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Rising Wage Dispersion Across American Manufacturing Firms, 1850 to 1880

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1. Introduction

The growth of manufacturing was a key feature of American economic development in the 19th century. In 1810, when the first attempt to enumerate the sector took place, approximately 3.2 percent of the total labor force (19.7 percent of the non-farm labor force) was engaged in manufacturing. By mid-century, manufacturing's share of the labor force had risen to 14.5 percent, and to 32.2 percent of the non-farm labor force. At the end of the 19th century fully one in five of all persons in the labor force worked in manufacturing, while the proportion of the non-farm labor force increased further to approximately 34 percent.¹

The growth of manufacturing was accompanied by fundamental changes in the nature of production. Early in the century most manufacturing took place in artisan shops, where individual journeyman fashioned custom articles from start to finish under the watchful eyes of a master craftsman. With little physical capital other than hand tools and the building in which production took place, artisan shops were highly intensive in the use of skilled labor. Over time the artisan shop was displaced by the factory system. The factory system economized on the relative use of artisans, by dividing up tasks – “division of labor” – into fine enough detail so that each could be performed by less skilled workers -- literally the origin of *manufactory*. With some notable exceptions (such as Waltham Mills), these early factories were neither highly capital intensive nor required the intensive use of inanimate sources of energy, such as steam power. For both reasons, the economies of scale achieved by simple division of labor were exhausted with relatively small numbers of workers.² Eventually, the development of new technologies led to a further evolution of manufacturing in which the division of labor became more acute and firms increased in size, capital intensity, and their use of inanimate sources of energy, steam power in particular.³

The implications of these changes in the nature of manufacturing for average labor productivity, and hence real wages, have long been recognized by economic historians. Research by Kenneth Sokoloff, Jeremy Atack, among many others, suggests that the displacement of the artisan shop, particularly by the powered factory, substantially raised the average level of labor productivity in manufacturing.⁴ Although data problems make it difficult to provide a reliable estimate of the aggregate growth rate over any long interval at this time, it is clear that, on average, real wages of manufacturing workers were higher in 1880 than, say, in 1820.⁵

Although it seems clear that, on average, manufacturing workers were “better off” in terms of real wages at the end of the 19th century, the evidence also suggests that wages were far from equally distributed. In the furniture industry, for example, workers at the 90th percentile of the distribution of hourly wages were paid 285 percent more per hour than workers at the 10th percentile. In the tobacco industry, the corresponding ratio was 311 percent.⁶ In contrast to the growth of real wages, the connections, if any, between the evolution of production methods in manufacturing just described and the degree of wage inequality in the sector at the end of the 19th century, are less well understood.

This paper analyses changes in the dispersion of wages across manufacturing firms between 1850 and 1880 using firm-level data drawn from the manuscript censuses of manufacturing. Although the data we examine are not individual-level per se -- in the sense that they refer to aggregations of workers employed by individual firms, not to the individual workers themselves -- we believe that changes in their dispersion provides important insights into how the evolution of production methods affected wage inequality in manufacturing by the end of the century.

Our central finding is that the degree of dispersion in average wages across manufacturing

establishments increased substantially between 1850 and 1880. The majority of the increase occurred below the median wage, and most of that can be attributed to the rising share of employment in large firms. Other features of the development of manufacturing, notably increased capital intensity, the use of steam power, and urbanization, were associated with higher than average wages. In addition, we present circumstantial evidence that the Civil War disrupted the process of regional labor market integration in manufacturing, although the War's impact appears to have been limited largely to small and medium size firms, and was partially reversed in the 1870s.

The growing concentration of manufacturing employment in large firms signaled a rise in the demand for unskilled labor relative to skilled labor. If the supply of unskilled labor to the manufacturing sector were upward sloping (and not shifting outwards or inwards), the increase in relative demand would have bid down the skill differential -- that is, the ratio of skilled to unskilled wages should have fallen. However, we find little evidence that skill differentials in manufacturing declined in the second half of the 19th century -- rather, the evidence suggests either stability or perhaps a modest increase in skill differentials.

It is important to stress the limited nature of our argument. Much evidence exists that manufacturing workers in the late 19th and early 20th centuries differed in their productivity at the individual level, and that the labor market rewarded (or penalized) these differences.⁷ Similarly, skills and higher productivity were rewarded within the world of the artisan shop. Master artisans, for example, were far better paid than experienced craftsmen, who themselves earned a premium over apprentices or newly-minted journeymen. Our argument glosses over these -- and many other -- sources of wage dispersion across individuals, focusing instead on how the evolution of organizational form influenced the broad distribution of manufacturing workers with respect to

skill and, hence, the distribution of their wages. Simply put, we are claiming that this evolution produced a manufacturing labor force in the late 19th century that, for the most part, was much less skilled compared with its artisan shop counterpart and, therefore, low-wage, when compared (contemporaneously) with skilled labor.

2. Evidence on the Distribution of Wages Across Manufacturing Firms

Our evidence derives from samples from the manuscript censuses of manufacturing for the years 1850 through 1880.⁸ The samples are random and nationally representative of the universe of surviving manuscript schedules. Each contains several thousand firms. The census enumerators were directed to obtain a wide variety information through personal inquiry of cognizant parties including the value of real and personal estate invested in each enterprise; the labor employed and wages paid; the values of inputs and outputs; the type of power used; and, after 1860, the months of operation. The data pertain to firm-level activities from June of the year prior to the census through May of the census year.

The censuses differed in the wage and employment information they collected. In 1850 and 1860 data were collected on the total monthly wages paid to male and female labor, and the number of male and female workers employed. Beginning in 1870 the question on monthly wages was dispensed with, and replaced by a question on the total annual wage bill; employees were classified into adult males (over age 16), females (over age 15), and children of both sexes; and (as noted earlier) the number of months the firm was in 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 regarding hours and months of operation.

Our analysis is conducted primarily in terms of average monthly wages at the level of the firm. In 1850 and 1860, the average monthly wage of the j th firm (w_j) is

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

while in 1870 and 1880, the average monthly wage is

$$w_j = (\text{annual wage bill} / \text{total months of operation}) / (\text{total employees})$$

Studies of wage inequality using post-1940 data typically impose restrictions on the support of the distribution of wages.⁹ Very low wage observations are deleted as outliers while, motivated partly by concerns of privacy, very high-wage observations have been “top-coded”.¹⁰ We have followed similar procedures by imposing lower and upper bounds although, in both cases, our motivation is to minimize the impact of outliers. These upper and lower bounds are indicated in the notes in Table 1 and are maintained throughout the analysis.

Our analysis is conducted in terms of weighted measures of the dispersion of the logarithm of w_j , where the weight is the number of workers employed by the firm, as reported in the census. We can interpret such measures in terms of the dispersion of manufacturing wages at the level of individual workers as the “between-group” component of the total dispersion, where the firm is the group. Equivalently, we are replacing each worker’s wage with the firm average, and then computing the measure of dispersion.¹¹

The analysis in this paper focuses on range statistics -- in particular, the difference in (log) wages between the 10th and 50th percentiles, or between the 50th and 90th percentiles, and their

composite (the 90-10 range). For similar work in this area, an increase in any of these statistics is taken to indicate a rise in wage dispersion. We use range statistics because changes in them over time can be readily decomposed into “price” and “quantity” components deriving from regression analysis (see section 3). Estimates of the range statistics for each of the samples are shown in Panel A of Table 1.

Panel A of Table 1 suggests that a rise in wage dispersion across manufacturing firms took place between 1850 and 1880. Wage inequality increased in every decade over this period; in terms of the 90-10 range, the increase in the 1870s was about twice as large as the increases in the preceding decades. In the 1850s and 1870s dispersion increased below the median, but declined above the median, while in the 1860s the reverse was true. The magnitudes of these changes were such that, when comparing 1850 with 1880, most of the increase in the 90-10 range occurred in the bottom half of the distribution: that is, the 50-10 range increased by 0.34 in log terms (approximately 40 percent) compared with a more modest increase (about 0.05, in logs, or 5 percent) in the upper half (90-50 range) of the distribution (see Panel B).

Comparisons of the magnitudes of change over time in Panel A with other known episodes of inequality change in American history are impossible to draw precisely because other relevant episodes have been documented at the level of individual workers, not firm-level averages. Nevertheless, such comparisons do suggest that the changes in wage dispersion documented in this paper are impressive.¹²

The data in Panel A are not “controlled” for in any way – that is, we do not adjust for any factors at the firm level that might have affected the distribution of wages, such as location, capital intensity, or use of steam power. We will return to this issue in Section 3. For the moment, however, we focus on another issue: could the rise in dispersion be a statistical artifact? As already noted, the

samples we analyze are random in design, so that is not the force of objection. Rather, the issue is whether changes over time in enumeration procedures may be responsible for the rise in dispersion.

Unfortunately for economic historians the 19th century manufacturing censuses were far from consistently enumerated over time; worse, not all of the inconsistencies can be quantified or even identified. We can, however, examine certain sources of bias. For example, one possibility concerns the change, noted earlier, in the definition of the monthly wage; recall that, in 1850 and 1860, the monthly wage bill was reported for male and female employees but not months of operation, while in 1870 and 1880, the total annual wage bill and months of operation were reported. The shift in reporting would not affect the measurement of changes in inequality during the 1850s or the 1870s, because the data are consistently measured in both pair-wise census-year comparisons – and, as evidenced in Table 1, inequality rose in both of these decades. However, visual inspection of the pre-1870 wage distributions reveals a greater tendency towards heaping on integer values compared with the 1870 or 1880 distributions. Such heaping will bias the standard deviation downward and thus potentially overstate the rise in wage inequality in the 1860s (since the 1860 and 1870 censuses bracket the change in reporting). We adjusted for the change in reporting by computing an artificial distribution in 1870 in which the estimate of the average monthly wage were rounded up or down to the nearest integer value. Compared with the actual 1870 distribution, the artificial distribution shows greater heaping and is less dispersed as we expected. However, the artificial distribution still shows greater wage dispersion when compared with the 1860 distribution. Consequently, we believe that the increase in wage inequality in the 1860s is a real historical phenomenon, not an artifact of changes in reporting procedures.

Another possible bias concerns changes in the likelihood that very small firms would be enumerated. In particular, the censuses of 1850 and 1860 required that firms produce at least \$500 in

output to be enumerated. However, the distinction between the gross value of output (including the value of raw materials) versus net value (value-added) was not made clear in the instructions to enumerators. The instructions were clarified in 1870 so as to include firms that produced at least \$500 of gross output.

The import of this change in enumeration procedure on the probability that firms would be enumerated is far from obvious. However, because the lower bound – \$500 – was expressed in nominal terms, it is possible that changes in the price level (or in relative output prices across firms) after 1850 altered the likelihood of enumeration of very low-output firms. If such firms paid wages that systematically differed from other firms, it is possible that the trends that we observe in wage dispersion might be biased. Unfortunately, we do not know exactly where “\$500” was in the true distribution of output in 1850. In what we believe to be a (very) conservative gesture, we deleted firms in the bottom 30 percent of the distribution of output, measured in gross terms (that is, including the value of raw materials), for each census year beginning in 1860.¹³ Range statistics from these truncated samples are shown in Panel C of Table 1. Deleting low-output firms has no effect on the change in the 90-50 range between 1850 and 1880, but dampens the increase in the 90-10 range between 1860 and 1870, and also slightly in the 50-10 range between 1850 and 1880. However, these changes are minor: the basic findings regarding inequality change are the same as in Panel A. Although further work would be most useful, we conclude, tentatively, that the rise in wage dispersion shown in Table 1 is a real historical phenomenon, not just an artefact of changes in census enumeration procedures or sample selection biases.¹⁴

3. Regression and Decomposition Analysis

We have documented that a rise in inequality in average wages across manufacturing firms occurred between 1850 and 1880. In order to understand the underlying sources of the change in wage inequality we compute decompositions based on log wage regressions.¹⁵

As a point of departure, imagine that the log wage in the base year, say 1850, can be written

$$\ln w_{it} = X_{it}\beta_t + \sigma_t\delta_t(X_{it})$$

where $\delta_t(\cdot)$ is the standardized regression residual in year t and σ is the standard deviation of the regression residuals.¹⁶ We compute

$$\ln w^*_{it} = X_{it}\beta_{t+1} + \sigma_t\delta_t$$

The difference between $\ln w$ and $\ln w^*$ is that the latter is computed using the regression coefficients from year $t+1$ rather than year t . Next we compute

$$\ln w^{**}_{it} = X_{it}\beta_{t+1} + \sigma_{t+1}\delta_t$$

The difference between $\ln w^*$ and $\ln w^{**}$ is due solely to σ_{t+1} , the standard error of the regression in year $t+1$.

Now consider the distributions of $\ln w_t$, $\ln w^*$, $\ln w^{**}$, and $\ln w_{t+1}$ – in particular, their range statistics (10-50 and 50-90). Differences between the range statistics of the distributions of $\ln w_t$ and $\ln w^*$ reflect the impact of changes over time in the regression coefficients; we refer to this as the

“prices” component of the decomposition. Differences between the range statistics of $\ln w^{**}$ and $\ln w_{t+1}$ capture the effects of changes over time in the distribution of the independent variables; we refer to this as the “quantities” component. For example, holding constant the relationship between firm size and the average wage, if the distribution of firm sizes became more unequal, wage dispersion would increase, and the decomposition would attribute the increase to the “quantities” term.

Finally, differences between the range statistics of $\ln w^*$ and $\ln w^{**}$ reflect the impact of changes over time in σ , the standard deviation of the regression residuals, which we call the “residual” component. If σ increases over time then, for any given position in the residual distribution the “distance” between that position and the median will have increased. Thus, for example, if a firm’s wage, controlling for X , puts it at the 30th percentile of the residual distribution, compared with another firm located at the 70th percentile of the residual distribution, an increase in σ will produce an increase in the difference between the wages of the two firms; conversely, for a decrease in σ .

As just described, the decomposition is computed from the base year – in this case, 1850. However, the decomposition could just as well have been computed “backwards”, that is, letting the terminal year be the base year – in which case, the computation of the different components would be done in reverse. As it happens, our substantive findings are not affected by the ordering of the decomposition, and thus we only report results going “forward” in time (for example, 1850 as the base year in a 1850-80 decomposition).

Firm Size

We begin by examining the relationship between the average wage and firm size, as measured

by the number of workers. The relationship between firm size and wages need not be a simple one.

As our earlier narrative suggested, scale (in terms of numbers of workers) was not necessarily independent of industry, capital intensity, or power type, any of which may have potentially affected the average wage, and there is some evidence that a wage premium was necessary to compensate workers for various disamenities of factory employment.¹⁷ Nevertheless, if division of labor was the dominant factor behind the growth of firm size, the (simple) correlation between firm size and the average wage should be negative.

To investigate this possibility we estimated univariate regressions of the log of the average wage on the log of the number of workers.¹⁸ As in Table 1, firms are weighted by the number of workers.¹⁹ The results are shown in Table 2.

Except in 1870 (see below), the dominant relationship between firm size and wages was negative. Compared with 1850, the coefficients of firm size in 1860 and 1880 were somewhat larger in absolute value, but any such differences were economically small.

The displacement of artisan shops would not necessarily result in a more unequal distribution of firm sizes. However, total manufacturing employment was also increasing sufficiently so that, in fact, the distribution of firm sizes in manufacturing did become more unequal. Table 3 presents range statistics of the distributions of firm sizes for the various samples. The gap between the 10th and 50th percentiles remained unchanged over this period, but that between the 50th and 90th percentiles increased steadily. By 1880, the 90-50 range in firm size was 0.44 log points larger than in 1850, or an increase of about 55 percent. The implication is that employment was becoming increasingly concentrated in large firms.²⁰

Table 4 shows the results of decompositions of the change in the 50-10 and 90-50 range statistics between 1850 and 1880, again based on the univariate regressions.. Using 1850 as the

base year, approximately 71 percent of the rise in the 10-50 spread can be accounted for by the “quantities” term which, given the fact that firm size is the only independent variable, can be attributed to the growing inequality in the distribution of firm sizes. A small portion – about 12 percent -- of the increase in wage inequality below the median can be attributed to the (slight) increase in the absolute value of the coefficient of firm size between 1850 and 1880.

While an explanation focusing on changes in the size distribution of firms does an excellent job in accounting for the increase in dispersion below the median wage, it is completely unsuccessful in explaining the – albeit, much smaller – increase in dispersion above the median. All of the increase in the 90-50 range, and about 17 percent of the increase in the 50-10 range, is attributed to an increase in the regression residual. Clearly, any explanation of the increase in wage dispersion above the median, as well as a non-trivial portion of that below the median, must be due to factors operating across firms, controlling for firm size.

Variation within Firm Size

In this section we analyze variation in wages across firms within firm size categories. To assure adequate sample sizes we decided not to estimate regressions for very fine categories (for example, firms with nine workers). Rather, following previous work by Sokoloff, we divided up the samples into three groups: small firms (1-5 workers), medium-size firms (6-15 workers), and large firms (more than 15 workers).²¹

For each size group we estimate regressions of the log wage, in which the independent variables are the percentage of workers who were female, the log of the capital-to-labor ratio, a dummy variable for use of steam power, the census region in which the firm was located, an urban

dummy variable, and a set of 21 industry dummies measured at the two-digit SIC (standard industrial classification) level.²² Because the firm size categories are rather broad, we also include the log of firm size as a regressor. Regression coefficients, except for the industry dummies, are reported in Appendix Tables 1-3.²³

The percent female is expected to have negative effect on the average wage. Generally speaking, female workers had less work experience and fewer skills than male workers, and there may have been some gender-based wage discrimination. This expectation is borne out by the data: all of the coefficients are negative and statistically significant. With the exception of the regressions for 1860, for which the coefficients are larger in magnitude, the estimates suggest that females, on average, earned between 60-65 percent of the male wage.²⁴

Recent theoretical work by Claudia Goldin and Lawrence Katz suggests that the coefficients of the capital-labor ratio and the dummy for steam power should be positive.²⁵ Goldin and Katz model the evolution of manufacturing as occurring in four stages -- artisan shop to factory to assembly line and, lastly, to "continuous process" production (see below). Their model also incorporates factor substitution between capital and labor, but the basic ideas are readily conveyed in a two-stage version of the model. There are three factors of production: capital, skilled (L_s), and unskilled (L_u) labor. In the artisan stage, skilled labor uses capital to fashion a final product. In the factory stage, the process of crafting the finished good is divided up into a series of steps, each of which can be performed by an unskilled worker, possibly with the use of some machinery, either hand or water-powered. Some skilled labor was retained to maintain and repair any such machinery (and, possibly, produce machinery). Because the factory was more productive than the artisan shop, in switching from artisanal to factory production, the capital-output ratio may have risen, but not necessarily the capital-labor ratio. However, because the

factory process economized on the relative use of skilled labor, $L_s/(L_s + L_u)$ -- the share of skilled labor -- was lower in factories than in artisan shops, and wages were a negative function of firm size -- as we demonstrated previously.²⁶

As the manufacturing sector evolved, some firms adopt “continuous process” technologies that require more capital per worker than factories, and also require an inanimate power source. Such firms had more workers than factories, but also used relatively more skilled labor because of the need to maintain continuous production or interchangeable parts machinery. Goldin and Katz note that continuous process firms began to diffuse rapidly throughout the economy in the early 20th century as a consequence of electrification, but they also point out that some of the relevant technology dates back into the 19th century and, in principle, the same arguments could apply to steam power, which began to be used more intensively after 1850.

The regression results are broadly consistent with the Goldin-Katz model. Across all three firm size categories, capital intensity was positively associated with wages; there is some evidence that the capital coefficient increased in magnitude for small and medium size firms, but the reverse was true for large firms. The findings are somewhat mixed in the case of steam power. Among small firms, three of the four coefficients were positive and statistically significant, but none of the coefficients for medium size firms were significant at conventional levels, and two of the four coefficients were significant for large firms.²⁷ Taken at the face value, the positive coefficients suggest that use of steam power was associated with an increase in the average wage of approximately 8-12 percent.

The region in which the firm was located could have affected its average wage. Recent work by Robert Margo suggests that nominal wages of unskilled labor in the South Atlantic region were already well below levels prevailing in other regions, a finding that is borne out by our

regressions for 1850.²⁸ Wage differentials that we estimate between the Northeast and Midwest in 1850 were relatively small, while firms in the South Central states paid wages that were lower than in the North, but higher than in the South Atlantic. The highest wages in the country were paid by the (very) small number of firms located in the West -- principally in California -- presumably as a consequence of the Gold Rush, which dramatically boosted wages in California.²⁹

In the 1850s regional differences in wages narrowed, especially so in the case of the West and the South Atlantic states. The western wage advantage continued to fall during the 1860s but, among small and, to a lesser extent, medium size firms, wage differentials between the other regions widened – considerably so, in the case of small firms. Workers at large firms seem to have escaped the havoc wrought to their wages by the war, particularly so in the case of firms in the South Atlantic states. However, wages in large firms in the South Atlantic fell behind once again in the 1870s. Still, in 1880, wage differences across regions were smaller, on average, than in 1850, suggestive of a movement towards a national labor market.

Another geographic feature of the evolution of manufacturing between 1850 and 1880 was a shift in production towards urban areas.³⁰ 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. Workers in 19th century firms tended to live close by where they were employed, and 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. With one exception (large firms in 1860) this hypothesis is borne out by the regressions. There is also some evidence that the rural-urban wage gap was larger in 1880 than in the earlier census years for small and medium size firms but not, however, for large firms.

Among small and medium size firms, the coefficients of firm size are generally small, not

consistently negative, and rarely significant statistically, when other factors are controlled for. However, among large firms, the coefficients are negative and significant, except in 1870.³¹

We use the regression coefficients to compute decompositions of the change in the range statistics (10-50 and/or 50-90) within firm size categories, in the same manner described earlier. Changes in these statistics are shown in Table 5. Among small firms there was a dramatic expansion of inequality in the 1860s, followed by some retrenchment in the 1870s. Wage inequality across medium size firms also increased in the 1860s but, in contrast to small firms, continued to rise in the 1870s. Among large firms, inequality increased below the median between 1850 and 1860, and above the median in the 1860s, but these changes were largely offset elsewhere in the distribution so that the 90-10 range did not change much. In the 1870s, however, the 50-10 range increased substantially among large firms, and the change was not offset by a decline in the 90-50 range, so that the 90-10 increased, by 0.25 log points.

Table 6 shows the results of the decompositions for the numerically most important decade-by-decade changes in the range statistics in Table 5, as well as over the entire 1850 to 1880 period. Although the results are somewhat complex, some themes emerge. Among small and medium size firms, changes in “prices” – that is the regression coefficients – accounted for a portion of the increases in the range statistics in the 1860s. We know from the regressions that wages in the South – both the South Atlantic and South Central states – fell sharply relative to the North – while the wage gap between the Midwest and Northeast also grew. The Civil War is a plausible culprit: regional capital market were similarly disrupted and the Southern labor market was in shambles during the immediate aftermath of the conflict. Second, changes in the distribution of the independent variables – the quantity term – were also quite important. Along with firm size (among large firms), the most important such changes appear to be the shift in

production towards urban areas, as well as growing capital intensity and use of steam power. Third, residual inequality increased in the 1860s, and this increase was the most important factor quantitatively behind the rise in wage dispersion across small and medium size firms in the 1860s.

4.0 Skill Differentials in Manufacturing, 1850 to 1880

We have shown that the distribution of wages across manufacturing firms became substantially more unequal between 1850 and 1880, and the great majority of the increase in inequality occurred between the 10th and 50th percentiles. While other factors are important, particularly the impact of the Civil War, most of the increase in the 10-50 range occurred because the distribution of firm sizes became substantially more unequal at the top end, and such firms, paid lower than average wages.

If the relative supply of unskilled labor to the manufacturing sector were upward sloping and, over the period under study, did not shift outward, then the increase in relative demand associated with the rise in firm size would have boosted the relative wage of unskilled labor. During the first phase of American industrialization – 1820 to 1850 – there is some evidence that such a boost occurred, at least to the extent that “unskilled” can be identified with the labor of women and children. According to Claudia Goldin and Kenneth Sokoloff, the earnings of female (and child) operatives relative to adult males rose after 1820.³² Beginning sometime in the 1840s, however, the increases in the female-to-male wage ratio ceased, as immigrants began to take the jobs formerly held by native (white) females.³³

If the effect of increases in relative demand for unskilled labor on the relative wage of unskilled labor were positive and of sufficient magnitude, it is possible that the distribution of wages across workers (rather than across firms) might have remain unchanged, even as a larger

share of workers became employed in factories. However, while the available evidence is scantier than one might like, what there is suggests that the skill premium in manufacturing – the ratio of skilled to unskilled wages – either remained constant, or more likely increased slightly, between 1850 and 1880. Jeffrey Williamson and Peter Lindert’s series of skill differentials for urban skilled workers, based partly on manufacturing wages, shows no difference in the ratio of skilled to unskilled daily wages in 1850 and 1880, slightly in excess of 1.7 in both years.³⁴ Clarence Long’s estimates of daily wages for five skilled occupations and for laborers in manufacturing imply a skill differential of 1.71 in 1880 compared with 1.54 in 1860; if the numerator (the skilled wage) is restricted to machinists (as suggested by Goldin and Katz’s model), the rise in the differential is somewhat greater (1.86 in 1880 compared with 1.56 in 1860).³⁵

Our 1880 sample provides evidence on the skill differential in manufacturing in that census year; unfortunately, none of the other samples do, but it is useful nonetheless to compute the 1880 figure as a benchmark for comparison with the other studies just mentioned. One problem with this computation is that the 1880 census did not separately report the number of skilled and unskilled workers, so we cannot weight the firm-level data. However, the wage ratios reported above are similarly based on data that are not weighted by the number of workers.

Our estimate of the skill differential in manufacturing in 1880 is 1.73, very close to Long’s as well as Williamson and Lindert’s. Long’s data did not give adequate coverage to firms located outside the Northeast. Robert Margo has recently made 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 Long. 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 aggregate estimate is 1.68, slightly below, but not significantly so, our estimate for 1880, consistent with the view that there was no change, or perhaps a slight rise, in the skill differential over this period.³⁶

If, in the face of growth in the share of employment in large firms, the aggregate skill differential in manufacturing either did not change -- and may have risen slightly -- between 1850 and 1880, the relative supply of unskilled labor to the sector must have increased. The sources of this increase in supply are not difficult to discern. Young women continued to enter manufacturing employment, as they had in the Northeast earlier in the century, the difference being that manufacturing employment could be had more or less throughout the country. Although not all women who entered manufacturing were “unskilled”, certainly relatively few were skilled artisans. Immigrants were a second potential source of supply. In the 1850s, fully 39 percent of immigrants who reported an occupation upon entry claimed to be “laborers”; by the 1870s, the figure had risen to 46 percent.³⁷

4. Conclusion

Over the course of the 19th century manufacturing was revolutionized by the growth of large scale firms. Yet this very transformation, so essential to 19th century growth productivity growth, also was responsible for some of the substantial variation in wages across manufacturing workers that existed at century’s end. This paper has demonstrated that, between 1850 and 1880, the variation in average wages across manufacturing firms increased, particularly below the median wage. Most of the increase in wage dispersion can be attributed to rising inequality in firm sizes; large firms paid lower than average wages, and a growing percentage of workers were

employed at such firms between 1850 and 1880. Other aspects of the evolution of manufacturing during this period – growing capital intensity, use of steam power, and urbanization – contributed to the rise in wage inequality, although their effects were largely secondary. The Civil War, too, appears to have played an important role, by interrupting a long-term narrowing of wage differentials across regions, among small and medium size firms. The growing concentration of manufacturing workers in large firms reduced the relative demand for skilled labor. If the relative supply of skilled labor were less than perfectly elastic, the skill differential in manufacturing should have decreased, offsetting some of the growth in wage dispersion. However, this did not happen, possibly because the relative supply of unskilled labor to the manufacturing sector was, in fact, increasing.

After 1880 manufacturing plants grew larger in size, as continuous process production methods started to diffuse in earnest.³⁸ Later, electricity began to replace steam as the inanimate power source of choice. According to Goldin and Katz, these changes boosted the relative demand for skilled labor and, had they not accompanied by shifts in relative supply, 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 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 between 1890 and 1940.³⁹

The analysis in this paper might be extended in two ways. First, it is clear that changes in residual wage dispersion – the “unexplained” variation across firms – account for a significant

portion of rising wage dispersion in the 1860s. While we are limited to the information available in the census (and that which can be linked to it), further exploration of these changes is warranted. Secondly, our argument rests, in part, on assumed relationships between firm attributes, like firm size and capital intensity, and the relative use of skilled labor. While these assumptions appear reasonable in light of the historical literature on 19th century manufacturing, direct evidence on the skill mix and its relationship to firm attributes would be useful.⁴⁰

References

- Atack, Jeremy. 1977. "Returns to Scale in Antebellum United States Manufacturing," Explorations in Economic History 14: 337-359.
- Atack, Jeremy. 1986. "Industrial Structure and the Size Distribution of Firms in American Industry in the Nineteenth Century," Journal of Economic History 46 (June): 463-476.
- 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. In Progress. "The Skill Mix in 19th Century Manufacturing: Evidence from the 1880 Census," Department of Economics, Vanderbilt University.
- Brown, Martin and Peter Phillips. 1986. "Craft Labor and Mechanization in Nineteenth-Century American Manufacturing," Journal of Economic History 46

(September):
743-
756.

Chandler, Alfred. 1977. The Visible Hand: The Managerial Revolution in American Business.
Cambridge: Harvard 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. 1999. "Egalitarianism and the Returns to Education During the Great Transformation of American Education," *Journal of Political Economy* 107 (December): S65-S94.

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.
- 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.
- 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.
- Lazonick, William and Thomas Brush. 1985. "The 'Horndal Effect' in Early U.S. Manufacturing," Explorations in Economic History 22 (January): 53-96.
- Lebergott, Stanley. 1964. Manpower in Economic Growth: The American Record Since 1800. New York: McGraw-Hill.
- Margo, Robert A. 1995. "Explaining Black-White Wage Convergence, 1940-1950," Industrial and Labor Relations Review 48 (April): 470-482.
- 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.
- 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. 1986. "Productivity Growth in Manufacturing During Early Industrialization:

- Evidence from the American Northeast, 1820-1860.” In S. Engerman and R. Gallman, eds. Long Term Factors in American Economic Growth, pp. 679-729. 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 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.

Table 1

Range Statistics: Distribution of Average Wages Across Manufacturing Establishments, 1850-80

A. Firms Hiring at Least One Worker, Log of Average Monthly Wage

	1850	1860	1870	1880
10 th percentile	2.37	2.36	2.89	2.50
50 th percentile	2.97	3.18	3.59	3.44
90 th percentile	3.50	3.58	4.20	4.02
50 - 10	0.60	0.82	0.70	0.94
90 - 50	0.53	0.40	0.61	0.58
# of firms	5,481	5,307	3,651	6,519
# of workers	44,428	47,842	42,962	78,219

B. Changes Over Time in the Range Statistics (from Panel A)

	1850-60	1860-70	1870-80	1850-80
Δ (50 - 10)	0.22	-0.12	0.24	0.34
Δ (90 - 50)	-0.13	0.21	-0.03	0.05
Δ (90 - 10)	0.09	0.09	0.21	0.39

C. Excluding Low-Output Firms: 1860-1880

	1850	1860	1870	1880
10 th percentile	2.37	2.35	2.90	2.53
50 th percentile	2.97	3.20	3.64	3.44
90 th percentile	3.50	3.62	4.20	4.02
50 - 10	0.60	0.85	0.74	0.91
90 - 50	0.53	0.42	0.56	0.58
# of firms	5,481	3,805	2,559	4,566
# of workers	44,428	44,683	39,721	74,226

D. Changes Over Time in the Range Statistics (from Panel C)

	1850-60	1860-70	1870-80	1850-80
Δ (50 - 10)	0.25	-0.11	0.17	0.31
Δ (90 - 50)	-0.11	0.14	0.02	0.05
Δ (90 - 10)	0.14	0.03	0.19	0.36

Notes: In both panels, certain very low-wage firms are excluded (the cut-offs are 1850, \$3.65; 1860, \$3.98; 1870, \$8.21; 1880, \$8.07) and very high-wage firms are top-coded (the top-codes

are 1850, \$100; 1860, \$125; 1870, \$175; 1880, \$166.67). Top-coded wages are replaced with values equal to 1.4 times the top-code (see Goldin and Margo, “The Great Compression” for a similar procedure). In Panel B, firms whose reported value of gross output fell approximately in the bottom 30 percent of the distribution of output in 1860 (< \$1,500), 1870 (< \$2,080) and 1880 (< \$2,147) are also excluded.

Table 2

Univariate Regressions: Log Wage on Log Firm Size

	1850	1860	1870	1880
β	-0.054	-0.069	0.0012	-0.061
t-statistic	15.497	19.034	0.267	17.136
σ^2_ε	0.468	0.470	0.531	0.545
R^2	0.043	0.064	-0.003	0.043

Source: see text. Dependent variable is the log of the average wage in the firm. Observations are weighted by the reported number of workers. Sample sizes are the same as in Panel A of Table 1.

Table 3

Range Statistics: Distribution of Firm Sizes

A. Log of Number of Workers

	1850	1860	1870	1880
10 th percentile	0	0	0	0
50 th percentile	1.10	1.10	1.10	1.10
90 th percentile	2.56	2.71	2.89	3.00
50 - 10	1.10	1.10	1.10	1.10
90 - 50	1.46	1.62	1.79	1.91
σ	1.05	1.10	1.17	1.20

B. Changes Over Time in the Range Statistics (from Panel A)

	1850-60	1860-70	1870-80	1850-80
Δ (50 - 10)	0	0	0	0
Δ (90 - 50)	0.16	0.17	0.12	0.45

Source: see text. Panel A: A value of "0" (eg. at the 10th percentile) indicates a firm with one worker. σ : standard deviation. Sample sizes are the same as in Panel A of Table 1.

Table 4

Decomposition of Change in Range Statistics of Distribution of Log Wage Based on Firm Size

Regressions, 1850 to 1880

	$\Delta (50 - 10)$	$\Delta (90 - 50)$
Prices	0.04	-0.03
Quantities	0.24	-0.03
Residual	0.06	0.11
Total	0.34	0.05

Source: see text. Total: from Table 1, Panel B

Table 5

Changes in Range Statistics, By Firm Size Group

A. By Decade

	1850-60	1860-70	1870-80	1850-80
Small				
Δ (50 - 10)	0	0.43	-0.07	0.36
Δ (90 - 50)	-0.05	0.31	-0.02	0.24
Δ (90 - 10)	-0.05	0.74	-0.09	0.60
Medium				
Δ (50 - 10)	-0.08	0.18	0.12	0.22
Δ (90 - 50)	-0.01	0.12	0.04	0.15
Δ (90 - 10)	-0.09	0.30	0.16	0.37
Large				
Δ (50 - 10)	0.21	-0.15	0.24	0.30
Δ (90 - 50)	-0.15	0.11	0.01	-0.03
Δ (90 - 10)	0.06	-0.04	0.25	0.27

B. Number of Workers By Firm Size Group

	1850	1860	1870	1880
Small	9,753	9,159	6,200	10,496
Medium	7,429	7,297	5,473	10,900
Large	26,946	31,386	31,289	56,823

Table 6

Selective Decompositions By Firm Size Group

	1860-70	1870-80	1850-80
Small			
Δ (50- 10)			
Prices	0.07		0.02
Quantities	0.11		0.04
Residual	0.25		0.30
Total	0.43		0.36
Δ (90 -50)			
Prices	0.13		0.08
Quantities	0.01		-0.05
Residual	0.17		0.21
Total	0.31		0.24
Medium			
Δ (50 - 10)			
Prices	0.06	0.03	-0.01

Quantities	0	0.10	0.08
Residual	0.12	-0.01	0.15
Total	0.18	0.12	0.22
$\Delta (90 - 50)$			
Prices	0.03		0.06
Quantities	0.03		0.05
Residual	0.06		0.04
Total	0.12		0.15
Large			
$\Delta (50 - 10)$			
Prices		0.01	-0.07
Quantities		0.24	0.29
Residual		-0.01	0.08
Total		0.24	0.30

Source: see text.

Appendix Table 1: Log Wage Regressions, Small Firms (1-5 Employees)

	1850	1860	1870	1880
Constant	2.640 (56.083)	2.689 (48.897)	2.579 (26.118)	2.493 (28.420)
% Women	-0.464 (8.888)	-0.580 (10.149)	-0.484 (5.243)	-0.401 (6.143)
Log (K/L)	0.044 (8.522)	0.050 (8.450)	0.135 (13.064)	0.100 (12.855)
Steam Power?	0.118 (4.789)	-0.030 (1.684)	0.082 (2.398)	0.077 (3.281)
Log (Size)	-0.034 (2.979)	0.005 (0.444)	0.065 (2.722)	0.016 (0.973)
Urban	0.200 (14.829)	0.160 (12.168)	0.210 (7.277)	0.370 (20.758)
South Atlantic	-0.285 (16.138)	-0.071 (4.329)	-0.229 (4.830)	-0.177 (6.357)
South Central	-0.187 (9.672)	0.017 (0.804)	-0.303 (6.205)	-0.093 (2.673)

Midwest	-0.020 (1.597)	0.031 (2.402)	-0.090 (3.590)	0.058 (3.250)
West	1.575 (30.079)	1.062 (23.652)	0.273 (3.607)	0.300 (6.059)
R ²	0.384	0.226	0.157	0.202
N (firms)	4,142	3,974	2,607	4,491

All regressions include 21 industry dummies, categorized by 2-digit SIC code; see Atack and Bateman, “Nineteenth Century U.S. Industrial Development”, p. 185 for a list of 3-digit SIC codes covering firms in the samples, which we collapsed to 2-digit codes. Absolute values of t-statistics in parentheses.

Appendix Table 2: Log Wage Regressions, Medium Size Firms (6-15 Employees)

	1850	1860	1870	1880
Constant	2.594 (18.010)	2.747 (16.870)	2.853 (10.655)	2.281 (13.138)
% Women	-0.434 (5.543)	-0.733 (9.014)	-0.432 (3.044)	-0.438 (4.422)
Log (K/L)	0.080 (5.819)	0.037 (2.584)	0.121 (6.282)	0.124 (9.077)
Steam Power?	0.066 (1.704)	0.002 (0.060)	-0.011 (0.205)	-0.014 (0.388)
Log (Size)	-0.049 (1.143)	0.120 (2.702)	0.021 (0.295)	0.027 (0.576)
Urban	0.197 (7.150)	0.152 (5.590)	0.127 (2.823)	0.280 (8.349)
South Atlantic	-0.355 (8.795)	-0.145 (3.584)	-0.335 (2.560)	-0.137 (2.499)
South Central	-0.179 (3.435)	-0.027 (0.488)	-0.084 (0.842)	-0.050 (0.775)

Midwest	-0.104 (2.961)	-0.005 (0.147)	-0.134 (2.921)	0.036 (1.120)
West	1.242 (10.785)	0.863 (6.547)	0.225 (1.886)	0.256 (3.480)
R ²	0.424	0.298	0.175	0.220
N (firms)	817	813	599	1,196

All regressions include 21 industry dummies coded at the 2-digit level; see Appendix Table 1.

Absolute value of t-statistics in parentheses.

Appendix Table 3: Log Wage Regressions, Large Firms (> 15 Employees)

	1850	1860	1870	1880
Constant	1.973 (9.207)	3.213 (17.328)	2.717 (12.472)	3.221 (12.344)
% Women	-0.346 (3.620)	-0.872 (9.112)	-0.490 (3.561)	-0.494 (5.863)
Log (K/L)	0.178 (9.758)	0.054 (3.361)	0.126 (5.614)	0.090 (5.581)
Steam Power?	0.047 (1.100)	0.082 (2.107)	0.004 (0.082)	0.096 (2.562)
Log (Size)	-0.062 (3.542)	-0.049 (2.840)	-0.016 (0.713)	-0.070 (4.437)
Urban	0.150 (4.111)	-0.027 (0.790)	0.146 (3.120)	0.140 (3.358)
South Atlantic	-0.383 (5.830)	-0.221 (3.785)	-0.015 (0.137)	-0.213 (3.359)
South Central	-0.168 (2.203)	-0.187 (1.834)	0.008 (0.053)	-0.132 (1.216)

Midwest	-0.014 (0.204)	-0.140 (2.175)	0.103 (1.828)	0.055 (1.374)
West	na	0.827 (2.848)	0.200 (0.950)	0.232 (2.289)
R ²	0.549	0.562	0.375	0.368
N (firms)	448	495	422	826

All regressions include 21 industry dummies coded at the 2-digit SIC level; see Appendix Table 1.

Absolute values of t-statistics in parentheses.

Notes

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1. Computed from Lebergott, Manpower, Table A-1, p. 510. Recent revisions to the labor force and non-farm totals by Thomas Weiss would alter the figures in the text somewhat but would not change the basic trend.
 2. For discussion of the role of the factory in the displacement of the artisan shop, see Sokoloff, “Was the Transition” and Nelson, Managers and Workers, pp. 3-4. The development of large-scale factories and the use of the steam power is examined in Chandler, The Visible Hand; and Hunter, A History of Industrial Power.
 3. Chandler, The Visible Hand; see also Brown and Phillips, “Craft Labor and Mechanization”.
 4. Sokoloff, “Was the Transition” and “Productivity Growth”; Atack, “Returns to Scale.”
 5. Sokoloff and Villaflor, “The Market for Manufacturing Workers”, p. 43 estimate that the growth rate of real wages for adult males in manufacturing establishments in the Northeast (where the bulk of manufacturing employment was located prior to the Civil War) fell between 1.2 and 1.6 percent per year, depending on various assumptions underlying constructing of the wage series and price deflator. Goldin and Sokoloff, “Women, Children, and Industrialization,” p. 760 argue that the wages of females and children in the sector grew relative to wages of adult males between 1820 and 1850, suggesting that a comprehensive index for the Northeast including women and children would show even faster growth. To our knowledge, no real wage indices for manufacturing workers outside the Northeast have been produced for the pre-1860 period; however, Margo, Wages and Labor Markets, finds real wage growth throughout the country for unskilled labor over the 1820 to 1860, and no significant differences in the level of wages between common labor and manufacturing labor in 1850 or 1860, suggesting the real wage growth in the sector prior to the Civil War was probably widespread. The standard series of nominal daily wages in manufacturing, when deflated by consumer prices, indicates growth of about 13.4 percent comparing 1880 to 1860 (computed from U.S. Department of Commerce, Historical Statistics, series D-728 divided by series D-737).
 6. See Goldin and Katz, “The Returns to Skill” for data on these and other industries.
 7. See, for example, Goldin, Understanding the Gender Gap, p. 96, estimates earnings functions for female manufacturing workers in 1888 and 1907. Both regressions show steep returns to experience; that for 1907 shows a positive, if small, returns to schooling. Because manufacturing workers in certain industries were paid by the piece individual initiative and productivity would necessarily translate into higher earnings. For evidence on the returns to master status among artisans before the Civil War, see Margo, Wages and Labor Markets, ch. 3.
 8. For a detailed discussion of the design and collection of the samples, see Atack and Bateman, “U.S. Historical Statistics.”

9. See, for example, Goldin and Margo, “The Great Compression”; and Katz and Murphy, “Changes in the Structure of Wages”.

10. By top-coding we mean that observations in excess of the top-code are replaced by a multiple of the top-code (in our case, 1.4 x top-code value; see Goldin and Margo, “The Great Compression” for a similar procedure).

11. To see this point, for example, in the case of the variance, let w_{ij} = wage of the i th worker in the j th firm, n_j = number of workers in the j th firm, and K = number of firms. The variance of w_{ij} , is

$$\text{Var}(w_{ij}) = \frac{1}{N} \sum_j n_j \sum_i (w_{ij} - \bar{w}_{..})^2$$

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 firm-level means. The variance can be decomposed:

$$\text{Var}(w_{ij}) = \text{within firms} + \sum n_j (w_j - \bar{w}_{..})^2 / N$$

It is the second term, the weighted variance across firms, that we are estimating from the data at hand.

12. Claudia Goldin and Robert Margo (“The Great Compression”) use census micro-data to document a substantial decline in inequality in weekly wages between 1940 and 1950. According to their estimates, the 10-90 spread in the logarithm of weekly wages for adult men (ages 21 and over, and engaged in full-time employment) fell by -0.39 during the 1940s. Katz and Murphy, “Changes in the Distribution of Wages,” show that, 10-90 spread for adult men increased in log terms from 1.18 to 1.46, or 0.38 in log terms.

13. We do not delete very small firms in 1850 because we are interested in determining if excluding such firms, because of changes in the price level after 1850, lowers the level of wage dispersion in 1860 (and subsequently) and hence, our perception about whether inequality increased, as the original data suggest.

14. Another problem with the 1880 sample is that firms in certain industries (see Atack and Bateman, “U.S. Historical Statistics,” p. 185 for a comprehensive list) were canvassed by industry experts; any such firms enumerated by regular census employees were mistakes. Based on wage regressions for 1880 including dummies for two-digit SIC codes (which encompass the industries in question) we believe that the exclusions probably biases the degree of wage inequality downward. For example, firms in woolens and worsteds were supposed to be enumerated by industry experts; the coefficient for SIC 22 (which includes woolens) is -0.22 (the regression

controls for firm characteristics and location, as well as industry). That is, if all the 1880 returns could have been located and a random sample of them included in the 1880 sample, the degree of wage inequality across firms would be larger than that reported in Table 1.

15. For other applications of the decomposition approach described in the text, see Goldin and Margo, “The Great Depression” or Margo, “Explaining Black-White Wage Convergence.”

16. The standardized residual is the actual residual divided by the standard error of the regression.

17. Goldin and Sokoloff, “Women, Children, and Industrialization”; Atack, Bateman, and Margo, “The Skill Mix.”

18. All regressions in the paper are estimated using the Panel A, Table 1 samples.

19. We also examined the relationship between firm size and wages using a non-parametric approach (essentially, estimating the mean wage for firms of size one, two, and so on, up to twenty, and then more than twenty workers, and examining the shape of the relationship). The results are more complex, but confirm the negative association revealed by the univariate regressions.

20. See also Atack, “Industrial Structure”.

21. Sokoloff, “Was the Transition”.

22. The urban dummy takes the value one if the firm was located in an incorporated village or city, zero otherwise.

23. The 21 dummies are not exhaustive. Rather, the industries were chosen on the basis of sample size; as a consequence, the left out dummy (the constant term) is a mixture of firms from different industries. For that reason (which produces some instability in the coefficients across years) as well as the very large number of dummies (21×3 firm size categories $\times 4$ years = 252 coefficients) we do not discuss the coefficients in the text (however, note that the coefficients are included in the decompositions). In general, the coefficients conform to prior expectations; for example, newspapers and book publishing tended to be relatively high wage, while cigars tended to be relatively low-wage. An appendix containing these coefficients is available on request from Robert A. Margo.

24. Some caution is warranted in interpreting the coefficients of percent female because of differences across the censuses in the enumeration of male and female workers. In particular, in 1850 and 1860 the census did not enumerate child workers separately; in effect, we are assuming that child workers are included in the counts of male and female workers, depending on their sex (see Sokoloff, “Productivity Growth,” p. 86). In 1870 and 1880 the percent female refers to women over age 16 (taking the census at face value). Because we do not control for percent child in 1870 and 1880, the “left-out” demographic group in 1870 and 1880 (i.e. that embedded in the constant term) is different from that in 1850 and 1860. However, if the majority of child workers were boys (as seems to have been the case, again see Sokoloff, “Productivity Growth”) then the

estimated earnings of female workers will be higher, relative to all males (that is, including children), than relative to adult males.

25. Goldin and Katz, “The Origins”.

26. In the Goldin and Katz model, the assembly line is the logical end of the “pure” factory, that is, economies of scale arising solely from division of labor, possibly aided by machinery.

27. If the data are pooled across firm size categories, the steam power coefficients are positive and significant in every year.

28. Margo, Wages and Labor Markets, Table 3A.5; and p. 104.

29. See Margo, Wages and Labor Markets, p. 132, and Table 6C.2; and Gerber, “Agricultural Expansion.”

30. Kim, “Urban Development.” In the 1880 sample, mean value of the urban dummy (weighted by the number of workers; recall that the urban dummy indicates that the firm was located in an incorporated town) was 0.73 (73 percent) compared with 0.44 (44 percent) in 1850.

31. Further work is necessary to clarify why the firm size effect among large firms vanishes in 1870. War-related demand may have created temporary rents to workers in large firms that were still in place in 1870; the 1870s witnessed a larger increase in the 90-50 range of the distribution of firm size than either the 1850s or the 1880s (see Table 3).

32. Goldin and Sokloff, “The Relative Productivity Hypothesis”.

33. Goldin and Sokoloff, “The Relative Productivity Hypothesis”; see also Lazonick and Brush, “The ‘Horndal Effect’”.

34. Williamson and Lindert, American Inequality, p. 307. Williamson and Lindert’s estimate of the skill differential in 1850 is 1.74, while that for 1880 is 1.73.

35. Long’s estimates are reproduced in U.S. Department of Commerce, Historical Statistics, p. 165.

36. For this calculation we use form regional estimates of the skill differential using Margo’s wage estimates for 1849 (which, in principle, correspond to the 1850 census year); see Margo, Wages and Labor Markets, Tables 3A.5-6. In computing the regional employment shares for the 1850 census year, we exclude firms in the far West.

37. Computed from U.S. Department of Commerce, Historical Statistics, p. 111.

38. Chandler, The Visible Hand; Nelson, Managers and Workers.

39. See Goldin, “Egalitarianism”; Goldin and Katz, “The Origins”; and Goldin and Katz, “The Returns to Skill.” Williamson and Lindert’s figures also imply a large decline in the skill differential during the first half of the twentieth century; see American Inequality, Appendix D, p. 310.

40. For a start in this direction, see Atack, Bateman, and Margo, “The Skill Mix”.