing between 1880 and 1890 was too large to be explained except by under-reporting of working capital in 1880. Sokoloff (1986, p. 713), however, argues that capital reported in 1850 and 1860 did include "at least a major component" of working capital. As Sokoloff (1986) points out, working capital was reported in the so-called 1832 McLane Report, a document prepared by the conclusion. Treasury Department that contains establishment-level data on manufacturing. If working capital were not reported in the 1820 or 1850 censuses, there would have been very large increases in capital between 1820 and 1832, and large declines between 1832 and 1850. No such movements in capital are observed – hence, Sokoloff's conclusion While we acknowledge Sokoloff's point, we tend to favor the conventional wisdom that working capital was under-reported prior to 1890. However, were we to adjust just the 1880 data for under-reporting, the resulting increase in the capital-output ratio between 1850 and 1880 is too large to be believable. Consequently, we have chosen for the sake of consistency to adjust all of our samples (the adjustment procedure is described in the text). However, our analysis does consider both points of view; for example, in Table 1, we present estimates of capital deepening assuming that the census reports were complete, along with estimates assuming that working capital was omitted. In general, the adjustment for the under-reporting of working capital does not alter our substantive findings with respect to trends or differences across establishments.

[5] Although we use separate ratios by state and industry, the values of the ratios are the same for each census year. A case can be made, however, that the share of working capital may have been higher in 1850 than

some caution because this imputation procedure may introduce bias of uncertain magnitude and direction. Following much previous work in nineteenth century manufacturing (for example, Atack 1977; Sokoloff 1984a), we measure production in value added terms (= value of outputs – value of raw materials).[6]

Measured in nominal terms, the aggregate capital-output ratio in the 1880 sample was approximately 30 percent higher than in 1850. Most of the deepening occurred in the 1870s; in particular, we observe little increase in capital/output ratios before the Civil War and (essentially) none at all during the Civil War decade. Although the levels of ratios underlying the two indices are very different, the trends are remarkably similar suggesting that, in practical terms, adjusting for working capital has relatively little impact.

By definition, the nominal ratios do not adjust for changes over time in the price of capital goods relative to the price of output. At the outset it must be recognized that any attempt we make to adjust for changes in the relative price of capital goods will be extremely crude and possibly subject to considerable error. The fundamental problem is that (with the exception of the type of inanimate power source being used, if any) the census did not collect information on the type and quantity of capital in use prior to 1890.

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that implied by the 1890 data; that is, over time, establishments increased their fixed capital relative to working capital due, in particular, to the diffusion of steam-powered machinery and other novel (for the time) technologies and to the increase in the frequency of full-year establishments (Sokoloff 1984b; Atack, Bateman, and Margo 2002) If this were the case, our estimates of capital deepening would be biased upwards because we are underestimating the extent of working capital in 1850. On other hand, if Sokoloff (1986) is correct that working capital was generally reported in 1850, our estimates may be biased downwards substantially. See, in addition, Sokoloff (1984b) who shows that, in 1832, larger firms, firms in urban areas, and firms whose markets were regional (or national) as opposed to local, tended to use more working capital relative to fixed capital --patterns that suggest that working capital may have been increasing in importance over time.

[6] It is not possible to construct a consistent series based on physical output measures because the 1880 census only reported the total value of all outputs produced, not quantities of specific goods. Yet another reason for using value added as the measure of output is that our model of manufacturing (see section 2) is framed in these terms; however, it is possible to recast the model in gross value terms (see Goldin and Katz 1998).

As a result, conventional hedonic methods (that is, valuing particular types of physical capital at fixed prices) cannot be applied to our data.

For the purposes of this paper, we developed aggregate output and capital price deflators. The output price deflator, taken from U.S. Department of Commerce (1975), is based on Gallman (1961).[7] This price index follows the familiar patterns suggested by other nineteenth century price indices over the 1850 to 1880 period. Prices rise slightly in the 1850s, increase sharply in the 1860s, followed by deflation during the 1870s. According to Gallman's estimates, output prices in manufacturing, on average, were about 9 percent higher in 1880 than in 1850.The capital price deflator follows the general procedure outlined in Sokoloff (1986). Specifically, we assume that capital was divided into equipment, structures, and working capital, and that working capital was further divided equally into finished output and raw materials. Like Sokoloff (1986), we use data from Brady (1966) to compute price indices for equipment and structures, albeit with some modifications that are discussed in the notes to Table 1. For the finished goods component of working capital, we use the output price deflator, and for the raw materials component, the Warren-Pearson wholesale price index (U.S. Department of Commerce 1975).

It is reasonable to assume that capital and output prices evolved differently in different industries; and, therefore, it would be better to make estimates of both at the industry level and then aggregate using fixed value added weights (see Sokoloff 1986). However, our preliminary work along these lines suggests that the overall trends would not change and, therefore, the aggregate deflators are not too far off the mark.

[7] Gallman (1961) reports estimates of nominal value added and value added in constant 1880 dollars. Dividing the former (nominal value added) by the latter (real) produces our price index. We re-scale the price index so that the value in 1850 is 100.

The general pattern emerging from the price deflators is that the relative price of capital goods was declining over time. Much of the decline in the relative price appears to have occurred between 1860 and 1870; like output prices, capital goods prices rose during this decade, but the extent of the increase was below that of output prices.

To convert the nominal capital/output ratios into constant dollars, we divide the nominal ratios by the relative price of capital or, equivalently, multiply the capital/output ratios by the ratio of output to capital goods prices. Because the relative price of capital goods was falling, the real ratios grew at a much faster pace than the nominal ratios. Again, however, relatively little of the increase in real capital deepening occurred before the Civil War (see Sokoloff 1986 for a similar conclusion). We do find an increase in real terms during the 1860s, largely driven by the fall in the relative price. Virtually all of increase in the real ratio during the 1870s, however, occurred because of pure capital deepening; that is, it would have occurred whether or not we adjust for changes in the relative price of capital. Overall, the capital-output ratio grew in real terms at an average annual rate of about 1.8 percent per year between 1850 and 1880.

To the best of our knowledge, there are no previously constructed aggregate series of capital-output ratios for manufacturing against which to compare the series in Table 1.[8] Gallman (1986, Table 4.8) presents nominal and real series of capital-output ratios for mining and manufacturing for the 1850-80 census years but because his series includes mining, it cannot be expected to track ours exactly. In terms of the long-term trend (1850-80), Gallman's series show somewhat more overall increase than our series, but

[8] Our series for manufacturing do grow more quickly than series for the aggregate economy. For example, Gallman's (1986, p. 186) variant A series shows a modest decline in the aggregate capital-output ratio between 1850 and 1880 in both nominal and real terms. Gallman's variant A series includes agricultural improvements, which grew more slowly than other forms of capital as the economy shifted away from farming; see Gallman (1986, p. 188).

the difference is slight in the case of the nominal series.[9] However, decade-to-decade growth in Gallman's series is more evenly spaced than in our series, and Gallman's real series shows a steep increase during the 1860s and a decline in the 1870s, opposite the behavior of our series. Although further work is necessary to reconcile the differences in decade-to-decade movements between Gallman's series and our series, some of the difference can clearly be traced to the choice of price deflators.[10]

3. A Model of Capital Deepening

As noted in the Introduction, the data analyzed in this paper unlike published census figures are able to shed light on the correlates of the capital-output ratio at the establishment level,. To provide intuition for such analysis, we rely a simple model of manufacturing that is very similar to the model of Goldin and Katz (1998). .

The Goldin-Katz model presumes that industrialization proceeded in three distinct phases – from the "artisan shop" (phase 1) to the "factory" (phase 2) to "continuous

[9]Gallman does not adjust for working capital, so his figures should be compared with our Index A ratios (Table 1). In index number form (1850 = 100), Gallman's (1986, Table 4.8) estimate of the nominal capital-output ratio in 1880 is 137.5, compared with our estimate of 132.1, a differences of 4 percent..His 1880 estimate of the real ratio is 193.0, compared with our estimate of 173.8, a difference of 11 percent. As pointed out in the text, some of the differences in the real ratios can be traced to the price deflators. If we deflate Gallman's 1880 nominal ratio by our 1880 price deflators, the result would be an index number of 180, 4 percent higher than our 1880 index number.

[10] Gallman's estimates were based on the census, and should (mining aside) be similar to our index A. Our selection criteria (see the text) exclude certain types of establishments from the computation (for instance, firms with negative value added) that cannot be excluded from the published volumes. However, if we do not impose the selection criteria, the resulting series do not differ appreciably from the series in Table 1. Gallman's price deflators, like ours, were based on Brady (1966); however, while his ratio of capital to output price shows a very similar decline between 1850 and 1880 (his 1880 index number (1850 = 100) is 71, whereas ours is 76, see Table 1), his shows a much steeper decline in the 1860s and a rise in the 1870s, unlike our relative price series. If we adjust Gallman's series using our relative price deflator, the capital-output ratio rises in real terms in the 1870s, whereas Gallman's original estimates show a decline, as noted in the text. Although we cannot be certain without access to Gallman's worksheets, we believe that the much of the difference between the relative price deflators can be traced to the adjustments that we make to Brady's 1870 index numbers and, possibly, to different weights in constructing the overall index.

processing." (phase 3). The focus in their model is primarily on differences in capital and skill intensity across the different phases of manufacturing, rather than the forces that propelled the transition from one phase to the next and their specific application of the model addresses the continuous processing phase.[11] Because thisphase occurred largely after the turn of the twentieth century and because our empirical analysis stops with 1880 when establishment-level data cease being available, our exposition here focuses primarily on the first two phases.

Within each phase – for instance, the artisan shop – the manufacturing process is divided into two stages. In the first stage, skilled labor (L_s) is combined with "raw" capital (K_r) —tools and buildings, for example—to produce, and subsequently maintain, an intermediate input called "operating" capital (K_w). Goldin and Katz (1998) assume that the production function for operating capital is Leontief, which can be written[12]

$$K_o = \min(\alpha L_s, K_r)$$

In the second stage, operating capital is combined with unskilled labor (L_u) to produce a finished good (Q). Substitution between workable capital and unskilled labor is permitted in the second stage as, for example, in a Cobb-Douglas technology,

[11] Goldin and Katz (1998), however, clearly have in mind two primary determinants of the transition. First, because the "division of labor was limited by the extent of the market" falling costs of transportation contributed to the initial shift away from the artisan shop. Second, advances in technology embodied in new capital goods raised the productivity of unskilled labor, creating an incentive to substitute capital and unskilled labor for skilled labor. Later in the section we argue that a reduction in the relative price of capital – a possible consequence of such technological improvements – can also cause a shift away from the artisan shop.

[12] As Goldin and Katz (1998) note, the Leontief assumption is made for simplicitly; that is, substitution between raw capital and skilled labor could be permitted in the first stage.

$$Q = AK_o^{\beta}L_u^{1-\beta}$$

Firms are assumed to select an optimal ratio of unskilled labor to operating capital. This is a function (Φ) of the ratio of rental price of operating capital to the unskilled wage ($f = r/w_u$) and, possibly, the level of output

$$L_u/K_w = \Phi(f,Q)$$

The capital-output ratio is the ratio of capital per worker ($k = K_w/(L_s + L_u)$) to output per worker ($q = Q/(L_s + L_u)$). From the above assumptions it follows that $k = (1-s)/\Phi$, where s is skill intensity ($= L_u/(L_u + L_s)$).

An important presumption in the Goldin-Katz model is that Φ is smaller in the artisan shop than in the factory; that is, in the artisan shop, a much smaller ratio of unskilled labor relative to workable capital is used in the second stage. The fundamental reasons is that, in the artisan shop, most finished goods were made to order; that is, they embodied a large component of workable capital from the first stage, and required relatively little unskilled labor in the second stage. By contrast, factory production tended to be standardized, in part to realize the gains in efficiency from division of labor. In terms of the model, this means that Φ was greater in the factory than in the artisan shop. However, skill intensity was lower in the factory, implying that (1-s) was higher.[13]

[13] Since $L_s = K_o/\alpha$, it follows that

$$s = (K_o/\alpha)/((K_o/\alpha) + \Phi K_o) = 1/(1 + \alpha\Phi)$$

As noted in the text Φ is presumed to be small in the artisan shop. In addition, Goldin and Katz assume that α was also small in the artisan shop. When α is small, relatively large amounts of skilled labor are

Whether the capital-labor ratio is higher or lower in the factory, therefore, depends on the relative magnitudes of these two effects. Specifically, if skill intensity is decreasing with respect to size at a faster rate than Φ rises with size, the capital labor ratio will be higher in the factory than in the artisan shop.

Even if the capital-labor ratio is higher in the factory than in the artisan shop, it does not follow that the same will be true of the capital-output ratio. Presumably a key factor motivating the shift in production from artisan shop to factory was that there were gains in labor productivity to be had (Sokoloff 1984a, 1986). However, as long as the gains in labor productivity were proportionately smaller than any increase in the capital labor ratio, the capital-output ratio will be higher in the factory than in the artisan shop.[14]

Continuous processing, the third phase of industrialization, differed from the factory primarily in the second stage of production, in that a vastly higher ratio of capital to unskilled labor was the norm. In this regard, the critical technological advance, according to Goldin and Katz (1998), was the development and diffusion of electric power. Electricity greatly altered the design of manufacturing plants, permitting the elimination of a wide range of unskilled jobs on the shop floor that were involved in the

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needed to transform raw capital into workable capital. While the overall capital requirements of most artisan shops were minimal, the operating capital itself might be complex or unique, requiring considerable skill to produce, cultivate and manage. Further, in the artisan shop, each worker was responsible for maintaining his own tools whereas, in the factory, a single worker (or a small number thereof) may have installed and maintained the machines operated by the unskilled labor in the second stage. Thus, possibly for both reasons – low values of α and Φ -- skill intensity will be higher in the artisan shop than in the factory and, consequently, 1-s will be higher in the factory.

[14] In the case where production in the second stage is Cobb-Douglas, the expression for the capital-output ratio can be simplified further, $K_o/Q = \Phi^{\beta-1}/A$. Taking logarithms of both sides, the total differential of the left hand side is $[(\beta-1)/\Phi]d\Phi - \ln \Phi d\beta - dA/A$. In the transition from the artisan shop to the factory, the first term in this expression will be negative, because $\beta<1$ and $d\Phi>0$. The third term will be negative if total factor productivity is higher in the factory ($dA>0$; see Sokoloff 1984). However, the second term will be positive, because $d\beta<0$ (the output elasticity of capital in the second stage is smaller in the factory than in the artisan shop).

movement of bulky materials and product from location to another within establishments. Continuous processing establishments not only had much higher capital-output ratios, they also tended to be relatively more skill intensive than factories, even though, in terms of production, they were much larger than factories.

With very few exceptions (such as reduction flour milling and the manufacture of cigarettes, both after 1880), the diffusion of continuous process technology in American manufacturing did not begin in earnest until after the turn of the twentieth century because it was dependent on electrical power,. However, electricity was not the first use of inanimate power in American manufacturing. Prior to the diffusion of electricity, establishments used steam or water to power equipment. Although water-power was more important initially, use of steam-powered machinery diffused rapidly after 1850 (see Fenichel 1966; Atack, Bateman, and Weiss, 1980).

The use of steam or water power does not appear to have altered the architecture of manufacturing plants in the same way as electricity and, therefore, arguably did not lead to the widespread elimination of unskilled jobs as did electricity (Goldin and Katz 1998). However, either source of power complicated the production in various ways that may have affected capital use. In terms of our model, we think of the use of steam or water as having two possible effects. First, steam- or water-powered plants may have had a higher ratio of skilled to raw capital in the first stage of production, in order to maintain equipment (steam engines, waterwheels). Second, steam- and water-powered establishments may have had more capital per unskilled worker in the second stage. If the second of these effects outweighed the first, and if the impact of steam or water on the productivity of unskilled labor was not too large, the capital-output ratio would increase with the use of steam or water.

Because production in the first stage in the model is Leontief, changes in the rental rate of raw capital relative to the wage of skilled labor do not affect factor intensities, holding the type of manufacturing – artisan or factory – constant. However, as the expression for the capital-output ratio shows, a fall in the rental price of capital relative to the unskilled wage in the second stage will lower the value of Φ and, other factors held constant, raise the capital-output ratio. It is possible that such increases might be proportionately greater in larger establishments, if the ease of substituting capital for unskilled labor was increasing in establishment size. Further, a fall in the relative cost of capital would also encourage a shift towards factory production in order to economize on relatively expensive skilled labor. The same could result from a rise in the skilled-unskilled wage ratio.

As we show in the previous section, the price of capital was apparently falling relative to output prices between 1850 and 1880. Over the same period employment grew in large establishments relative to small establishments (Atack, Bateman, and Margo, forthcoming). Real wages in manufacturing were rising over this period and there is some, albeit, controversial evidence that skill differentials were also rising (Margo 2000a, b; Engerman and Sokoloff 2000; Williamson and Lindert 1980). Although we do not investigate the hypothesis in this paper directly, it is possible that shifts in factor prices – or rather, the factors that caused the shifts in factor prices - may also be partly responsible for spread of the factory system.

4. Multivariate Analysis

In this section we estimate multivariate regressions of capital-output ratios using the establishment samples. Because our interest is primarily in the long-term trend – that is, 1850 to 1880 -- and, as pointed out in section 2, our estimates of this trend are broadly similar to previous work (Gallman 1986), we present regression results just for the base year (1850) and terminal year (1880) samples.. The results of the regressions are interpreted in light of the model of manufacturing sketched in the previous section.

The dependent variable in the regressions is the log of the ratio of the value of capital to value added and the independent variables are establishment characteristics. Capital is as reported to the census enumerators plus the adjustment for working capital described in the previous section. We do not adjust for changes in the relative price of capital since this amounts to adding a fixed number to the constant term in the 1880 regressions; the reader should keep in mind, however, that the dependent variable here corresponds to the nominal capital-output ratio in Table 1. Separate regressions are estimated for 1850 and 1880. The results for 1850 are reported in Panel A of Table 2 and those for 1880 in Panel B.

The first column reports regressions with three dummies for establishment size, as measured by the number of workers: 6-15, 16-100, and 100 or more. This classification is a slight extension of that used by Sokoloff (1984; see also Sokoloff and Villaflor 1992). It is difficult to say precisely at what level of employment the artisan shop ceased and the factory began but, as Sokoloff (1984) shows, there appear to have been gains in efficiency even at the relatively modest size represented by the second of these dummies

(6-15 workers). In what follows, we refer to the left-out size classification (1-5 employees) as the artisan shop.

In both years, establishments with more than 16 workers had significantly higher capital-output ratios than either artisan shops or slightly large establishments (6-15 workers). However, in 1850, the positive dependence of the capital-output ratio on size largely disappears once we control for other characteristics, particularly in the specification in column 3. When other factors are controlled for, a modest U-shaped pattern emerges in 1850; that is, the capital-output ratio declined as employment first increased beyond the (hypothesized) boundary of the artisan shop (1-5 workers to 6-15 workers), and then rose slightly as employment grew further. However, we emphasize that the U-shaped pattern is quite modest and is not, in fact, statistically significant, so we cannot reject the hypothesis that, in 1850, size (in terms of employment) was irrelevant as a determinant of the capital-output ratio.

By 1880, this U-shaped pattern had disappeared and the capital-output ratio rose sharply with establishment size. The capital-output ratio in the 6-15 size group was about 8 percent higher that in the artisan shop, but this difference is not statistically significant. However, the ratio in the next size group (16-100) workers was about 29 percent [=exp[0.255] – 1) higher than the ratio in the artisan shop, controlling for other factors. In the very largest establishments (100+ workers), there appears to be a slight decline compared with the preceding size group, but the largest establishments nevertheless used about 24 percent more capital per unit of output than did artisan shops, controlling for other factors, considerable more in relative terms than was the case in 1850.

In column 2 we add the steam and waterpower dummies and in column 3 we add the percent of employees who were female, and dummy variables for urban status, region, and two-digit SIC industry codes.[15] We do not report the coefficients for the industry dummies. However, not surprisingly, we find that including industry dummies increases the explanatory power of the regression, indicating the different industries had different capital-output ratios, controlling for other establishment characteristics (see also Sokoloff 1984b).

In both 1850 and 1880 establishments using steam or water had significantly higher capital-output ratios. These differences are quite substantial in the column 2 regressions, which do not control for establishment characteristics other than size. Controlling for the additional characteristics in column 3 reduces the magnitudes of the power dummies. However, the differences in capital intensity associated with the use of either source of power in 1850 are still striking.[16] Use of steam power was associated with a higher capital-output ratio in 1880 but the coefficient on waterpower, while still positive, was statistically insignificant.

Our model of manufacturing does not make a specific prediction as to whether less skill intensive establishments should have had lower or higher capital-output ratios; and, in any case, the proportion of workers who were female is, at best, an imperfect measure of skill (Goldin and Sokoloff 1982). Nonetheless, in both years we observe a

[15] It is important to keep in mind that the percent female is females/(females + males) in 1850 and adult females/(adult males + adult females + children) in 1880; that is, the definition of the variable is not fully consistent over time. However, if most children employed in manufacturing in 1850 were boys (see Sokoloff 1986), the inconsistency should be very minor. As the regression results show, percent female is negatively related to the capital-output ratio in both 1850 and 1880.

[16] There is anecdotal evidence that some establishments using water rented power, and the rental agreements included access to capital that was probably not included in the value of capital reported to the census; if so, the capital-output ratio for such establishments would be biased downwards. We have no idea if this was common or not; if it was, the coefficients on the water dummy would be biased downward.

negative relationship: female-intensive establishments tended to have lower capital-output ratios, all other factors held constant..[17]

Urban establishments in 1850 had slightly lower capital-output ratios than rural establishments but the difference was not significant. However, the negative effect of urban location on capital use apparently increased by 1880 (to about 10 percent). A possible explanation is that the price of land – a component in the price of structures – may have increased in urban areas relative to rural areas after the Civil War.[18] Before the Civil War establishments located in the Midwest and especially the Far West had lower capital-output ratios than establishments in the Northeast, but there was no difference in capital-output ratios between the South and the Northeast. After the Civil War, Midwestern and Western establishments still used less capital per unit of output than establishments in the Northeast, but the differences were much smaller than before the War (and statistically insignificant). However, Southern establishments after the War were far less capital intensive than before the War, relative to the Northeast or the other regions. Since these regressions control for size, power, and industry, regional differences in the evolution of factor price ratios may account for the changing regional contrasts in capital-output ratios. Recent work by Hutchinson and Margo (2003; see also Wright 1986) demonstrates that, compared with factor price ratios in the North, interest rates in the South rose sharply relative to unskilled wages after the War. Such an increase, according to our model, should have induced southern establishments to

[17] The significant negative coefficients are sensitive to the adjustment for working capital; if no adjustment is made, the coefficient on percent female is slightly positive in 1850 and insignificant; in 1880 the coefficient is negative, smaller in magnitude than as reported in Panel B of Table 3, and insignificant.

[18] See, for example, Atack and Margo (1998) who find a substantial rise in the price of vacant land in New York City after the Civil War. An alternative explanation, which we cannot rule out, is that urban establishments relied more heavily on leased capital, which was excluded by the census prior to 1890.

substitute labor for capital and, holding productivity fixed, this should have lowered the capital-output ratio in the South relative to other regions, which is what we observe.

Shifts in the distribution of production across power types and employment size classes can explain some of the rise in the capital-output ratio between 1850 and 1880. In the samples analyzed in this paper, the proportion of value added produced using steam increased sharply between 1850 and 1880 while the proportion produced by water declined.[19] Using the 1880 coefficients (column 3, Panel A, Table 2), the net effects of these shifts was to increase the capital-output ratio, on average, by 0.051 log points, compared with an overall increase of 0.237 between 1850 and 1880.[20] Thus, the replacement of water and hand power with steam can account for 22 percent [=0.051/0.237] of the increase in the capital-output ratio.

Between 1850 and 1880 the proportion of value added produced in artisan shops in the samples declined from 27 to 16 percent, and the share produced in the two largest size classes (16-100 workers, and 100+ workers) increased from 53 percent to 65 percent. If we use the 1880 coefficients to compute the impact of these changes, the net effect was to raise the capital-output ratio by another 0.027 points, raising the percent explained by just these two shifts – power and the employment-size distribution – to 33 percent. However, if the 1850 coefficients are used to value the shifts in power and size, the

[19] Specifically, the share of value added produced using steam power rose from 0.259 in 1850 to 0.600 in 1880 while the share of value added produced using water power declined from 0.25 to 0.089. Details of the calculation of these figures are available from Robert A. Margo on request.

[20] The figure 0.237 is the increase in log points in the geometric mean of the capital-output ratio between 1850 and 1880, weighting each establishment by value added (see Table 1). The impact of the relative shift to steam is computed as 0.051 = 0.192*[0.600-0.259] + 0.096*[0.099-0.254]. Note that, if some firms using water rented access, this estimate of the importance of the relative shift to steam power will be overstated if the extent of leasing was greater in 1850 than in 1880.

percent explained declines to 21 percent. Including additional explanatory variables does not appreciably improve the degree of explanatory power.[21]

While numerically and economically significant, it is clear that other factors besides the diffusion of steam power and increasing establishment size per se must have played a role in the capital deepening that occurred after 1850. Perhaps the obvious economic explanation –a general decline in the relative price of capital goods – is the correct one: a fall in the price of capital goods relative to output induced establishments to increase the capital-output ratio. For this explanation to be correct, however, it must explain why, after controlling for other factors, capital deepening was concentrated within the two largest size categories (see Table 2, column 3, both panels). Either the price elasticity of demand for capital in such establishments exceeded unity, or there were factors unmeasured by the census in such establishments that were positively associated with the demand for capital. Further progress on this issue, however, will require establishment-level data that is fundamentally more informative and detailed about capital structure in nineteenth century manufacturing plants and its determinants than the census manuscripts.

4. Rates of Return

We have shown that manufacturing establishments used more capital per unit of output in 1880 than in 1850 measured in nominal terms and especially when measured in constant

[21] For instance, production shifted towards urban areas between 1850 and 1880. However, because capital-output ratios were either unrelated to urban status (1850) or negatively related (1880), the urbanization of production cannot explain capital deepening. The proportion of female workers was slightly lower in 1880 than in 1850, but evaluating this shift raises the percent explained by less than a log point, and thus does not change the substantive conclusion.

dollars terms. This capital deepening may have had implications for the rate of return to capital. By definition, the (nominal) rate of return (π) to capital is

$$\pi = \delta Q/K$$

where Q is value-added and δ is capital's share. . If δ were fixed over time, a rise in K/Q would imply a decline over time in π. However, if δ were not fixed but instead were falling, it is possible that the rate of return would not fall, and might even increase.

We can estimate π using an "accounting" approach that has been previously used to estimate rates of return in mid-nineteenth century manufacturing and also in agriculture (Bateman and Weiss, 1981; Atack and Bateman 1987; Atack and Passell 1990). The details of the computation are described in detail in the appendix (see section 6). In brief, we subtract an estimate of various omitted and neglected production costs from value-added, in addition to labor costs. These omitted and neglected costs are meant to be inclusive --- for instance, they include depreciation, and miscellaneous expenses – however, they do not, by construction, include the opportunity costs of capital. We then divide "profits" – the difference between value added and costs – by the sum of reported value of capital invested and our adjustment for working capital—that is we use the capital estimates that we have used in the analysis above..

The estimates presented here significantly improve on earlier estimates in two ways. First, the national samples used in this paper are designed to be self-weighting, which is not the case with versions of the samples used in previous work (eg. Bateman and Weiss, 1981; Atack and Passell 1994, p. 206). Second, we present estimates for 1870 and 1880, while previous work has focused just on the antebellum period.

There are numerous difficulties entailed in using any accounting method to estimate rates of return from our samples. These are discussed at length in the appendix. Here we highlight three specific problems. First, our procedure occasionally yields rates of return that are either very large and negative or very large and positive. Because our estimates of return are "realized" not "expected," negative returns cannot be dismissed on theoretical grounds. However, it is also possible that extreme values are due to simple measurement error. Consequently we truncate our samples to those firms whose estimated rate of return lies between the 1st and 99th percentile of the distribution.[22]

Second, annual labor expenses and annual months of operation were not reported before the Civil War; rather, only monthly labor costs were reported. To compute annual labor costs for 1850 and 1860, we assume that all establishments operated on a full year basis, which is almost certainly factually incorrect (see Atack, Bateman, and Margo 2002). On average, we believe that this procedure overstates wages by an average of about 16% (that is firms probably averaged about 10 months per year, not twelve, in 1850 and 1860). As a result, our estimates of returns for 1850 and 1860 are biased downwards. Judging from the post-bellum evidence (Atack, Bateman, and Margo 2002), which shows that full year operation was a positive function of establishment size, it is likely that the downward bias is also largest for the smallest establishments.

On the other hand, unlike Sokoloff (1984) in his analysis of economies of scale in ante-bellum manufacturing, we make no explicit allowance for the possibly unreported

[22] Adopting a somewhat stricter amount of trimming (for example, the 5th through the 95th percentiles) does not change our substantive findings.

labor input of owners. We believe a case can be made that any such input was included in the census reports on employment and wages, although we acknowledge that the case is (1) largely circumstantial (2) considerably stronger for 1850 and 1860 than for 1870 and 1880. If, contrary to our assumption, the census did not report the labor input of owners, then our estimates will be biased upward, possibly more so for the post-bellum than the ante-bellum censuses, and particularly for the smallest establishments (see below).[23]

Column 1 of Panel A of Table 3 shows our estimates of mean rates of return. Despite the problems just noted, the levels of returns, ranging from 11 to 18 percent, seem plausible, at least in light of estimates previously made for other sectors, such as agriculture (particularly if capital gains to land are included; see Atack, Bateman, and Parker, 2000, p. 279) and consistent with the comments of contemporaries (US Congress 1846). The estimates, as noted above, are nominal – they are not adjusted for changes over time in the price of capital relative to output. And they are, as just argued, likely to be biased downwards before the Civil War.

If we could adjust the ante-bellum estimates properly for annual labor costs it seems likely that the mean rate of return would have fallen modestly from 1850 to 1870, and then declined sharply in the 1870s. The sharp decline in the 1870s, of course, coincides with an increase in nominal capital deepening, as documented in Table 1. In real terms – that is, when the estimates are adjusted for the decline over time in the relative price of capital -- there is a more pronounced downward trend. Indeed, in real terms, the mean return in 1880 was approximately half of the level in 1850; and, this

[23] However, because we know annual labor costs in 1880 the first bias is no longer relevant.

decline, because of the bias resulting from the overstatement of annual labor costs in 1850, is understated.

It is possible to use our estimates of mean rates of return to infer a time series of capital's share, using the estimates made previously of the capital-output ratio. These estimates of capital's share are shown in column 3 of Panel A. Capital's share appears to rise in the 1850s, remain constant in 1860s, and then decline in 1870s to a level slightly below that in 1850. A simple average of the four figures in column 3 gives a value of 0.334, implying that capital's share of value added was one-third on average during the period. This seems highly plausible, and suggests that our procedure for estimating mean returns, for all its potential pitfalls, yields results that, on average, may not be too far off the mark.

Panel B of Table 3 reports regressions of the estimated rate of return on establishment characteristics, using the column 3 specification from Table 3. If (1) capital markets were "perfect" (2) there were no systematic errors in our estimation procedure, and (3) there were no differences in risk either across locations or types of establishments, rates of return should have been equalized. We already know that assumption (2) is likely to be false, because we cannot observe annual labor costs for the census establishments before the Civil War.

In any case, the regressions reveal that rates of return varied across establishments in systematic ways. The geographic differences that we observe – for instance, the urban premium prior to the Civil War – and the lower returns to establishments in the Northeast, particularly in comparison with the Midwest and South after the Civil War, are consistent with previous research (Bodenhorn and Rockoff 1992; Hutchinson and Margo

2003). No significant correlations are observed, however, between rates of return and the percent female or the use of steam or waterpower.

Perhaps the most intriguing finding in Panel B is the negative relationship between the rate of return and establishment size. Because we are forced to annualize labor costs in 1850 and 1860 and this assumption arguably biases down the rate of return for the smaller establishments, it is likely that the true negative gradient between the returns and size is even steeper in 1850 than we estimate. That is, if we were able to make the appropriate adjustment, it is likely that, relative to artisan shops, the larger establishments earned lower returns, but the gaps in this regard were probably no larger in 1880 than in 1850 – despite the substantial rise in capital-output ratios that took place in the larger establishments, relative to artisan shops, over this period.

With the information at our disposal it is not possible to identify the cause, or causes, of the negative relationship between returns and size. It is possible, for instance, that the culprit is measurement error. As we noted above, we make no adjustment for the labor input of owners, on the grounds that the census counted this input if it materially contributed to production. If we are wrong about this, returns will be biased upwards for establishments in which the owner's contribution was proportionately larger – in the smallest establishments.

Absent an explanation based on measurement error, there may be numerous reasons why size and returns were negatively correlated. One obvious possibility is that size is a proxy for risk – that is, larger establishments were less risky investments than smaller establishments. Post-bellum evidence suggests that larger establishments were more likely to operate on a full year basis than smaller establishments (see Atack, Bateman, and Margo 2002), which is consistent with the hypothesis that larger establishments were less likely to shut down or go out of business. In this sense, capital invested in large establishments make have been at lower risk than capital invested in smaller establishments. On the other had, if we compute coefficients of variation (standard deviation/mean) of rates of return by size class of establishment, we find no evidence that the dispersion in returns was decreasing in establishment size – which we might expect to see if large establishments were less risky. In short, further research is needed, using much more detailed data, is necessary to explain the negative association between rates of return and size observed in our samples.

5. Conclusion

This paper has used establishment level data to examine capital deepening in nineteenth century U.S. manufacturing. Adjusted for changes in the price of capital relative to output, each unit of output used approximately 70 percent more capital in 1880 than in 1850. In 1850, the capital-output ratio followed a U-shaped pattern with respect to establishment size, but even the largest establishments did not use much more capital per unit of output than did artisan shops. By 1880, however, the capital-output ratio was positively related to establishment size. A portion of the twist in the relationship between capital and size can be attributed to the diffusion of steam power. Steam or water powered establishments used more capital per unit of output, other factors held constant. Over time, steam accounted for an increasing share of total value added, relative to water or hand power, and the diffusion of steam can explain, in a proximate sense, a portion of capital deepening after 1850. However, other factors clearly mattered, including rising establishment size but others as well not revealed by the information in the census data.

The rise in the capital-output ratio implies that capital productivity was falling over time on average and we also show that capital's marginal product – the rate of return – was also falling, especially when adjusted for changes in the relative price of capital goods. Rates of return varied with the location of the establishment in ways that seem consistent with previous research using other data. Large establishments earned lower returns than small establishments but determining the cause of the negative relationship between size and returns will require much more information than was reported in the censuses.

6. Appendix: Calculation of Rates of Return to Capital

The purpose of this appendix is to describe our calculations of rates of return to capital. By "rate of return" we mean the difference between revenues less all non-capital costs of production, per dollar of capital. Here "capital" includes the value of capital invested in the establishment, as reported in the census, plus estimated working capital which is assumed to not have been reported

The equation for estimating the rate of return, π, is as follows: :

$$\pi = (VA - W - E)/(K_i + K_w)$$

Where

VA = value added = gross value of output – value of raw materials used in production

W = cost of labor used in production

E = other non-labor costs of production

K_f: value of capital reported by the census

K_w: estimated working capital

We discuss the components of this equation in turn.

Each of the censuses reported the value of output. As best as we can determine, value was measured "f.o.b." – that is, at the factory gate.[24] For 1850, 1860, and 1870, the census instructions directed the enumerators to account for up to six different products, which we have summed into a single, overall figure. In 1880, only the aggregate value of output was reported.

A firm's profits derive from its revenue, but revenue is not the same as the value of production. However, by definition, revenue, R, in any given year is

$$R = Q - \Delta I$$

Here Q is the value of output and $\Delta I = I_{t+1} - I_t$, is the change in value of inventories. In

[24] The instructions to enumerators in 1860 specifically stated that value was to be determined "at the place of manufacture … exclusive of the cost of transportation to any market"; see U.S. Census (1860, p. 27). See also Wright (1900, p. 315).

any given year revenue would also include realized payments on outstanding debt. On the expense side, these would be offset by an allowance for bad debt. We have no information on either and thus we are assuming that both are zero, or their difference is zero. Note that, if ΔI is positive, $R < Q$ – revenues are less than the value of production – and if ΔI is negative, revenues exceed the value of production. Because we do not observe inventories in calculating profits we must assume that ΔI is zero, in which case, $R = Q$. For many establishments this may be a reasonable assumption. For example, establishments that produced processed food items the change in inventories across years may have been close to zero, because such items were perishable. More generally, much manufacturing in the nineteenth century was of a custom nature, made to order. Almost by definition, the value of output for a custom manufacturer would equal revenues. Still, we cannot rule out the possibility that the change of inventories was non-zero for any given establishment, and this introduces some error in our estimates.

Over long time periods with frequent observation, we might expect this error to cancel out on average. However, this might not be true because profitability is also influenced by the business cycle. On the basis of twentieth century evidence, we would expect profits to be pro-cyclical, rising in booms and falling in recessions. The 1850 census year coincides with the middle stages of a moderately serious downturn that began in 1847 and ended in December 1854. The 1860 census was towards the end of an expansion following the 1857 panic. The 1870 census followed the business cycle peak but was well in advance of the 1873 nadir. The 1880 census in contrast was taken during the recovery from the prolonged downturn of the 1870's. Modern research suggests that profits are a leading economic indicator.[25] If this were also the case in the nineteenth century, profits for the 1850 census year were probably below average; those for 1860, above average; and those for 1870 and 1880 perhaps more nearly average for their time. However, we would also expect that during recessions, inventories piled up unsold, while during booms, the change in inventories may have been negative. If this were true, our estimates of returns for 1850 may be biased downwards relative to their true value while, for 1860, our estimates may be biased upwards. Thus our procedures will tend to dampen any procyclical movement in returns that might have existed. With only four census years represented in the data, we cannot, in any case, analyze the relationship between profits and business cycle; at best, we can merely point out the possible relationships assuming that they follow the same pattern as in more recent data..

The censuses all reported raw materials costs on a "c.i.f." basis—the value of materials used in the production process. For those raw materials or intermediate inputs that were directly incorporated into the final product, the data seems to be reliable and comprehensive. We are less certain about fuel although we note that, in 1850-1870 at least, firms using steam power consistently listed wood and coal among their inputs, and that the 1870 census contained a specific instruction to include the cost of fuel (see U.S Census 1870, p. 22). We do not, however, find firms in Lowell, for example, that rented waterpower from the Locks and Canal Company listing such expenditures in their accounting to census enumerators.

The reporting of labor costs varied across the censuses. For 1850 and 1860 the average monthly cost of male and female labor was reported, but not the average months

[25] On the relationship between profits and the business cycle, see Moore (1961). On the dating of nineteenth century business cycles see Burns and Mitchell (1946, Table 16, p. 78), Calomiris and Hanes (1994), and http://www.nber.org/cycles.

of operation. To estimate annual labor costs in these years we assume that establishments operated on a full-year basis (i.e.12 months), an assumption that almost certainly biases downwards our estimated rates of return for both years. In 1870 and 1880, actual annual labor costs were reported.

An important question in interpreting the census data on labor costs is the treatment of the so-called "entrepreneurial labor input". Our interest is in the return on capital, not in the return to the labor effort of the owner (or owners). Consequently, if the census did not measure the value of this labor input we would need to inflate the reported figures on labor costs.

In general, we believe that the entrepreneur was almost always included in the count of employees if he or she "materially contributed" to production. We say, "in general" because the evidence for this belief is circumstantial and it is stronger overall for the pre-Civil War censuses and stronger for 1880 than for 1870.

The evidence is in two parts. The first concerns the instructions to enumerators. In 1850, the instructions clearly specified enumerators "to include the individual labor of a producer" (U.S. Census 1850, p.xxiv). In 1860, the instruction read: "the average number of hands and the average monthly wages are to be returned so that dividing the latter by the former, the result will show the average earnings of individuals. <u>This is also to include in the individual labor of the producer "</u>(U.S. Census 1860, p.27).

If most entrepreneurs did work alongside their employees – and it seems likely that they did, particularly in small establishments – and if the census enumerators followed their instructions to the letter we should observe very few establishments in 1850 or 1860 that reported a "zero" for the labor input (or left the relevant columns blank). In fact, very few did – just 0.4 percent of the sample firms in 1850 and 0.8 percent of the sample firms in 1860.

In 1870 and 1880 the instructions were less specific. For example, in 1870 enumerators were instructed to not include "the cost of Superintendence" in materials, but there was no offsetting instruction to count such expenses as wages (U.S. Census 1870, p. 22). The proportion of establishments reporting zero employees jumped to 4.2 percent of the sample in 1870 and to 5.1 percent in 1880.

It is possible that some enumerators in 1870 and 1880 might have interpreted the instructions as indicating that managerial and supervisory labor, including that of the entrepreneur, should be ignored. However, this could not have been common, because the size distributions by employment, particularly among the smaller firms in 1870 and 1880, are not very much different from what they were are earlier censuses. In 1850, 21.4 percent of establishments reported just one employee. In 1860, the fraction rose slightly to 21.9 percent. Ten years later, 29 percent of establishments reported employing only one person but by 1880 the fraction of such firms had fallen back towards its level at mid-century--23.6 percent. In 1850, 27 percent of producers had two employees. This was virtually unchanged at 26.4 percent ten years later. It declined thereafter, dropping to 21.9 percent is 1870 and to 20.1 percent in 1880.

If the entrepreneur had been systematically excluded from the labor statistics, we presume that we would have found a much higher fraction of firms reporting zero employment than we did and that firms with just one worker would have dominated, but such firms did not. Only in 1870 did the fraction of firms with only one employee exceed that the fraction with two. Although this evidence is circumstantial, we believe that it favors the point of view that the entrepreneurial labor input was counted if the owner (or owners) was actively working in the establishment.

Since the questions on the physical quantity of inputs (such as labor) and their costs were complementary, it stands to reason that, if the entrepreneurial labor input was counted, it would have been valued in some manner. Certainly this seems to have been the intent in 1860, as noted above. But how was this carried out in practice?

Because the census instructions are silent on this issue, any evidence is necessarily indirect. For example, suppose we assume that establishments with one reported employee were, in general, sole proprietorships. If the custom were to <u>not</u> impute a wage for this work, we would expect such firms to report zero wages. In 1850 and 1860, this was clearly <u>not</u> the case. The fraction of enterprises reporting no wages was essentially the same for those with just one worker as for those with more. Both were miniscule (well under one percent). In 1870, however, the case is not so clear. About 30 percent of firms with just one worker reported zero wages. But in 1880, the situation looks much more like that existing in 1850 or 1860 than 1870: Relatively few firms (under five percent) reported zero wages regardless of the number of workers employed.

In sum, our operative assumption is that the entrepreneurial labor input was counted if the owner (or owners) "materially" contributed to production and that the enumerator – presumably in consultation with the owner – assigned a value to it. We believe this assumption applies to the vast majority of establishments in 1850 and 1860 and probably 1880, but there were likely some exceptions in 1870 (as described above). Consequently, it is possible that our estimate of the average return in 1870 may be biased upwards, although we do not believe the bias to be very large, especially when the data are weighted by capital at risk (see below).

The next term in the equation concerns non-labor expenses. With some exceptions, most of these were not reported prior to 1890. For example, most establishments did not report annual expenses of purchased waterpower rights, insurance payments, the cost of repairs, or payments to contractors (unless they resulted in a raw material input to the production process) No establishments reported paying property taxes nor did they report paying corporate franchise fees to the state.

On the other hand, the general opinion of contemporaries is that allowance was made for excise taxes in either the cost of materials deducted from the value of output (U.S. Census, 1895: 12; U.S. Census, 1902: cxxxiv-v). Prior to 1862 such taxes were of little consequence but there after federal excise taxes on tobacco products and alcoholic beverages began to be imposed to ease the fiscal crisis created by the Civil War. These taxes seem to have had a major impact upon the profitability of firms in these industries is so far as we note a sharp drop in the rate of return in such activities beginning with the 1870 data.

Although we do not know how much each firm spent on these various miscellaneous expenses, is seems reasonable to suppose that these depended upon each firm's output level. For example, firms that operated longer and faster should have higher repair and maintenance costs and pay more excise taxes if they produced more output. We have therefore made an adjustment to each firm's costs based upon the gross value of output. The adjustment is derived from the ratio of miscellaneous expenses to output for firms in the same state and industry in 1890 when these data were first reported. We have made these calculations at a level that corresponds roughly to the three or four-digit SIC (standard industrial classification) level of detail. The inquiry required separate amounts for "(1) amount paid for rent of tenancy, power, and heat; (2) for taxes; (3) for insurance; (4) for repairs, ordinary, of buildings and machinery; (5) for commissions and expenses of sales department; (6) for interest on cash used in business; (7) for all other sundries not reported elsewhere." (US Census, 1902, cxxxiv). Unfortunately, because the 1890 census manuscripts themselves were burnt in a fire at the Commerce Department in 1921, our estimates are based solely upon the published summary figures and we are unable to factor in any role that size or other firm characteristics may have played in the determination of these costs.

No inquiry regarding depreciation was made prior to 1890, when respondents were required to report the average annual depreciation allowances since 1880. Unfortunately these allowances were not tabulated and were lost when the original census schedules burned in a fire. The published volumes, however, do give a breakdown of fixed capital into land, buildings and machinery by industry and state. We have used these as a basis for our estimates of depreciation assuming that fixed capital (see below) at earlier dates was divided in the same proportions as in 1890. We have arbitrarily assigned a useful life of 15 years to machinery and 50 years for buildings and used straight-line depreciation. No depreciation is taken on land.

As an example, consider Pennsylvania flourmills. In 1890, such mills had slightly more than 44 percent of their fixed capital tied up in machinery and almost 37 percent in buildings. Thus at the earlier censuses we would make a capital depreciation allowance equal to 2.96 percent of reported capital for machinery (= 1/15 of 0.4436) and 0.74

percent for buildings (= 1/50 of 0.3698). Thus depreciation for a Pennsylvanian flourmill capitalized at, say, $10,000 is estimated to be $370 during the census year. A flourmill in New York state capitalized at the same amount is assumed (on the basis of the 1890 figures) to have had less in plant and equipment and more in land. Its depreciation charge would have been $359.

The denominator in our equation consists of the value of capital reported in the census plus estimated working capital. As noted in the text, we are presuming, in the direct calculation (unlike the production function estimates) that working capital was not included in the census enumerations. We estimate working capital by again making use of the data for 1890, specifically by taking the ratio of live assets to output (most items included in live assets are clearly closely related to output) for 1890 by industry and state and applying it to output at earlier census years to generate an estimate of the working capital which the firm may have employed. [26]

As noted in section 2, so-called "special agent" industries are under-represented in the 1880 sample. We have no reason to believe, however, that firms in such industries that were included in the 1880 census were anything but randomly selected. Consequently, to correct for the under-sampling, we re-weight the 1880 data prior to estimating sample statistics.

[26] Aside from borrowed capital, some capital may be leased. We make allowance, as noted above, for rents but do not make any adjustment for leased capital because it is clear from the commentary in the 1890 census that leased capital was not generally reported prior to 1890.

References

Atack, Jeremy. 1977. "Returns to Scale in Antebellum United States Manufacturing." Explorations in Economic History 14: 337-359.

Atack, Jeremy. 1987. "Economies of Scale and Efficiency Gains in the Rise of the Factory in America, 1820-1900," in Peter Kilby ed. Quantity and Quiddity: Essays in U.S. Economic History, Wesleyan University Press.

Atack, Jeremy and Fred Bateman. 1987. To Their Own Soil: Agriculture in the Antebellum North. Ames Iowa: Iowa State University Press.

Atack, Jeremy and Fred Bateman. 1999. "U.S. Historical Statistics: Nineteenth Century U.S. Industrial Development Through the Eyes of the Census of Manufactures," Historical Methods 32: 177-188.

Atack, Jeremy and Robert Margo. 1999. "'Location! Location! Location! The Price Gradient for Vacant Urban Land: New York, 1835-1900." Journal of Real Estate Finance and Economics 16: 151-172.

Atack, Jeremy and Peter Passell. 1994. A New Economic View of American History. New York: W.W. Norton.

Atack, Jeremy, Fred Bateman, and Robert A. Margo. 2002. "Part-Year Operation in Late Nineteenth Century American Manufacturing: Evidence from the 1870 and 1880 Censuses," Journal of Economic History 62: 792-809.

Atack, Jeremy, Fred Bateman, and Robert A. Margo. Forthcoming. "Skill Intensity and Rising Wage Dispersion in Nineteenth Century American Manufacturing," Journal of Economic History.

Atack, Jeremy, Fred Bateman, and William N. Parker. 2002. "The Farm, the Farmer, and the Market." In. Stanley L. Engerman and Robert E. Gallman, eds. The Cambridge Economic History of the United States, pp. 245-284. New York: Cambridge University Press.

Atack, Jeremy, Fred Bateman, and Thomas Weiss. 1980. "The Regional Diffusion and Adoption of the Steam Engine in American Manufacturing," Journal of Economic History: 281-308.

Bateman, Fred and Thomas Weiss. 1981. A Deplorable Scarcity: The Failure of Industrialization in the Slave Economy. Chapel Hill, NC: University of North Carolina Press.

Bodenhorn, Howard and Hugh Rockoff. 1992. "Regional Interest Rates in Antebellum America," in C. Goldin and H. Rockoff, eds. Strategic Factors in Nineteenth Century American Economic History, pp. 159-187. Chicago: University of Chicago Press.

Brady, Dorothy. 1966. "Price Deflators for Final Product Estimates," in Output, Employment, and Productivity in the United States After 1800, pp. 91-115. Volume 30, Studies in Income and Wealth, Conference on Research on Income and Wealth. New York: Columbia University Press.

Brown, Martin and Peter Phillips. 1986. "Craft Labor and Mechanization in Nineteenth Century American Canning," Journal of Economic History 46: 743-756.

Burns, Arthur and Wesley C. Mitchell. 1946. Measuring Business Cycles. New York: Columbia University Press.

Calomiris, Charles and Christopher Hanes. 1994. "Consistent Output Series for the Antebellum and Postbellum Periods: Issues nad Preliminary Results," Journal Of Economic History 54: 409-422.

Chandler, Alfred. 1977. The Visible Hand: The Managerial Revolution in American Business. Cambridge: Harvard University Press.

Delle Donne, C.R. 1973. "Federal Census Schedules, 1850-1880: Primary Sources for Historical Research. National Archives and Records Service Reference Information Paper No. 67, General Services Administration, Washington DC.

Engerman, Stanley L. and Kenneth L. Sokoloff. 2000. "Technology and Industrialization, 1790-1914." In Stanley L. Engerman and Robert Gallman, eds. The Cambridge Economic History of the United States, Volume II: The Long Nineteenth Century, pp.367-401. New York: Cambridge University Press.

Fenichel, Allen H. 1966. "Growth and Diffusion of Power in Manufacturing, 1838-1919," in Output, Employment, and Productivity in the United States After 1800, pp. 443-479. Volume 30, Studies in Income and Wealth, Conference on Research on Income and Wealth. New York: Columbia University Press.

Gallman, Robert. 1961. "Gross National Product in the United States, 1834-1909," in Output, Employment, and Productivity in the United States After 1800, pp. 3-76. Volume 30, Studies in Income and Wealth, Conference on Research on Income and Wealth. New York: Columbia University Press.

Gallman, Robert. 1986. "The United States Capital Stock in the Nineteenth Century." In. Stanley L. Engerman and Robert E. Gallman, eds., Long-Term Factors in

American Economic Growth, pp. 165-213. Volume 51, Studies in Income and Wealth, Conference on Research on Income and Wealth. Chicago: University of Chicago Press.

Gallman, Robert. 1987. "Investment Flows and Capital Stocks: U.S. Experience in the Nineteenth Century" In Peter Kilby, ed. Quantity and Quiddity: Essays in U.S. Economic History. Middletown, CT: Wesleyan University Press.

Goldin, Claudia and Lawrence Katz. 1998. "The Origins of Technology-Skill Complementarity," Quarterly Journal of Economics 113: 693-732.

Goldin, Claudia and Kenneth Sokoloff. 1982. "Women, Children, and Industrialization in the Early Republic: Evidence from the Manufacturing Censuses," Journal of Economic History 42: 741-774.

Hutchinson, William and Robert A. Margo. 2003. "The Transition from Slavery to Freedom and its Effects on Factor Prices and Factor Intensities," working paper, Department of Economics, Vanderbilt University, August.

Margo, Robert A. 2000a. Wages and Labor Markets in the United States, 1820-1860. Chicago: University of Chicago Press.

Margo, Robert A. 2000b. "The Labor Force in the Nineteenth Century." In Stanley L. Engerman and Robert E. Gallman, eds. The Cambridge Economic History of The United States, Volume II: The Long Nineteenth Century, pp. 207-243. New York: Cambridge University Press.

Sokoloff, Kenneth. 1984a. "Was the Transition from the Artisanal Shop to the Nonmechanized Factory Associated with Gains in Efficiency? Evidence from the

U.S. Manufacturing Censuses of 1820 and 1850," Explorations in Economic History 21: 329-350.

Sokoloff, Kenneth. 1984b. "Investment in Fixed and Working Capital During Early Industrialization: Evidence from U.S. Manufacturing Firms," Journal of Economic History 44: 545-556.

Sokoloff, Kenneth. 1986. "Productivity Gains in Manufacturing During Early Industrialization: Evidence from the American Northeast, 1820-1860." In Stanley L. Engerman and Robert E. Gallman, eds. Long-Term Factors in American Economic Growth, pp. 679-729. Volume 51, Studies in Income and Wealth, Conference on Research on Income and Wealth. Chicago: University of Chicago Press.

Sokoloff, Kenneth and Georgia C. Villaflor. 1992. "The Market for Manufacturing Workers During Early Industrialization: The American Northeast, 1820 to 1860." In Claudia Goldin and Hugh Rockoff, eds. Strategic Factors in Nineteenth Century American Economic History, pp. 29-65. Chicago: University of Chicago Press.

U.S. Census. 1853. Seventh Census of the United States: 1850. Washington, DC: Robert Armstrong.

U.S. Census. 1860. Eighth Census, United States, 1860: Instructions to U.S. Marshalls, Instructions to Assistants. Washington, DC: George Bowman.

U.S. Census. 1870. Ninth Census, United States, 1870: Instructions to Assistant Marshals. Washington, DC: Government Printing Office.

U.S. Census. 1880. Tenth Census of the United States: Instructions to Enumerators. Washington, DC: Government Printing Office.

U.S. Census. 1895. Report on Manufacturing Industries in the United States at the Eleventh Census: 1890, Part I. Washington, DC: Government Printing Office.

U.S. Census. 1902. Census Report, Volume VII: Manufactures, Part I. Washington, DC: U.S. Census Office.

U.S. Congress. 1846 "Report from the Secretary of the Treasury on the State of the Finances," 29th Cong., 1st Sess. Senate Doc 2.

U.S. Department of Commerce. 1975. Historical Statistics of the United States. Washington: Bureau of the Census.

Williamson, Jeffrey G. and Peter H. Lindert. 1980. American Inequality: A Macroeconomic History. New York: Academic Press.

Wright, Carroll D. 1900. History and Growth of the United States Census. Washington DC: Government Printing Office.

Wright, Gavin. 1986. Old South, New South. New York: Basic Books.

Wright, Gavin. 1990. "The Origins of American Industrial Success, 1879-1940," American Economic Review: 651-668.

Table 1: Indices of Capital/Value-Added in Manufacturing, 1850-1880: Atack-Bateman National Samples

A. Capital/Value-Added, Nominal (1850 = 100)

	Sample Size	Index A	Index B
1849	5,040	100.0	100.0
1859	5,085	103.7	104.5
1869	3,885	104.6	105.9
1879	7,199	132.1 [130.6]	129.6 [126.7]

B. Price Deflators

	Capital	Output
1849	100.0	100.0
1859	97.4	103.6
1869	131.1	165.2
1879	83.0	109.2

C. Capital/Value-Added, Real (1850 = 100)

	Index A	Index B
1849	100.0	100.0
1859	110.3	111.1
1869	131.8	133.4
1879	173.8	170.6

Notes: Sample size: number of establishments. To be included, establishments have to meet the following criteria (1) positive value added (value of outputs – value of inputs > 0) (2) value of inputs > 0 (3) value of capital invested > 0 (4) employment > 0 (5) very low or very high realized rate of return establishments are excluded (see the text). Source: Atack and Bateman (1999).

Panel A: Figures are index numbers (1850 = 100) of weighted sample averages of establishment estimates of capital/value added. Figures in [ ] are index numbers for 1880 (1850 = 100) based on weighted geometric means of establishment level ratios. Weight is value-added. Index A: Assumes that reported capital invested includes working capital.
Index B: Assumes reported capital invested refers to fixed capital only. Working capital is estimated by multiplying gross output by the ratio of working capital/gross output in the 1890 census for the state-two digit industry group.

All 1880 figures are re-weighted for the under-sampling of special agent industries. are restricted to non-special agent industries, the 1880 nominal estimates (Panel A) in index number form (1850 = 100) are 132.6 (index A) and 130.3 (index B).

Panel B: Price Deflators: Capital deflator is a weighted average of price index numbers for equipment, structures, and working capital; see Sokoloff (1986). Weights: equipment, 0.412; structures, 0.275; working capital, 0.313. Working capital is presumed divided equally between finished output and raw materials. Weights are computed from 1890 census of manufactures. Equipment capital price is from Brady (1966, pp. 110-111, “Machine-shop products”). Structures capital price is from Brady (1966, pp. 110-111, “Factories, Office Buildings” with imputation for 1859 based on change in construction costs for “Houses, churches, schools” between 1854 and 1859 and imputation for 1869 based on change in construction costs from 1869 to 1879 implied by Riggleman building cost index; see U.S. Department of Commerce (1975, series N138, p. 629). Price index for finished products component of working capital is set equal to output price deflator. Price deflator for raw materials component of working capital is set equal to Warren-Peason wholesale price index. Output price deflator computed by taking the ratio of Gallman’s (1961, Table A.13) estimates of aggregate nominal and real value added in manufacturing, 1849-1879, and re-scaling so that 1850 = 100.

Panel C: Figures are nominal capital/value added ratios x (Output price deflator)/Capital price deflator.

Table 2: Establishment Level Regressions: Log [Capital/Value-Added]

A. 1850

	(1)	(2)	(3)
Constant	0.488 (0.013)	0.209 (0.013)	0.220 (0.634)
6<=labor<=15	0.044 (0.052)	0.051 (0.060)	-0.050 (0.042)
16<=labor<=100	0.280 (0.060)	0.253 (0.082)	0.045 (0.070)
101<=labor	0.534 (0.096)	0.361 (0.096)	0.086 (0.086)
Steam Powered?		0.435 (0.068)	0.344 (0.084)
Water Powered?		0.696 (0.079)	0.493 (0.075)
Percent Female			-0.182 (0.132)
Urban			-0.007 (0.055)
Midwest			-0.138 (0.046)
South			0.029 (0.110)
West			-0.979 (0.076)
2-Digit SIC Dummies?	No	No	Yes
Adjusted R^2	0.082	0.250	0.394

Dependent variable is log of capital/value added. Capital = reported value of capital invested + adjustment for working capital. Value added = value of outputs – value of raw materials. See Table 1 for sample inclusion criteria and definition of labor. Robust standard errors are shown in parentheses. Urban =1 if establishment located in town or city of population>2,500. Industry dummies: two-digit standard industrial classification codes. Sample size is 5,040 establishments, all columns. Observations are weighted by value-added. 1880 sample is re-weighted to correct for under-sampling of special agent industries.

B. 1880

	(1)	(2)	(3)
Constant	0.443 (0.042)	0.234 (0.044)	0.288 (0.154)
6<=labor<=15	0.127 (0.086)	0.044 (0.098)	0.079 (0.064)
16<=labor<=100	0.283 (0.090)	0.132 (0.078)	0.255 (0.068)
101<=labor	0.292 (0.094)	0.089 (0.097)	0.217 (0.088)
Steam Powered?		0.354 (0.014)	0.192 (0.060)
Water Powered?		0.199 (0.101)	0.096 (0.086)
Percent Female			-0.274 (0.136)
Urban			-0.104 (0.057)
Midwest			-0.034 (0.059)
South			-0.377 (0.101)
West			-0.052 (0.136)
2-Digit SIC Dummies?	No	No	Yes
Adjusted R^2	0.023	0.072	0.325

Dependent variable is log of capital/value added. Capital includes the adjustment for working capital; see the text. See Table 1 for sample inclusion criteria and definition of labor. Robust standard errors are shown in parentheses. Industry dummies: two-digit standard industrial classification codes. Sample size is 7,199 establishments, all columns. Observations are weighted by value added. 1880 Sample is re-weighted to correct for under-sampling of special agent industries.

Table 3: Rates of Return in Manufacturing

A. Mean Rates of Return, Nominal and Real, and Implied Output Elasticity of Capital

	Nominal	Real (1850 $)	Implied Capital's Share
1849	0.162 [0.210]	0.162	0.319
1859	0.179	0.168	0.368
1869	0.173	0.137	0.361
1879	0.113 [0.154]	0.086	0.288

Panel A: Figures in column 1 ("Nominal") are mean nominal returns to a dollar of capital; column 2 ("Real") = column 1 x [capital price deflator/output price deflator]. Establishment estimates are weighted by estimated capital (= capital reported in the census + adjustment for working capital). See Table 1 for price indices. Implied Capital's Share = column 1 x (inverse of K/Q series used to produce Index B, Panel A, Table 1). 1880 figures are re-weighted to correct for under-sampling of special agent industries. Mean nominal rate of return of non-special agent industries shown in [].

B. Regressions of Rate of Return on Establishment Characteristics, 1850 and 1880

	1850	1880
Constant	-0.010 (0.048)	0.277 (0.090)
6<=labor<=15	-0.018 (0.022)	-0.062 (0.018)
16<=labor<=100	-0.053 (0.027)	-0.086 (0.018)
101<=labor	-0.089 (0.039)	-0.116 (0.022)
Steam Powered?	-0.026 (0.038)	-0.021 (0.016)
Water Powered?	-0.049 (0.036)	0.008 (0.024)
Percent Female	-0.040 (0.052)	0.033 (0.043)
Urban	0.046 (0.018)	0.007 (0.016)
Midwest	0.064 (0.023)	0.072 (0.015)
South	0.060 (0.032)	0.125 (0.026)
West	0.898 (0.102)	0.016 (0.023)
2-Digit SIC Dummies	Yes	Yes
Adjusted R^2	0.252	0.231

Dependent variable is rate of return to estimated capital; see text and appendix. Sample sizes are the same as in Table 3. Observations are weighted by estimated capital prior to estimation. 1880 sample is re-weighted to correct for under-sampling of special agent industries.