RISING WAGE DISPERSION ACROSS AMERICAN MANUFACTURING ESTABLISHMENTS, 1850-1880

by

Jeremy Atack

and

Fred Bateman

and

Robert A. Margo

February 2002

Jeremy Atack is Professor of Economics and History, Vanderbilt University, and Research Associate, National Bureau of Economic Research. Fred Bateman is Nicholas A. Beadles Professor of Economics, Terry College of Business, University of Georgia. Robert A. Margo is Professor of Economics and History, Vanderbilt University; and Research Associate, National Bureau of Economic Research.. We are grateful to Stanley Engerman, Claudia Goldin, Daniel Hamermesh, Lawrence Katz, Gavin Wright, and workshop participants at George Washington University, Princeton, Harvard, McGill, Texas, Toronto, the Fourth World Congress of Cliometrics, the NBER, and the 2001 ASSA meetings, for helpful comments. Corresponding author: Robert A. Margo.

ABSTRACT

We use data from the manuscript censuses of manufacturing for 1850, 1860, 1870, and 1880 to study the dispersion of average monthly wages across establishments. We find a marked increased in wage inequality over the period, an increase that cannot be explained by biases in the data or changes in census enumeration procedures. Based on log wage regressions on establishment characteristics (for example, size, capital intensity, use of steam power, and so on) we compute a decomposition of the change in wage inequality between 1850 and 1880. Most of the rise in wage inequality can be attributed to an increased concentration of employment in large establishments, which paid relatively low wages. We present indirect evidence that the negative effect of size on wages reflected differences in skill composition: workforces in large establishments were less skilled than in small establishments.

Jeremy Atack
Department of Economics
Vanderbilt University
Nashville TN 37235
and NBER
jeremy.atack@vanderbilt.edu

Fred Bateman
Department of Economics
Terry College of Business
University of Georgia
Athens GA 30602
bateman@terry.uga.edu

Robert A. Margo
Department of Economics
Vanderbilt University
Nashville TN 37235
and NBER
robert.a.margo@vanderbilt.edu

JEL No. N61, N31

1. Introduction

During the second half of the nineteenth century the United States developed a formidable manufacturing sector. Output per worker grew substantially in real terms, as did capital intensity and establishment size measured in terms of average employment (Chandler 1977; Atack 1985). The rapid diffusion of the steam engine after 1850 freed manufacturers from locating solely where nature had left adequate water supplies (Atack, Bateman, and Weiss 1982). After 1880 production processes were altered radically as electricity began to replace steam power (Goldin and Katz 1999). The range of products widened, as specialized firms created an "endless novelty" of intermediate and final goods to satisfy the various and growing demands of other manufacturers and consumers (Scranton 1999). These trends were so strong that, by century's end, the United States had already become the world's leader, or was poised to become so, in a wide array of industries, as well as in manufacturing overall (Wright 1995).

In this paper we document a previously unnoticed aspect of the growth of American manufacturing during the second half of the nineteenth century – a substantial and sustained rise in the dispersion of the "establishment" wage across firms, when weighted by establishment size. By the "establishment" wage we mean the average wage – in our case, measured on a monthly basis – at each firm. Our empirical analysis is based on random samples of establishments from the surviving records of the Censuses of Manufacturing of 1850-1880. For the period covered by our samples we show that the rise in establishment wage inequality is robust to a variety of tests for biases. That is, it appears to have been a genuine historical phenomena -- not an artifact, for example, of changes in census reporting procedures.

The specific timing of changes, their location in the overall distribution of wages, as well as any correlations with establishment level characteristics provide clues to the underlying reasons behind the rise in wage dispersion. For example, measures of overall dispersion jumped sharply between 1860 and 1870, a timing that is obviously suggestive of a role for the Civil War. On the other, inequality in the lower half of the distribution -- that is, below the median establishment wage – increased more uniformly over time, a feature of the data that cannot be explained so readily by any impact of the War.

In general, the establishment wage can be thought of as a weighted average of the mean wage of workers indexed by skill group (for example, skilled and unskilled), with the weights equal to the group-specific share of employment in each firm. Dispersion in the establishment wage, therefore, is a function of (1) within-establishment differences in the group means, (2) the variances across establishments of the group means, (3) the variances of the employment weights and (4) the co-variances of the group means and the employment weights. Our data are not rich to decompose the variance in the establishment wage into these various components. However, we do have information on a variety of establishment level characteristics that are correlated with the establishment wage. We use the results of regressions of establishment wages to produce various simulated distributions for each sample year.

The simulated distributions demonstrate that an important component of the overall rise in establishment wage inequality was an increase in the residual variance (the dispersion that remains after controlling for establishment level characteristics) among small to median sized establishments. However, we also find that an economically significant portion of the increase in dispersion below the median establishment wage can be attributed to the increased

concentration of employment in large establishments. Census evidence from the late 20th century indicates that, "today", the establishment wage in manufacturing is a positive function of size (Davis and Haltiwanger 1992). By contrast, in our data the relationship between the establishment wage and size is more complex. Among very small to medium sized firms, the establishment wage had become a mild positive function of size by 1880. Beyond a certain size, however, the establishment wage declined as size increased. The concentration of employment in very large establishments grew substantially between 1850 and 1880. This increased concentration of employment produced an increased density of employment in low-wage establishments -- which we observe as rise in the dispersion below the median establishment wage.

Because our data do not precisely identify the skills (or most other characteristics) of the workers employed at each establishment, we cannot be certain of the exact reasons behind the negative relationship between the establishment wage and size in large firms. However, for one of our samples – 1880 – it is possible to use additional evidence on the average daily wages of common labor and "mechanics" (skilled labor) that strongly suggests that the negative relationship is attributable to a declining share of skilled labor as establishment size increased (see Atack, Bateman, and Margo 2002). That is, compared to small or medium size establishments, workers in large establishments were less skilled, and this was reflected in a lower establishment wage, conditional on other establishment characteristics.

The idea that the growth of large establishments in manufacturing was associated with declining share of skilled labor is hardly novel to this paper. Indeed, it is the essence of what labor historians mean by "de-skilling" (Scranton 1999). Our empirical contribution is to

demonstrate that de-skilling left a previously unnoticed, but measurable footprint in its effects on the distribution of establishment wages.

2. Evidence on the Distribution of Wages Across Manufacturing Establishments, 1850-1880

Our evidence derives from samples from the manuscript censuses of manufacturing for the census years 1850, 1860, 1870 and 1880 (Atack and Bateman1999). The samples are random and nationally representative of the universe of surviving manuscript schedules. Each contains several thousand establishments. The census enumerators were directed to obtain information through personal inquiry of cognizant parties. The data pertain to economic activities from June of the year prior to the census through May of the census year.

The earlier censuses differed somewhat from the later ones in the wage and employment information they collected. In 1850 and 1860 data were collected on the average total monthly wages paid to male and female labor, and on the average number of male and female workers employed. A defensible reading of the instructions to census enumerators is that "average" means "during a "typical" month, where "typical" can be interpreted in "full-time equivalent" (FTE) terms.

Beginning in 1870 the question on monthly wages was replaced by a question on the total annual wage bill; employees were classified into adult males (over age 16), females (over age15), and children of both sexes; and the number of full-time equivalent months of operation was reported. In 1880 questions were added about the average daily wage of skilled and unskilled labor (see section 4) and a more complex set on months of operation which can be used to estimated full-time equivalent months (see below). An important limitation of all of our data – indeed, of all extant

nineteenth century establishment-level data on manufacturing – is that they do not distinguish between production and non-production workers (but see below).

Given the limitations of the information reported in the 1850 and 1860 censuses did not report months of full-time operation, we focus our attention on the average monthly establishment wage. In 1850 and 1860 the monthly wage of the jth establishment ($w_{.j}$) is

$$w_{.j} = (\text{total monthly wages, male} + \text{total monthly wages, female})/(\text{total employees})$$

while in 1870 and 1880, the monthly wage is

$$w_{.j} = (\text{annual wage bill/full-time equivalent months of operation})/(\text{total employees})$$

Studies of wage inequality using twentieth century data impose restrictions on the full range of the estimated distribution of wages, essentially to minimize the impact of severe outliers on distributional statistics (Goldin and Margo 1992; Katz and Murphy 1992). We take a similar approach by "trimming"; specifically, we delete observations whose establishment wage puts them below the 1rst percentile or above the 99th percentile of the full distribution.[1] Wage values at these (extreme) percentiles are indicated in the notes in Table 1.

In addition to trimming, we imposed two other selection criteria. We deleted the small number of establishments located in the far western states, the majority of which were in California. In 1850 California was in the midst of the Gold Rush and there is good evidence that wages were temporarily very high, either by pre- or post-Gold Rush standards (Margo 2000). Second, we

deleted establishments for which real gross value of output (in 1850 dollars) fell below $500. In principle, such establishments were not to be enumerated, at least if the census instructions were followed to the letter. In practice, some were but, as we have no way of knowing if these were representative to not, we elected to delete those that were enumerated from each sample in an economically consistent way over time.

Panel A of Table 1 reports nominal values of the establishment wage at the 10^{th}, 50^{th}, and 90^{th} percentiles; the mean and standard deviation; the number of establishments and total employment, for each census year. Panel B shows the associated range statistics (for example, the ratio of wages at the 50^{th} to the 10^{th} percentile) and the coefficient of variation.. The various distributional statistics (for example, the mean) in the panels are employment-weighted; that is, each establishment is treated as the equivalent of N observations on individual workers, where each worker is paid the establishment wage. Thus, in particular, the coefficient of variation can be interpreted as the "between-group" component of overall wage inequality, where the grouping variable is the establishment.[2]

Whether measured by the coefficient of variation, or by the 90-10 ratio, overall inequality in the establishment wage distribution was clearly much higher in 1880 than in 1850. Although a slight increase in overall inequality took place during the 1850s, essentially all of the long-term rise occurred in the 1860s; overall inequality appears to have declined between 1870 and 1880. Examination of the 50-10 or 90-50 ratios confirms the existence of a sharp jump in inequality between 1860 and 1870 followed by decline in the 1870s, but these ratios also suggest that rising inequality below the median was already underway before the Civil War. Above the median (the 90-50 ratio) wage inequality was somewhat higher in 1880 than in 1850, but there was no apparent

upward trend prior to 1860.

Even allowing for the possibility of a prior upward trend in inequality below the median, the apparent "structural break" in the 1860s is obviously suggestive of a role for the Civil War. But it is also possible the break merely reflects changes in the definition of the wage variables (see above) or other changes in enumeration procedure that somehow make it more likely that the establishment wage would be more dispersed after the War than before. Although not all sources of systematic bias can be investigated, several of the more likely candidates can.

For example, it is evident upon inspection of the wage distributions that it was far more likely in 1850 or 1860 than in 1870 or 1880 for the establishment wage to be an exact integer, suggesting that the individual responding to the census had in mind a "round number" monthly wage (for example, $20.00 per month) per worker, rather than an actual average. Such heaping could, in principle, bias downward the standard deviation and thus the coefficient of variation. To address this issue, we rounded the establishment wage to the nearest integer in 1850 and again in 1880 and re-computed the distributional statistics. The results are shown in Panel A of Table 2. Because the 1850 data were already "heaped" to some extent, the rounding has little effect on the overall degree of inequality in that year. Artificially heaping the 1880 distribution by rounding does reduce inequality, but still leaves intact a much higher level in 1880 than in 1850, particularly below the median wage.

Our underlying samples were drawn randomly from the distribution of surviving manuscript records. For the most part, failures of survival appear to have been random – some records, for example, were destroyed by accident or lost prior to be transferred to government archives. However, in one important way in 1880, survival was clearly non-random: certain industries in 1880

were supposed to be canvassed by "special agents" rather than by regular census enumerators. The agents were chosen for their knowledge of industry conditions, and it was thought (at the time) that such knowledge would improve the quality of enumeration. Unfortunately, the manuscript schedules collected by the agents have never been found, and are presumed lost (Delle Donne 1973). In practice, the distinction between "special agent" industries and other industries was not air-tight. Some firms that should have been enumerated by special agents were, in fact, enumerated by regular Census employees (and appear in our 1880 sample). However, there is no question that the "special agent" industries are under-represented in the 1880. Fortunately, the identities of the "special agent" industries are known, so it is possible to exclude establishments in the relevant SIC codes.[3]

Panel B of Table 1 retains the rounding imposed in Panel A, but excludes establishments in special agent industries in both 1850 and 1880. The number of excluded establishments in 1880 is, unfortunately, too small for reliable distributional analysis. However, for the non-special agent industries, it is clear that inequality was higher in 1880 than in 1850, again primarily below the median.

Although Table 1 attempts to control for severe measurement error by trimming, it could be argued that the trim is insufficient for 1880. As noted earlier, the 1880 census also reported the average daily wage of unskilled labor and the average daily wage of "mechanics". As an additional trim on the left tail of the distribution, we assume that no establishment in 1880 could have paid a monthly wage lower than $10.40, which equals 26 days (a full-time month) at $0.40 per day, the value at the first percentile of the distribution of the average daily unskilled wage. Analogously, we assume that no establishment in 1880 can pay more than $91 per day, which is 26 days at $3.50 per day, the 99th percentile of the distribution of the average daily mechanic wage. Imposing this trim

on the 1880 data, while retaining the restrictions in Panels A and B, produces the statistics in Panel C of Table 2. The additional trim dampens the increase in inequality, almost completely so above the median. However, the additional trimming does not change our substantive finding that inequality below the median was higher in 1880 than in 1850.

Our next sensitivity analysis is perhaps the most controversial and the most speculative. There is an unresolved debate among economic historians as to whether the labor input of establishment owners was included in the reported number of workers. For 1870 and 1880, the instructions to enumerators are silent on this issue. However, for 1850 and 1860 the instructions indicate that "average monthly wages" were to include, in effect, the imputed "wages" of the owner if the owner materially contributed to production To assure a meaningful monthly average, it would have been necessary in such cases to include the entrepreneur in the count of workers.

Circumstantial evidence that owners were so counted in 1850 compared with 1880 can be gleaned by examining the proportion of establishments that reported positive value added and either (a) reported zero employment or (b) reported zero wages. In 1850, only a minute fraction of such establishments fall into category (a) and (b) but, in 1880, nearly 5 percent do. Although this is not definitive evidence, it does suggest that owners were included, at least some of the time, in the numerator – total average monthly wages – and the denominator – total employment – in 1850, but probably not in 1880.

As a way of gauging whether the wage distribution in 1850 is affected by the inclusion of owners, we adjust the reported total monthly wage bill by subtracting the mean wage at one-worker establishments. Next, we subtract one from the count of workers, and recompute the average establishment wage. By design, this procedure deletes one-worker establishments from the 1850

sample. Obviously, the adjustment may be inadequate for establishments with more than one owner, but we have no way of knowing which establishments these were.

Panel D shows the results of imposing this adjustment for the labor input of owners in 1850, assuming as well the same restrictions imposed in Panels A through C. The adjustment for the labor input of owners reduces inequality above the median and raises it below the median, leaving overall inequality slightly higher in 1850. As a result the increase in overall inequality between 1850 and 1880 is dampened, and is more uniform throughout the distribution than in Panels A through C. However, the adjustment for the labor input of owners does not change our substantive conclusion that establishment wage inequality increased between 1850 and 1880. As measured by the coefficient of variation, overall inequality was about 20 percent higher in 1880 than in 1850, somewhat less if judged by the increase in the 90/10 ratio.

Our regression analysis (see below) makes use of the log of the establishment wage. The log of the establishment wage, however, is not the same as the geometric mean of the wages of individual workers in each establishment (except in establishments with a single worker). In Panel E we impose the same restrictions as in Panels A-D but substitute the log for the level. The same patterns are apparent in log wages as well as in levels: inequality was higher in 1880 than in 1850, more so below the median than above it. Moreover, the magnitudes of the changes in inequality are very similar: the coefficient of variation of the wage in levels increased by x percent between 1850 and 1880, compared with y percent for the standard deviation of the log wage.

3. Regression and Decomposition Analysis

The establishment wage can be written as a weighted average of the mean wages of workers grouped by skill. We have no direct information on worker characteristics consistently defined for all sample years. However, we do have information on a variety of establishment level characteristics that arguably are correlated with skill.

To make use of this information, we estimate log wage regressions of the standard form

$$\{\text{eq. 1}\}: \ln w = X\$ + ,$$

where the X's are a set of establishment level variables. Included in X are the dummy variables for the size of establishment, as measured by employment; dummies for location in the South Atlantic or South Central states; an urban dummy; a dummy variable indicating the use of steam power, and industry dummies measured at the 2-digit SIC level. Because it is clear from Table 1 that inequality in 1880 was higher than in 1850 (regardless of the trend in the 1870s), we estimate regressions for 1850 and 1880. The dependent variable, the log of the establishment wage, is defined as in Panel E of Table 2. The regressions fit the data reasonably well; however, the standard error of the regression was larger in magnitude in 1880 than in 1850, indicating an increase in residual wage varation.

In modern data the establishment wage is a positive function of establishment size. Although there are myriad causes of the positive relationship, at least a portion of it is due to skill – larger establishments are more skill intensive (Davis and Haltiwanger 19x). Over roughly the past three decades the returns to skill in the United States have increased substantially. Using the modern analogue to the data analyzed in this paper, Davis and Haltiwanger show that the rise in the returns

to skill is manifested in a steepening of the positive size-wage gradient over time.

It is debatable, however, whether the modern relationship should hold in the nineteenth century. The positive correlation between skill and size evident in modern data is at least partly due to the capital-skill complementarity. As a general characteristic of manufacturing, capital-skill complementarity is thought to have become common in the late nineteenth and early twentieth centuries (Goldin and Katz 1998). Rather, the prevailing view among economic historians is that industrialization in the mid-19th century was "deskilling". Early in the century production took place in small, artisan shops (Sokoloff 1982). Workers in these shops were highly skilled, and most labored from start to finish on a single product. Capital intensity was low, and few, if any, inanimate power sources were used.

Over time, manufacturing shifted away from artisan shops to factories. As Adam Smith so famously described, the factory system economized on skilled labor though division of labor and capital-labor substitution. Some skilled labor might be retained for finishing purposes, or to build and maintain equipment. But, in general, factories substituted unskilled labor – often, women and children – for skilled, and thus had a lower skill intensity – proportion skilled – than artisan shops.

Because the division of labor was "limited by the extent of the market" factories were larger in size than artisan shops. As long as there were no other factors causing wages to rise with establishment size, we might, therefore, expect to see a negative relationship between wages and size. And in fact, wages were a negative function of size in 1850. The relationship was monotonic and steep; conditional on the other factors in the regression, the average wage in establishments with 16-50 employees was 25 percent below the average wage in the smallest establishments. Moving from 16-50 employees to the largest size class – 250 or more employees – reduced the average wage

by another 27 percent.

But the firm size-wage relationship appears to have changed markedly between 1850 and 1880. In 1880 the relationship was essentially flat up to the largest size class, at which point the average wage declined. However, the gap in the average wage between the largest and smallest establishments in 1880 was about 14 percent, far smaller than the gap prevailing in 1850.

In 1850 the establishment wage was about 25 percent lower in the South Atlantic, holding other factors constant, than in the North, but there was no wage gap between the South Central States and the North. By 1880 a gap had opened up between the South Central states and the North, which is suggestive of a Civil War effect. However, while wages in 1880 in the South Atlantic were lower than in the North, the gap in 1880 was evidently smaller than in 1850.

As manufacturing evolved in the nineteenth century production shifted towards urban areas, a pattern clearly noticeable in our data (Kim 2000). The price of land was higher in urban locations; thus an urban location would have to confer a productivity advantage to offset higher non-labor costs. During the period most workers were constrained (by very high commuting costs) to living close by where they were employed. Thus workers in urban firms would typically face a higher cost of housing than rural workers. Consequently, nominal wages – the data that we are analyzing – would need to be higher in urban firms.[4] There is some evidence that the urban-rural wage gap was larger in 1880 than in 1850, although the difference between the coefficients was relatively small (about 5 percent).

The diffusion of the steam engine was another important aspect of the evolution of manufacturing after 1850. Steam-powered machinery required maintenance and there was also the possibility of industrial accidents. Controlling for other factors, steam-powered establishments paid

wages that were about 18 percent higher than non-steam powered establishments in 1850. In 1880, when steam power was more widely diffused, the wage premium had declined to approximately 6 percent, and was not statistically significant.

A notable features of manufacturing wages in the twentieth century is the existence and stability of inter-industry wage differentials (see the references in Allen 1995). To control for industry effects we included industry dummies measured at the 2-digit SIC level; in the interests of space the coefficients are not reported.[5] Several features of the coefficients of the worth noting. First, differences across industries were important; F-tests indicate that coefficients of the dummy variables were jointly significant in both years. Second, the coefficients of the dummies were positively correlated across the two years. Third, there is evidence of regression to the mean: industries that were high-wage in 1850 were less so in 1860 (conversely for low-wage industries). Fourth, inter-industry differentials declined somewhat between 1850 and 1880; weighted by employment, the standard deviation of the industry coefficients of was 0.089 in 1880, compared with 0.102 in 1850.

Simulated Wage Distributions

Following Juhn, Murphy, and Pierce (1993; see also Katz and Murphy 1992, and Goldin and Margo 1992) we use the regression results to compute simulated wage distributions. We rewrite the regression as follows

$$\{\text{eq. } 2\}: \ln W = X\$ + F8$$

where θ is the standardized residual (= , /σ). Loosely speaking, we think of β and σ as the wage "structure". That is, conditional on a value of X -- the establishment's observable characteristics -- and a value of θ – the establishment's position in the residual distribution – ln w can be recovered if β and σ are known.

We use the coefficients to compute decompositions of the changes in the range statistics between 1850 and 1880. We first compute ln w*

$$\ln w^* = X_{1850}\beta_{1880} + \sigma_{1850}\theta_{1850}$$

Difference between the range statistics of ln w_{1850} and ln w* reflects the impact of changes in the regression coefficients – the β's – on the change in wage inequality between 1850 and 1880.

Next, we compute ln w**

$$\ln w^{**} = X_{1850}\beta_{1880} + \sigma_{1880}\theta_{1850}$$

The difference between the range statistics of ln w* and ln w** reflect the impact of changes in σ, the standard error of the regression.

Lastly, the difference in the range statistics of ln w_{1880} and ln w** reflect changes over time in the distribution of establishment characteristics X, along with the mapping between X and an establishment's position in the residual distribution. Again following Juhn, Murphy, and Pierce

(1993), and loosely speaking, we think of such changes in the distribution of the X's as "quantity" changes..

As just described the simulation treats 1850 as the base year. However, the simulation can just as readily be computed in reverse – that is, treating 1880 as the base year. Because neither is theoretically "correct", we present the results of both calculations in Table 4.

The basic finding in Table 4 is that changes in the regression coefficients led to a reduction in overall wage inequality, as measured by the 90-10 range statistic, between 1850 and 1880. Chief among these was the flattening of the size-wage gradient and the narrowing of inter-industry differences. The increase in overall inequality occurred because the distribution of measured establishment characteristics changed in ways that made wages more unequal, and because unexplained variation in establishment wages increased.

4.0 Discussion

During the second half of the 19th century the United States experienced substantial growth economic growth, in both aggregate and per capita terms. Labor productivity rose, and a pronounced shift of labor out of agriculture occurred. In particular, manufacturing's share of the labor force increased from approximately 14 percent in 1850 to 20 percent in 1900; indeed, fully 34 percent of all non-farm labor was employed in manufacturing at the start of the 20th century.[6] Although data problems make it is difficult to provide a precise estimate of the aggregate growth rate over any long interval, few (if any) economic historians would dispute the claim that, on average, real wages of manufacturing workers were substantially higher in 1880 than in 1820, when the American economy

first began to industrialize (Williamson and Lindert 1980; Sokoloff and Villaflor 1992).

While it may seem obvious (at least to economic historians) that the average American worker in the 19th century was (in real wage terms) made "better off" by the growth of manufacturing, the impact of such developments on the wage structure is far from obvious. We find that the dispersion of establishment wages in manufacturing increased substantially between 1850 and 1880. The rise in wage inequality did not occur primarily because of changes in the relationships between the establishment wages and establishment characteristics such as capital intensity or the use of steam power which, we claimed (and provide some evidence for in the Appendix) were proxies for the skill composition of establishment workforces – that is, our results provide no evidence that the "skill differential" in manufacturing rose over the period.[7] However, as we noted earlier, movements in the skill differential – as captured by changes in the regression coefficients -- do not adequately summarize the structure of establishment wages over the 1850 to 1880 period, because residual wage inequality increased.[8] By its very nature it is difficult to explain why residual wage inequality rose. Certainly, it is possible that the rise in residual inequality represents a rise in the returns to skills embodied in workers not proxied by the independent variables in the regression.[9] In any event, it is clear from our results that, overall, changes in the wage structure do not account for the rise in establishment wage inequality between 1850 and 1880.

As manufacturing evolved after 1850, the share of employment in large establishments increased. Our decompositions demonstrate that the growing concentration of employment in large establishments was a major factor in the rise in inequality in the establishment wage. These were precisely the establishments that were substituting operatives for skilled artisans, in the process of implementing production technologies that emphasized division of labor and which made increasing

use of steam power and complex machinery. The former – division of labor – increased the share of the manufacturing workforce that was unskilled compared with the artisan shop, while the latter boosted the demand for skilled labor of various sorts – engineers, machinists, and a variety of other specialized technical occupations. Our results show that, in terms of the distribution of establishment wages, the compositional effects of size via division of labor – "de-skilling" – dominated, producing a rise in wage dispersion across establishments.

Our data on wage inequality, we reiterate, pertain to establishment wages, not to individual workers. The rise in wage inequality documented in this paper need not have translated into a rising inequality across individuals manufacturing workers, if wage inequality within establishments declined while wage inequality across establishments was on the rise. Unfortunately, we know of little hard evidence on this issue; nor is it likely that anything other than scattered archival sources could be found for the 1850 to 1880 period. However, while employment was becoming increasingly concentrated in large establishments, the median size establishment was still very small in 1880 (3 employees). Thus, if within-establishment inequality declined to a sufficient degree to offset the rise across establishments, the decline would have to have been concentrated in large establishments to be economically meaningful. But these were the establishments which had carried division-of-labor to its logical conclusion, subdividing tasks to a fine degree and reducing their dependence on skilled artisans. Because this process was an ongoing one it is not likely that wage differentials within establishments declined between 1850 and 1880; indeed, if anything it is more likely that such differentials were increasing.

It is always perilous to draw economy-wide inferences from sectoral data – doubly so, in our case because much of the labor force in the United States between 1850 and 1880 was engaged in

agriculture, either self-employed or otherwise not working for wages. Two points, however, can be made. First, workers who were self-employed in agriculture may have worked for wages in other sectors, such as manufacturing, during seasonal lulls in agricultural production. Certainly, there is little evidence of significant wage gaps between agriculture and other sectors, controlling for location and worker characteristics (Williamson and Lindert 1980). Second, for other periods in American history there is an impressive degree of co-movement between series on individual earnings inequality and the sort of data analyzed in this paper. Allen (1995) has shown that the time-series behavior of the coefficient of variation of average annual earnings across two-digit industries closely mimics measures of overall earnings inequality: good examples include the 1940s, when both the across-industry coefficient of variation and overall earnings inequality declined sharply, and the post-1970 period of rising wage inequality.

If the rise in wage inequality across manufacturing establishments is symptomatic of a more broadly based rise in wage inequality, the decomposition suggests that the fundamental source would have been an increase in the economy-wide proportion of workers who were "unskilled". Unfortunately, because of limitations of census evidence on occupations, it is not possible to produce, in a fully consistent manner, national estimates of the proportion of the labor force that was unskilled in 1850 compared with 1880. However, it is possible to produce estimates for adult white males. Table 5 shows estimates derived from the IPUMS (integrated public use microdata) samples of the 1850 and 1880 federal censuses, using two definitions of unskilled, one narrow and the other somewhat broader. These estimates are consistent with the hypothesis that, between 1850 and 1880, the share of the labor force that was unskilled increased.

After 1880 manufacturing plants grew ever larger in size, as continuous process production

methods started to diffuse in earnest (Nelson 1975; Chandler 1977). Later, electricity began to replace steam as the inanimate power source of choice. According to Goldin and Katz (1998), these changes boosted the relative demand for skilled labor and, by themselves, would have substantially increased the skill differential in manufacturing above the level prevailing at the end of the 19th century. However, the so-called "high school movement" intervened. Rapid growth in educational attainment associated with the movement greatly expanded the relative supply of educated labor. Many of the newly minted graduates entered the "glamour" manufacturing industries of the day, which had much higher skill requirements than old line industries of the first industrial revolution. However, the increase in relative supply was so great that the returns to skill were bid down and, accordingly, the 90-10 range in wages among manufacturing workers fell sharply after the turn of the century, as did the range of inequality in establishment wages (Williamson and Lindert 1980; Goldin and Katz 1999; Brissenden 1929).

5. Concluding Remarks

The 19th century is largely uncharted territory in the history of wage inequality in the United States.. Previous work has focused almost exclusively on movements in skill differentials, the ratio of skilled to unskilled wages (Williamson and Lindert, 1980; Margo 2000). By contrast, this paper has examined the dispersion in wages across manufacturing establishments between 1850 and 1880. We find that this dispersion increased substantially during this period, primarily because of an increasing share of employment in large establishments, which paid lower than average wages, rather than changes in the structure of wages across establishments. As such, this paper provides the first

quantitative evidence that we are aware of that "de-skilling", as labor historians call it, altered the distribution of wages in 19th century manufacturing.

This work could be extended in two directions. First, we have suggested that the trends in inequality in manufacturing uncovered in this paper may be representative of the economy as a whole. Although such a claim has a basis in parallel patterns found in later periods, as well as some evidence on changes over the period in the skill composition of the labor force, direct evidence for sectors other than manufacturing would clearly be useful. Second, we have emphasized the purely economic implications of our findings in this paper. However, the post-1880 period witnessed rapid growth in labor strife, culminating in rising rates of unionization. Large establishments were frequently the targets of strikes, shutdowns, and other forms of labor activism. The results of this paper suggest that this was no accident, because the growth of large establishments fueled growing wage inequality within manufacturing. But the precise links between the findings of this paper and the political economy of the labor movement in the late 19th century remain to be investigated.

References

Allen, Steven G. 1995. "Updated Notes on the Inter-industry Wage Structure, 1890-1990," Industrial and Labor Relations Review 48 (January): 305-320.

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 (Fall): 177-188.

Atack, Jeremy, Fred Bateman, and Robert A. Margo. 2002. "Skill Intensity in Late Nineteenth Century Manufacturing: Evidence from the 1880 Census," unpublished paper, Department of Economics, Vanderbilt University, July.

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: A Volume to Honor Robert W. Fogel, pp. 159-187. Chicago: University of Chicago Press.

Brissenden, Paul F. 1929. Earnings of Factory Workers, 1899-1927: An Analysis of Pay-Roll Statistics. Washington: Government Printing Office.

Brown, Charles and James Medoff. 1989. "The Employer Size-Wage Effect," Journal of Political Economy 97 (October): 1027-1059.

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

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

Coehlo, Phillip and James Shepherd. 1976. "Regional Differences in Real Wages: The United States, 1851-1880". Explorations in Economic History 13 (April): 203-30.

Davis, Steve J. and John Haltiwanger. 1991. "Wage Dispersion Between and Within U.S. Manufacturing Plants, 1963-86" Brookings Papers on Economic Activity: Microeconomics 1991: 115-180.

Engerman, Stanley and Claudia Goldin. 1993. "Seasonality in Nineteenth Century Labor Markets," in D.Schaefer and T. Weiss, eds. Economic Development in Historical Perspective. Stanford, CA: Stanford University Press.

Gerber, James. 1997. "Agricultural Expansion During the Gold Rush: California Grain Farming as a 'Booming' Lagging Sector." Unpublished paper, Department of Economics, San Diego State University.

Goldin, Claudia. 1990. Understanding the Gender Gap: An Economic History of American Women. New York: Oxford University Press.

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

Goldin, Claudia and Lawrence Katz. 1999. "The Returns to Skill in the United States Across the Twentieth Century," National Bureau of Economic Research Working Paper No. 7126, May, Cambridge, MA.

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

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

(December): 741-774.

Goldin, Claudia and Kenneth Sokoloff. 1984. "The Relative Productivity Hypothesis of Industrialization," Quarterly Journal of Economics 99 (August): 461-88.

Habbakuk, H.J. 1962. American and British Technology in the Nineteenth Century. Cambridge: Cambridge University Press.

Hunter, Louis C. 1979. A History of Industrial Power in the United States, 1780-1930. Volumes 1 and 2. Charlottesville, Virginia: University Press of Virginia.

Juhn, Chinhui, Kevin M. Murphy, and Brooks Pierce. 1993. "Wage Inequality and the Rise in the Returns to Skill," Journal of Political Economy 101 (June): 385-409.

Katz, Lawrence and Kevin Murphy. 1992. "Changes in Relative Wages, 1963-1987: Supply and Demand Factors," Quarterly Journal of Economics 107 (February): 35-78.

Kim, Sukkoo. 2000. "Urban Development in the United States, 1690-1990." Southern Economic Journal 66 (April): 855-880.

Lebergott, Stanley. 1964. Manpower in Economic Growth: The American Record Since 1800. New York: McGraw-Hill.

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

Nelson, Daniel. 1975. Managers and Workers: Origins of the New Factory System in the United States, 1880-1920. Madison, WS: The University of Wisconsin Press.

Rosenbloom, Joshua. 1996. "Was There a National Labor Market at the End of the Nineteenth Century? New Evidence on Earnings in Manufacturing," Journal of Economic History 56 (September): 626-656.

Sokoloff, Kenneth. 1984. "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 (October): 329-350.

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

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

Table 1: Wage Inequality Across Manufacturing Establishments, 1850 and 1880: Log of Monthly Establishment Wage

Panel A: 1 Percent Trim

	1850	1860	1870	1880	) 1880-1850
50-10	0.603	0.707	0.996	0.899	0.296
90-50	0.500	0.405	0.613	0.560	0.060
90-10	1.103	1.112	1.609	1.459	0.356
F	0.447	0.471	0.649	0.579	0.132

Panel B: 5 Percent Trim

	1850	1860	1870	1880	) 1880-1850
50-10	0.475	0.568	0.739	0.898	0.423
90-50	0.405	0.316	0.545	0.488	0.083
90-10	0.880	0.884	1.284	1.386	0.506
F	0.312	0.309	0.508	0.513	0.200

Source: Atack and Bateman (1999) samples of manuscript censuses of manufacturing; see text.

50-10, 90-50, 90-10: range statistics, for example, 50-10 is the difference the value of the log wage at the 50^{th} and 10^{th} percentiles

Observations are weighted by employment.

In Panel A, establishments outside the 1rst and 99^{th} percentiles of the full distribution of the establishment wage are deleted. In Panel B, establishments outside the 5^{th} and 95^{th} percentiles of the full distribution of the establishment wage are deleted.

Table 2: Wage Regressions: 1850 and 1880

	1850		1880	
	$	t-statistic	$	t-statistic
Constant	2.174	43.918	2.387	22.070
Size	0.059	4.661	0.159	12.159
$Size^2 \times 10^{-1}$	-0.147	-7.875	-0.240	-14.929
% women	-0.527	-17.842	-0.440	-14.218
ln (capital/labor)	0.106	20.532	0.090	15.315
Steam power?	0.142	9.023	0.077	5.357
Urban	0.181	10.253	0.210	14.197
Midwest	-0.036	-2.444	0.054	3.776
South Atlantic	-0.329	-18.407	-0.197	-8.680
South Central	-0.093	-4.027	-0.110	-3.070
West	1.414	22.107	0.244	6.851
N	5,036		6,346	
Adjusted R^2	0.514		0.325	
F	0.342		0.458	

Dependent variable is the natural logarithm of the monthly establishment wage; see text. Observations are weighted by employment. Size= log (employment). Regressions include 18 industry dummies coded at the 2-digit SIC level (see Atack and Bateman 1999 and footnote x). N: number of establishments.

Table 3: Decomposition of Change in Wage Inequality, 1850-1880

A. The Change in the 90-10 Range Statistic: Log of the Establishment Wage

	Value
Total Change, 1850 to 1880	0.310
Due to regression coefficients	-0.118
Due to standard deviation	0.156
Remainder (independent variables and standardized residuals)	0.272

B. The Role of Establishment Size: Explaining the Rise in the 9-1 Wage Gap

Total Change, 1850 to 1880	0.219
Change in 9-1 gap in:	
Size	-1.559
Size squared	-17.572
$\$_{1880}$ ( ) X_{1880} -) X_{1850})	0.177

Notes:

Panel A: see text for description of terms in the decomposition

Panel B: $\$_{1880}$ ( ) X_{1880} -) X_{1850}) = 0.159 x (-1.559) - 0.0240 x (-17.572) = 0.177. Change in 9-1 gap in size and size squared: the change between 1850 and 1880 in the difference in the mean values of size and size squared of establishments in the 9th and 1rst deciles of the distribution of establishment wages.

Table 4: Aggregate Estimates of the Proportion Unskilled: White Males, Ages 20-60, in 1850 and 1880

Definition of "Unskilled"	1850	1880
Narrow	0.142	0.194
Broad	0.163	0.244

Source: IPUMS samples for 1850 and 1880. The narrow definition of unskilled includes only individuals who reported occupations of agricultural laborer, laborer (not elsewhere classified), or operative in manufacturing establishment (not elsewhere classified). The broader definition includes herders, teamsters, janitors, and individuals enumerated as manufacturing operatives in a specific industry (a list is available from Robert Margo on request).

Notes

1. The need to remove outliers was also noted by Census Bureau in its 1929 study: "[t]hese extreme items are not only unrepresentative cases; they are to a certain extent spurious cases, representing perhaps establishments having only one or two employees, and in operation for, possibly, only a week or two during the year" (Brissendon 1929, p. 40).

2. To see this point, for example, in the case of the variance, let w_{ij} = wage of the ith worker in the jth establishment, n_j = number of workers in the jth establishment, and K = number of establishments. The variance of w_{ij}, is

$$\text{Var}\,(w_{ij}) = \sum_{j}^{K} \sum_{i}^{n_j} (w_{ij} - w_{..})^2/N$$

where $N = \sum n_j$, the number of workers, and the "." notation indicates the sample mean taken over the i or j subscripts – or both simultaneously, the grand mean, the weighted average of the establishment-level means. The variance can be decomposed:

$$\text{Var}\,(w_{ij}) = \text{within establishments} + \sum n_j(w_{.j} - w_{..})^2/N$$

It is the second term, the weighted variance across establishments, that can be studied with the data at hand.

3. The three-digit SIC codes of the "special agent" industries are silk and cottons (SIC 221, 222, 223, 225, 227, 228, and 229), coke (SIC 492 and 331), glass (SIC 321), ship-building (SIC 373), and distilleries and breweries (SIC 208).

4. An urban wage advantage could also arise if the average worker at urban establishments was more skilled than at rural establishments; see, however, section 3.3, where we present evidence for 1880 that differences in skill intensity between urban and rural establishments were statistically insignificant.

5. An appendix containing the coefficients is available on request from Robert Margo.

6. Computed from Lebergott (1966, p. 510). Recent revisions to Lebergott's estimates by Weiss (1992) would alter these figures somewhat but would not reverse the basic trend.

7. Because our 1880 sample reports the average daily wage of mechanics and common laborers, we can also estimate the skill premium (mechanics relative to common labor) in manufacturing in 1880. Our estimate is 1.73, very close to Williamson and Lindert's (1980) However, the data used by Williamson and Lindert give inadequate coverage to establishments located outside the

Northeast before the Civil War. Margo (2000, ch. 3) has recently produced regional estimates of daily wages of common labor and skilled artisans for the 1850 census year; while these do not pertain to manufacturing per se, their geographic coverage is far superior to the data used by Williamson and Lindert. If Margo's regional estimates of the skill differential (artisan-to-common labor) are weighted by the regional shares of manufacturing employment found in our 1850 sample, the estimate of the aggregate skill differential is 1.68, slightly (3 percent) below our estimate for 1880. For this calculation we formed regional estimates of the skill differential using Margo's wage estimates for 1849 (which, in principle, correspond to the 1850 census year); see Margo (2000, Tables 3A.5-6). In computing the regional employment shares for the 1850 census year, we exclude the very small proportion of establishments located in the far West.

8. Our finding that the "between" component of establishment wages (the regression coefficients) declined between 1850 and 1880 while the "within" component (residual inequality) is reminiscent of Juhn, Murphy, and Pierce's (1993) very similar result for the 1970s, which also witnessed declines in between-group wage inequality and rises in within-group wage inequality. Juhn, Murphy, and Pierce interpret their result as evidence that a uni-dimensional (or "single index") model of skill cannot adequately describe wage variation in the 1970s.

9. It is also possible (and difficult to refute) that, for example, the marginal impact of capital intensity on skill composition was smaller in 1880 than in 1850, but the skill differential was higher, such that the marginal impact of capital intensity on wages was the same. Our wage regression would not register any change in the capital intensity coefficient; however, to the extent that the residual captures unmeasured variation in skill composition, the rise in the skill differential would show up as a rise in the standard deviation, that is, in residual wage inequality.