DOWNTIME IN AMERICAN MANUFACTURING INDUSTRY: 1870 AND 1880

by

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ABSTRACT

Using unpublished manuscript census data for 1869/70 and 1879/80, we estimate that manufacturing establishments in the mid/late nineteenth century averaged about 10 months of fulltime operation per year; somewhat longer in 1880 fractionally less in 1870. Months of operation, however, varied greatly by industry and systematically by region and size of establishment, with establishments in the South working fewer months and larger establishments working more months. This evidence in turn has broad implications for efforts to measure productivity and for our interpretation of levels and trends in manufacturing profitability.

JEL Classification: N61, N31, J23, J22

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Downtime in American Manufacturing Industry: 1870 and 1880

Our understanding and appreciation of the impact of American industrialization upon employees and the general population is greatly hampered by the lack of information about many aspects of work and employment. This is particularly true for the nineteenth century and more so earlier in the century than later. Wages and wage trends have been well documented by Stanley Lebergott (Lebergott 1964), Clarence Long (Long 1960), Albert Rees (Rees 1961) and others, notably and most recently by Robert Margo (Margo 2000). However, as yet, we have only meager information on other aspects of industrial work such as the constancy and predictability of employment over the year or the business cycle, the length of the working day, and the intensity of work effort. The issue, according to an Ohio report was that "the prosperity of the laborer cannot be gauged from a knowledge of his weekly wages, but that the number of weeks' employment must also be known" (Ohio. Bureau of Labor Statistics. 1879, 10).

In this paper we chip away at the informational lacuna by addressing the question posed by the Ohio study albeit indirectly. Specifically, we present new evidence on the extent and impact of production downtime, defined as "the period of time when something, such as a factory or a piece of machinery, is not in operation" (1992, 558) in American manufacturing industry during the late nineteenth century. Downtime is the inanimate resource analog to labor underemployment and unemployment. However, it is neither exactly nor necessarily coincident with either, although if workers are tied to establishments then when the establishments stop work, labor is either involuntarily unemployed or is forced to use the opportunity for leisure activities.

Our measure of downtime--months of full-time operation--is very imprecise. In 1870, the nature of our data restricts reported downtime at the establishment level to integer values between zero and twelve. Even in 1880, it can only take on a limited set of non-integer values. The measure thus misses many short-term interruptions--those of a few hours. It is also likely that interruptions of several days were ignored by the census even when these may have occurred repeatedly over the course of a year.

Although downtime is not the same as labor unemployment or underemployment, our estimates link to the labor supply perspective in work by Alexander Keyssar (Keyssar 1986) for Massachusetts and the work on seasonality by Stanley Engerman and Claudia Goldin (Engerman and Goldin 1994). They also mesh with contemporary estimates published by the Massachusetts Bureau of Labor Statistics (Massachusetts. Bureau of Labor Statistics. 1872; Massachusetts. Bureau of Labor Statistics. 1873; Massachusetts. Bureau of Labor Statistics. 1876; Massachusetts. Bureau of Labor Statistics 1879; Massachusetts. Bureau of Labor Statistics. 1881). Various implicit assumptions underlie these comparisons most notably that shorter hours each day were either not substituted for layoffs and suspension of operations or else that these were treated as equivalents by the census and reported as less than fulltime operation.[1]

Our evidence comes from samples from two large, nationally representative sample of manufacturing establishments from the 1870 and 1880 censuses of manufacturing. The 1870 sample has almost 5,300 establishments. The 1800 sample has over 8,000. These national samples are supplemented by state-level samples, typically of 200 or more firms from each state whose records have survived (Atack and Bateman 1999, especially Tables 3 and 4).[2] Both of these censuses included questions regarding the number of months of full-time operation worked by each manufacturing establishment during the census year. However, the responses to these queries were never published or even tabulated (Atack and Bateman 1999, 180, 184). Consequently they have lain largely unknown (and almost totally unused) for more than a century. The data are not perfect. They cover just two benchmark dates They are less detailed than we would have liked and are not so easily interpreted. But, they offer the earliest comprehensive, in the sense of covering all manufacturing activities and locations, picture of the extent of downtime in American manufacturing industry during this period.

We report estimates of the average number of full-time months that manufacturing establishments worked by region and industry group (2-digit SIC groupings) as well as for a few, more narrowly defined industries in these two census years. Nationally, we find that, on average, U.S. manufacturing establishments operated for the equivalent of 9.94 months of full time work per year in 1870, while in 1880 they averaged 10.11 months. The difference, while apparently small, is statistically significant. Moreover, it occurs at a time when increasing mechanization was leading to growing complaints regarding the intensity of work effort and worker fatigue (Goldmark and Brandeis 1912; Atack and Bateman 1991). It thus provides more fuel to the debate about changes in the intensity of work that accompanied industrialization (Marglin 1974). Our finding that working year lengthened has the effect of flattening any estimated productivity growth in manufacturing. Moreover, it minimizes any seemingly superior productivity in larger mills and factories since such establishments turn out to have worked more days per year. At the same time, working more days per year diminished the impact of the shorter working day. Further analysis of the data reveals that months of operation varied systematically by region, by industry, and by size of establishment. Unfortunately, the data do not provide a satisfactory basis for modeling the establishment's decision regarding months of operation since we lack sufficient information to identify either supply or demand. Nor do they prove capable of providing the means to discriminate between plants that operated different numbers of months: there is simply too much idiosyncratic variation between establishments. However, the evidence we assemble here prove extremely useful in helping resolve a puzzle regarding profit estimates for 1850 and 1860 made by Atack and Bateman (Atack and Bateman 2000) and by Bateman and Weiss (Bateman and Weiss 1981) and refine the relationship between establishment size and productivity (Sokoloff 1984).

Resource Employment and Time: The Historical Record

Time enters employment contracts in three quite distinct ways. First, there is the number (and intensity) of hours worked each day. Second, there is the question of how many (and when) days were worked each year. Third, there is the issue of employment duration and stability. Some work has been done on each of these topics; most of it with respect to labor.

Jeremy Atack and Fred Bateman (Atack and Bateman 1992, 136) show that there was a persistent long-run decline in daily hours of work in manufacturing throughout the nineteenth century. Around 1832, establishments operated about 11 hours 20 minutes a day in 1832 and probably longer earlier (See, for example, (Montgomery 1840, 173)).[3] By 1880, however, the ten-hour day was a reality for most American industrial workers, a decade earlier than the traditional dating and well before laws demanded it in every state. In general, many workers wanted shorter hours as part of their income-leisure trade-off

Employers, on the other hand, saw longer hours as the key to higher productivity and reduced fixed costs (Massachusetts. Bureau of Labor Statistics. 1881, “Uniform Hours of Labor,” 323-475). The resulting length of the working day was the product of bargaining, growing political and legal pressure and an often-reluctant recognition of the changing nature of work as the mechanization of industry proceeded apace (Goldmark and Brandeis 1912; Marglin 1974; Whaples 1990). In agriculture, on the other hand, the trend may well have been in the opposite direction (Craig and Weiss 2000).

Engerman and Goldin have investigated the seasonal nature of nineteenth and early twentieth century work but, absent any detailed evidence on manufacturing activities before the end of the nineteenth century, they focused primarily upon seasonality in agriculture (Engerman and Goldin 1994). Any loss of generality from this limitation is, however, marginal. Agriculture was the dominant occupation in the nineteenth century, employing about two-thirds of the labor force in 1850. It still employed almost half as late as 1880.[4] Moreover, agriculture and manufacturing competed for labor both on the margin (for example, (Wright 1986, especially 137)) and at different points during the year, particularly in certain areas of the country where peak labor demand was particularly pronounced (See, for example, (Margo 2000, chapter 4) and (Schob 1975)). Of course, the seasonal nature of agriculture comes as no surprise. It is still highly seasonal today.

Mechanization provided a partial solution but so long as people were still required to operate the machines, peaks and toughs could not be completely eliminated. In farming, some of the seasonally "unemployed" farm workers were family members for whom work could always be found if needed, especially during the farm formation years in activities such as clearing land, digging ditches, repairing fences or other capital formation activities (Primack 1962; Primack 1977). Those who were not farm family members often moved on, following the seasonal harvests (McWilliams 1942; McWilliams 1969; Coalson 1977; Wright 1993). Moreover, not all rural inhabitants depended upon agriculture for their livelihood even in the mid-nineteenth century. Much of early manufacturing was rural rather than urban before the advantages of agglomeration, increasing returns to scale and cheap transportation asserted themselves (Meyer 1989). There was also often a substantial service sector (Weiss 1975; Atack and Bateman 1987). Moreover, the various sectorial activities may have shared the available pool of labor, dove-tailing their operations and thus smoothing local aggregate demand for labor.

Systematic evidence on seasonal fluctuations in manufacturing dates only from 1900 when the census tabulated information on the average number of workers, age 16 and over, by gender employed each month between January and December (United States. Bureau of the Census. 1902, cvi-cxxxiii and 635-6). Engerman and Goldin's examination of these data is limited to the broadest of industry categories, roughly corresponding to the 2-digit SIC level (Engerman and Goldin 1994, Figure 6.2, 111-12). They find a bimodal pattern to employment with employment for dipping 15-20 percent in the depths of winter and 10 percent or so at the height of summer.[5]

Using California Bureau of Labor data from 1892, primarily for workers in the San Francisco area, Carter and Savoca found that the average non-union male could expect to work for the same employer for thirteen years and that fewer than 7 percent of workers had job tenures shorter than three years (Carter and Savoca 1990). Jacoby and

Sharma, however, have used these same data to show that job spells for most workers were brief (Jacoby and Sharma 1992). Moreover, following World War I, there was a switch to longer job tenure with the emergence of internal labor markets (Jacoby 1985). Jacoby's story is more consistent with the traditional view of how the early labor markets operated and with the notion that workers neither acquired nor needed much establishment-specific human capital during the early phases of industrialization.

Lastly, work by Margo using the 1910 public use sample reveals that around the turn of the century workers faced a much higher incidence of unemployment than today but the duration of unemployment spells was much briefer (Margo 1990). Our results are consistent with this pattern.

Despite the apparent likelihood of spells of unemployment, it attracted relatively little governmental attention until late in the nineteenth century. However, when policy makers finally noticed unemployment, particularly in the wake of the 1870s depression, their primary focus was on law and order in the cities.. They were concerned with the public—social—costs of unemployed labor, rather than the private and personal ones.

Massachusetts, which by then was among the most urban and industrialized states, was the first to recognize the problem of "involuntary idleness" among industrial workers. In their *Third Annual Report*, the Massachusetts Bureau of Statistics of Labor assembled a variety of largely narrative accounts of seasonal layoffs. For example, in boy's clothing manufacture, they reported "the average season of work per year does not exceed twenty-four weeks" (Massachusetts. Bureau of Labor Statistics. 1872, 74). Workers making matches were reported as averaging 40 weeks per year while chairmakers averaged 45 weeks (Massachusetts. Bureau of Labor Statistics. 1872, 96, 94). Subsequent Massachusetts Bureau of Labor Statistics reports are exhaustively reviewed by Keyssar (Keyssar 1986) but his focus differs from ours. In particular, he examined labor supply and the economic and social effects of unemployment, especially in urban areas, rather than upon the demand for labor by businesses and the causes of fluctuations in that demand. Consequently, he paid virtually no attention to the scraps of data on the irregularity of industrial work contained in the earlier Massachusetts Bureau of Labor Statistics reports.[6] Instead, Keyssar relied upon state census data and other information from 1885 onwards—a time period later than that of interest here.

Months of Operation at the 1870 and 1880 Censuses of Manufacturing

The instructions for the Eighth Census in 1860 asked enumerators to report months of operation if plants were idled for "long" (United States. Census Office. 8th census 1860. 1860). Unfortunately, they neither defined "long" nor provided any space for responses to the query on the census return. From our work with the 1860 census manuscripts we know that either very few plants were idle for very long—which we doubt—or few enumerators asked the question (or bothered with the answer).

For the 1870 census, the question regarding operations was more specific. Enumerators were instructed to determine for each establishment which they visited "the number of months of active operation, reducing part time to full time" during the census year (United States. Census Office. 9th census 1870. 1870). There was also space on the forms to report the answers. But there was still a problem: No guidance was given as to how part-time hours were to be reduced to full-time equivalents.

We believe that the Census intended enumerators to treat two months at half-time as the equivalent of one month at full time. This is what we have done. It is also the way in which the Massachusetts Bureau of Labor Statistics interpreted the 1870 data for their state (Massachusetts. Bureau of Labor Statistics. 1873, 315). Indeed, they used a procedure very similar to ours.[7]

The distribution of equivalent months of fulltime operation in the 1870 census year (which ran from June 1, 1869 through May 31, 1870) is shown in Figure 1. The distribution is heavily skewed to the right (skewness = -1.34). Because of the way in which the original data were reported—whole months—only 13 values are possible: 0 through 12. The nature of this distribution makes econometrics tricky. Slightly more than 60 percent of all establishments reported working 12 months of the year. The median establishment thus worked year round.

Looked at differently, almost 40 percent of establishments during the 1870 census year were either shutdown for at least a month or laid off enough workers for a sufficiently long time that they lost the equivalent of at least a month's fulltime output.[8] These establishments, taken together, lost sufficient time during the census year that the average number of months that manufacturing establishments operated fell significantly short of the year round potential. There was a marked local maximum at 6 months—about 7.5% of all plants worked only six months a year—and smaller local maxima at four, eight and ten months. Fewer than one percent of establishments reported being idle for the entire year.[9] The inter-quartile range was 8 to 12 months of operation during the 1870 census year.

The solitary question regarding months in operation in 1870 was expanded into five for the 1880 Census. establishments were asked for the number of months in operation on "full time," "on three-fourths time only," "on two-thirds time only," "on one-half time only," and "idle." Enumerators were instructed to account for all 12 months. Funding, however, ran out before these data were tabulated by the census although the manuscripts have survived. We have used them to generate an estimate of the number of fulltime equivalent months that each establishment operated during the census year. To do this we treated one month on three-quarters time as three-quarters of a fulltime equivalent month and so on.

In 1880, almost sixty percent (59.2%) of establishments reported working exactly 12 months—essentially the same percentage as in 1870 (Figure 2).[10] Indeed, the two distributions look remarkably alike. The obvious visual similarities between the two distributions and the dominance of year round work (which was both the mode and the median months of operation for manufacturing establishments in those years), however, belies what prove to be important differences within and between the distributions as we will show below. The differences between them are sometimes subtle. For example, a smaller percentage of plants were idled in 1880 than in 1870 (0.38 percent v 0.65 percent) or worked just six months (5.99 percent reported exactly 6 months in 1880, 6.59 percent between 5.5 and 6.5 months) and in 1880 the inter-quartile range was slightly narrower than in 1870, ranging from nine to twelve months. More importantly though, the means of the two distributions are different. In 1870, establishments worked an average of 9.94 months per year. In 1880, they averaged 10.11 months. This difference, though small, is statistically significant (Table 1).[11]

Its small size is partly a function of our choice of metric. We report months of operation in terms of decimal months. Others, such as the Massachusetts Bureau of Statistics of Labor, have used days. Months of work may be converted into working days by multiplying by 25.75. This implies that there were 309 working days during the typical year.[12] Such a working year could be composed of 52 six-day work weeks per year less certain other days. It is consistent with contemporary evidence.[13] Thus, the difference between 1870 and 1880 amounts to 4 or 5 days or 1 to 2 percent of the working year—small but not quite so small on this metric.

The shorter working year in 1870 relative to 1880 is consistent with the different stages of the business cycle when each census was taken. According to the NBER business cycle reference dating, the economy reached its peak during the first month of the 1870 census year (June 1869) declining thereafter to a trough in December 1870, seven months after the census year ended.[14] The 1870 census year therefore coincides with a contraction. This is particularly relevant in the context of the measures we are examining. Employment and production are (nowadays, at least) thought of as coincident economic indicators, while hours, layoffs, and labor accession are key leading economic indicators that typically lead the business cycle by 4-6 months. Thus, these measure could have turned down about the start of the census year and fallen throughout the period (Moore and National Bureau of Economic Research. 1961, I, 56). In contrast, the Tenth Census in 1880 was collected during a particularly sharp and sustained upturn that began March 1879—two months before the start of the census year—and lasting well beyond until March 1882. It marks the first recorded use of the term “boom” to describe business conditions (Fels 1959, 121). Consequently all key economic indicators relevant to our story here should have been improving throughout the 1880 census year.

Firms worked more months in 1880 census year as compared with the 1870 census year in each region. The increase was biggest in the Midwest; smallest in the

South. Regardless of the year-to-year differences, however, months of operation were longest in the Northeast and shortest in the South. This was true even controlling for industry mix.[15] These differences were not only statistically significant, they were also large.[16] Establishments in the Northeast averaged one month more work per year than establishments in the southern states. Moreover, according to estimates by Atack and Bateman, manufacturing establishments in the Northeast also worked significantly more hours per day in 1880 than those in the South (Atack and Bateman 1992). Consequently, the implication is that annual hours of work per person in the North far exceeded those in the South. This adds yet another dimension to the quality-quantity of labor debate and its implications for productivity.[17] Nor was this phenomenon confined to the industrial sector. It was also true in agriculture, including the period under slavery when forced labor might have been required to work long hours year round (Olson 1992).

Some fraction of the shorter working year in the South reflects regional differences in the industry mix. Agricultural services, for example, were more common in this region. However, even within the same industry, southern establishments generally worked fewer months per year than their northeastern counterparts. For example, southern flour mills in 1880 averaged 8.85 months compared with 10.20 months for northeastern mills; southern cigar-makers worked 9.94 months while northeastern cigar manufacturers averaged 11.06 months annually in 1880.[18]

Although southern producers on average operated fewer months per year than those in any other region, establishments in the Midwest also worked significantly less time per year than those in the Northeast, even in 1880.[19] The state level estimates appear in Appendix A. Nor was this purely an artifact of differences in the regional mix of industries although that clearly plays a role. Even after controlling for differences in the industry mix, there remain significant state-to-state variations and systematic regional differences.

Industry-to-industry differences dwarf all others. (Table 2). Not surprisingly, the working year was shortest in agricultural services (SIC 7)—the industry most closely related to agriculture and primarily representing cotton ginning and rice cleaning in the South with some grain threshing operations in the northern states. In this industry, establishments typically operated for about a third of the year or less. Establishments in two other industries also operated much less than year round—lumber products (SIC 24) and pottery and clay products (SIC 32). To the extent that lumber products industry was dominated by lumber mills, this finding is hardly surprising in an era when most mills depended upon logs arriving by water often riding seasonal floodwaters. Similarly, brick yards were heavily represented in SIC 32. In some industries, however, almost all establishments everywhere must have operated essentially year round. Printing and publishing establishments, for example, averaged more than 11.5 months in operation in both the 1870 and 1880 census years and blacksmiths and furniture makers averaged more than eleven months per year.

Within a few of these broad industry groups there were also some large differences between establishments producing various kinds of products. These are also reported in Table 2. Within the Food Group (SIC 20), for example, creameries and dairies (SIC 202) operated just about half the year on average, while flour mills (SIC 204) averaged better than three-quarters of the year and breweries (SIC 2082) operated closer to 11 months. In the Lumber Products Group (SIC 24), lumber mills (SIC 242) operated an average of 7 months of the year while coopers (SIC 249) worked between 9 and 10 months. Brick yards (SIC 325) ran about half of the year; potteries (SIC 326) produced for about 10 months, on average.

The seasonal nature of some activities revealed by our data—for example, agricultural services, meat packing, and lumber milling—comes as no surprise. Indeed we would have doubted our data had this proved otherwise. Some industries such as construction or food canning were—and still are—seasonal while other industries such as textiles are less so, except to the extent that bad weather interrupted power or disrupted shipments, or the plant chose to close for a scheduled event such as a summer vacation.

Do the Data Tell Us Anything about Unemployment?

It is clear even from a casual review of the data that larger establishments typically worked more months than smaller ones. This is a matter of some importance. Policy-makers were generally not concerned about unemployed capital in closed-down factories. However, people idled for lack of work and their families "in want" for lack of income presented a different picture. Consequently, when and where states reported statistics on labor unemployment, they typically reported these data by occupation rather than by industry. This makes it difficult to compare our data on plant shut-downs and "short-work" with the unemployment data. We have tried to adjust for this by reporting months of operation for narrowly defined industry groups in which occupations are presumably more homogeneous and reporting a weighted average where the weights are provided by the number of employees.

Weighting has a big impact. Nationally, the weighted average of annual months of operation in 1870 is estimated at 10.75 months compared with 9.94 months for the unweighted data. This difference is both large and highly significant statistically (t-statistic = 14.5). The difference was not as extreme in 1880, perhaps because some of the very largest establishments were not enumerated as part of the regular census and their census records have never been found—but it remained large and statistically significant. In that year, the average employee could expect to work 10.57 months of the year whereas the average establishment worked only 10.11 months (the t-statistic for the difference between these means was 10.7). The aggregate national statistics, weighted by employment in each establishment, are reported in Appendix B for those industries in which we have at least 10 establishments in our samples.[20]

This exercise is useful because we know things about the establishments in our samples that we do not know about the former employers of the unemployed workers—for example, the capital-labor ratio, the gender and age mix of the workforce, the location, and the source of power.[21] Unfortunately, the documentary evidence on unemployment was not collected at the same time as the censuses. Consequently, given the differences in timing and the impact of the business cycle on unemployment, we did not expect an exact match.

This comparison between the census data and the state survey data plays two roles. First, the survey data serve as an independent check and a benchmark for the census data. Second, we seek to draw attention to these scattered estimates of months of operation in early state BLS surveys that are either unknown or have been ignored. Where we use occupational data alone, we implicitly assume that workers with each skill were necessary for the successful production of a finished product and that the establishment employed them in fixed proportions.

The most extensive data for the period covered by our samples are for Massachusetts. These data were not analyzed by Keyssar. In Table 3, we compare some of our estimates by industry at the 3 digit SIC level (the basic product level) in 1870 and 1880 with the scattered Massachusetts Bureau of Labor Statistics data for these same industries or, where necessary, for specific occupations in these industries. These data are reported in terms of the number of days worked per year—the metric reported in the Massachusetts BLS reports. We have translated our estimates of annual months of operation into days by assuming that there were 309 working days per year, that is 25.75 days per month. This is approximately the mid-point of working days per year used by the Massachusetts BLS at various times.[22] Some of the figures are very close to one another—particularly the aggregate, state-wide data. For example, based on the 1875 state census, the Massachusetts BLS concluded that the 233,000 people then employed in manufactures in the state worked an average of 267 days (Massachusetts. Bureau of Labor Statistics 1879). This compares with our estimate for 1870 of 261 days with a 95% confidence interval of 248 to 274 days and 268 days with a confidence interval of 262 to 274 days in 1880. Indeed, the 1875 Massachusetts data are most like our sample data. The occupational figures reported in the 1876 report fit the least well with our data (Massachusetts. Bureau of Labor Statistics. 1876). Interestingly, these 1876 data tended to be much lower than our industry estimates where these occupations dominated.

There are also good data on the number of weeks worked by establishments and by workers in different occupations in Ohio, principally during 1877 (Ohio. Bureau of Labor Statistics. 1879). These were collected by a survey sent to over 1800 establishments. Responses were received from about 50 percent of the plants, but we do not know how these differed from the non-respondents. In Table 4 we report estimates from our Ohio state samples for 1870 and 1880 for those industries at the three digit SIC level where we had at least ten establishments reporting and compare them with estimates from the Ohio BLS report (Ohio. Bureau of Labor Statistics. 1879). Since the Ohio BLS reported operation during the year in terms of weeks, we have converted the months reported by the federal censuses to weeks by multiplying by 4.33. Once again, we are struck by the general degree of concordance between our data for the census benchmark years and the state survey data, making due allowance for the differences in timing. Statewide, for example, the Ohio BLS estimated that workers worked an average of 44.4 weeks during the year (1877) while our samples produce estimates of 46.2 weeks in 1870 and 44.2 weeks in 1880.

Some Implications of our Findings on Months of Operation in 1870 and 1880

Today, most workers seem to prefer certain and long-term working arrangements to shorter, less certain spells. Workers with greater risk of unemployment have to be paid a compensating differential. Not only is unemployment generally regarded as a bad, but workers subject to periodic unemployment have to spread their earnings over time to smooth consumption and may be forced to engage in (possibly expensive) job searches. Consequently within a model of compensating differentials, we would expect that workers in industries where the aggregate employment spells over the course of the year were shorter would demand and receive higher wages. We find very strong evidence of this with our 1870 and 1880 data.

We have estimated the following crude wage equation:

$$\ln \text{(monthly wage per worker)} = \beta_0 + \beta_1(\text{\% labor force adult male}) + \beta_2(\text{months of operation}) + \Sigma^n_{i=3}\beta_i(D_i)$$

where D_i is a matrix of state and/or industry dummies. If the disamenity/compensating wage differential story is consistent with the data then the coefficient, β_2, on months of operation would be negative. This proved to be the case (Table 5). Indeed, for such a simple specification standard errors were very low and we estimate the coefficients with a relatively high degree of precision. The coefficient on months of operation implies between a 1 and 2.5 percent reduction in the monthly wage rate for a one month increase in employment. This is not an especially large impact but the result is consistent and clearly measurable. In 1870, a regression weighted by employment, showed an effect that was much larger—on the order of a 7 percent premium. For 1880, however, results from the weighted regression were similar to the unweighted ones. In each equation, the constant term represents food processing establishments and/or Massachusetts.

Based upon the dummies, labor in most southern states was paid well below the monthly wages in Massachusetts. Wages in Arkansas and Mississippi were especially low. Those in California were especially high. There were also significant differences between industries. These were much larger than the premium associated with seasonal work.

One story of the changes that accompanied industrialization is of a lengthening of the working year to make better use of the growing fixed capital in establishments (see, for example, (Sokoloff 1984)) and an intensification of labor as work came to be paced by the machines whose introduction was facilitated by the division of labor (Goldmark and Brandeis 1912). Our observations of the months of operations in 1870 and 1880 do not provide a establishment basis for a trend in the length of working year over the course of the nineteenth century but scattered documentary and anecdotal evidence (for example, from the 1832 McLane Report (United States. Dept. of the Treasury. 1969), Massachusetts Bureau of Labor reports such as (Massachusetts. Bureau of Labor Statistics. 1872) and the 1880 Weeks' Report (United States. Census Office. 10th census 1880., Walker et al. 1991, v. 20)) clearly support the argument and our evidence is also consistent with it. For example, PROBIT regressions where the dependent variable is either fulltime (that is year round operations = 0) or part-time (fewer than 12 months of operation per year =1) ascribe a large impact to the capital-labor ratio with more capital-intensive firms being much less likely to operate only part-time, although industry-to-industry differences still dominate.

Firms in certain industries (such as bakeries or printers and publishers) were much more like to operate year round than establishments in other industries. Establishments in certain states and regions (for example, the New England states) typically operated more months of the year than those in others. Moreover, smaller establishments (regardless of metric) worked fewer months than larger establishments regardless of industry or state. Unfortunately, these regularities prove of little use in modeling the establishment's choice of how many months of the year to operate, let alone developing a complete supply and demand model of the decision. We know absolutely nothing, for example, about the workers employed by the establishment beyond the most general gender and age composition and assumptions about the pool from which they were drawn—the population residing in the general area where the plant was located. We also know nothing about the precise production technology and methods employed by the establishment or the nature of demand for the product beyond, for example, the establishment's capital-labor ratio and its use of inanimate power. Consequently, we haven't even tried to model the determination of months of operation.

Our data raise some questions about other aspects of the argument regarding intensity of operation and labor use. Months of operation were negatively correlated with the use of inanimate power which was essential for mechanization. This result holds true if inanimate power is restricted to steam power. On the other hand, months of operation were positively correlated with hours of work per day, although the correlation was not particularly high (correlation coefficient = 0.098).[23] Consequently, in 1880 at least, workers working more days per year also worked more hours each day consistent with the position of Marglin (Marglin 1974) and others. However, without detailed information about the tasks being performed and how these were organized and supervised the evidence is not definitive. To add to the confusion, our data also suggest a modest decline in value-added per worker and per male equivalent worker between 1870 and 1880. This decline is more marked when the data are adjusted for months of operation and are most pronounced among the largest establishments (which we have defined as those reported as producing $100,000 or more of output valued in nominal dollars).[24]

We have, however, tried—unsuccessfully—to find ways to discriminate between establishments working different numbers of months per year. Regressions, for example, using the characteristics of the establishments—particularly, industry, location and size (the factors noted above) do better than a random assignment (that is to say we get an R^2 greater than zero), but not that much better and not always reliably. One such regression for lumber mills is shown in Table 6. Establishment size, measured here by output (in hundreds of thousands of dollars) was statistically significant and relatively large in that for each addition $100,000 of output, the typical establishments would work almost 1.5 extra months per year. A mill producing $100,000 worth of lumber, however, had better not be located in Arkansas—the omitted state variable in the equation—where the very smallest lumber mills worked an average of 10.5 months (actually 10.515 hours) during the 1870 census year, otherwise, our equation predicts that it would have worked (fractionally) more than 12 months of the year. In most other states, the very smallest lumber mills operated much less than 10.5 months per year. For example, very small mills in New Hampshire worked 5 months less (actually 5.03 months), that is 5.48 months per year. Based upon this regression, only those lumber mills in New Hampshire producing more than about $400,000 would have worked close to 12 months of the year. None in the lumber mills in the 1870 New Hampshire sample was that large and the only lumber mill there which reported working year round produced just $3000 worth of sawn lumber—much less than the $400,000+ predicted by the regression equation. We give this example to illustrate what a poor job any regression does in predicting months of operation.

Given this experience, it should not be surprisingly that efforts to use discriminant analysis which attempts to find orthogonal weighted combinations of characteristics separating one set of observations from another were even less successful. As a result we have little to say about the estimates of months of operation themselves beyond what we have said already. They are what they are and they appear internally consistent and fit well with other external evidence.

Our solution to this conundrum was to resort to brute force over finesse: Monte Carlo simulation. We know the exact distribution of months of operation by industry and by state. By industry, sample sizes are generally "large"—20 or more for most industries found in 1850 or 1860; several hundred for the most common industries such as flour and lumber milling, leather tanning, boots and shoes and blacksmithing. Sample sizes are also large at the state level—typically 200 or more. Unfortunately cell sizes when the data are classified by industry and state are often unacceptably small. We have therefore only classified establishments by industry because it is here that we find the greatest differences and where our primary interests lie.

The advantage of Monte Carlo simulation is its ability to reproduce exactly any arbitrary distribution. The method is simple. Our 1870 national sample provides an unbiased estimate of the distribution of months of operation by industry taking account of any state to state variations within the industry. It accomplishes this by correctly weighting observations from each state within the overall distribution (although the separate state themselves are not identified). Thus, for example, among printing and publishing establishments, no establishments reported operating less than 6 months of the year; 1.54 percent reported working 6 months; 3.08 percent reported working 7 and 8 months each; none reported 9 months, 89.2 percent reported operating year round and the rest worked 10 or 11 months of the year. The distribution is far from normal and is discontinuous. Yet it is easily simulated using Monte Carlo methods. The pseudo-random number generator generates uniformly distributed random numbers over the interval from zero to one. Since 1.54 percent of establishments in the industry work six months and none reported working less, if we assign a value of 6 months of operation whenever the random number generator produces a value of 0.0154 or less, this will occur on average about 154 times for every 10,000 draws, that is to say 1.54 percent of the time. If the random number generator produces a number between 0.0154 and 0.0462, which it will do about 3.08 percent of the time, we assign a value of seven to the months of operation, and so on for the cumulative percentage distribution of hours. Thus, months of operation are assigned a value of 8 for random numbers between 0.0462 and 0.769. The only trick in this method is that random numbers between 0.0769 and 0.923 are assigned 10 months of operation per year. As a result, no establishments are predicted to work nine months. The result is an almost perfect ability to reproduce this arbitrary and discontinuous distribution of months of operation at will. Indeed the method works particularly well because of the absence of any strong correlates (positive or negative) with months of operation. Increasing the number of samples drawn increases the precision of our estimates but each is an unbiased estimate of the underlying population. The advantage of this procedure over using the simple mean is that rather than produce a single point estimate, it can generate the entire distribution of plausible values from which confidence intervals and the like can be constructed.

We have used the resulting simulated estimates of the number of months of operation for each establishment in the 1850 and 1860 samples as our best estimate of how long that establishment might have operated during those earlier census years. Our purpose is to gauge the impact of less than year round operation on estimates of the establishment rate of profit by Bateman and Weiss (Bateman, Foust et al. 1975); (Bateman and Weiss 1981) and by Atack and Bateman (Atack and Bateman 2000). This is desirable because, at these earlier censuses, wages were reported as the average monthly wage bill so as to accurately reflect average monthly earning of the typical worker rather than the aggregate cost of labor over the census year. Consequently, in the absence of better information and to bias their profit estimates downwards, Bateman and Weiss and others have assumed year round operation and employment. We believe that the data on months of operation from the 1870 and 1880 censuses provide us with a better means of dealing with this problem.

Basing our estimate of annual labor costs in 1850 and 1860 on monthly wages then and the distributions of months of operation by industry at the later censuses raises the average establishment rate of return by about a third—in other words, wages were an important business cost (Table 7). In 1850, the median establishment rate of return as estimated by the methods usually used by Bateman and Weiss and by Atack and Bateman was 14.2% (8.1% weighted by capital). In 1860, the median rates of return were 14.3%, or 12.2% if weighted by capital. After taking into account the distribution of months of operation in 1870 and imposing the same distributions upon 1850 and 1860, we generated estimates of the rates of return for each establishment using the Monte Carlo methods described above. Here we report the results of just ten runs. Additional runs would narrow the standard errors but not, we believe, change our estimates much. Mean returns were higher but we report the medians because they are invariant with the symmetric truncation of outliers which possibly reflect data or transcription errors. Indeed, in Table 7, we also report the 1^{st} – 99^{th} and the 5^{th} – 95^{th} percentile spreads.

The unadjusted returns in 1850 and 1860 have represented something of a puzzle. They were low compared with parallel estimates for 1870 and 1880. In those years, the median returns estimated by Atack and Bateman were 24.6% (4.9% weighted by capital) in 1870 and 23.9% (8.3% weighted) in 1880. The result of the adjustment to putative months of operation in earlier years was to narrow the difference between establishment rates of return across the entire range of samples sharply. Most significantly, however, the weighted returns now look very close to those in alternative activities such as agriculture.

Concluding Remarks

Anecdotes and scattered documentary evidence have long suggested that many industrial establishments operated only part of the year during the nineteenth century. Our data from the 1870 and 1880 censuses of manufacturing provide the first hard, comprehensive, evidence on this important aspect of work, albeit for late in the century when (presumably) operations were becoming more year round. By the mid/late nineteenth century, the typical establishment was operating year round but there were still many which did not. These tended to be smaller establishments and located in the South. Patterns of seasonality in production still present today were apparent in these data too. If months of operation are weighted by employment, the resulting numbers (regardless of the metric in which they are expressed) correspond surprisingly closely with estimates of the time that workers were spent out of work around then. The estimates also suggest that labor productivity gains were less rapid than hitherto supposed as a result of systematic bias in the overstatement of labor inputs earlier on in the century relative to later. This in turn provides a somewhat different perspective on the debate over the intensification of labor effort with the coming of the factory and the mechanization of the production process. Finally, applying these data on months of operation to earlier census years raises estimated rates of return in manufacturing, reducing some the Civil War decade discontinuity and providing a measure of the downward bias imparted to rates of return by the conservative estimating techniques used by Bateman and Weiss.

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TABLE 1

Average Months of Operation for Manufacturing establishments During the 1870 and 1880 Census Years, by Region

Region	1870	1880
Midwest	9.82	10.18
Northeast	10.25	10.36
Pacific West	9.82	10.13
South	9.26	9.35
Nation	9.94	10.11

Note: See text for method of computation.

Source: Computed from the national samples of manufacturing establishments collected by Jeremy Atack and Fred Bateman and available from http://www.vanderbilt.edu/Econ/faculty/ Atack/atackj.htm

TABLE 2

Average Months of Operation by Industry Group, 1870 and 1880

Standard Industrial Classification Grouping	Industry	1870	1880
7	Agricultural Services	3.78	4.13
17	Construction Services	9.36	10.12
20	Food Processing	9.25	9.53
201	Meat Packing	7.24	10.62
202	Creameries and Dairies	6.19	5.34
204	Flour Milling	9.77	9.46
208	Distilled Liquors	5.59	7.72
208	Breweries	10.75	11.23
21	Tobacco Products	10.80	10.79
22	Textile Products	10.16	9.97
23	Clothing	11.23	10.79
24	Lumber Products	7.84	8.29
242	Lumber Milling	6.92	7.10
244	Barrels	9.86	10.45
25	Furniture	11.50	11.18
26	Paper		10.69

TABLE 2 (continued)

Standard Industrial Classification Grouping	Industry	1870	1880
27	Printing and Publishing	11.58	11.59
28	Chemicals	8.78	10.19
31	Leather Products	11.20	11.13
32	Pottery and Clay Products	7.41	7.53
325	Bricks	5.55	6.19
326	Pottery	9.88	10.54
328	Cut Stone	9.22	10.26
33	Primary Metals Products	10.49	9.96
34	Fabricated Metal Products	10.85	11.25
35	Machinery	10.20	11.01
37	Transportation Equipment	11.07	10.88
38	Instruments		11.87

TABLE 2 (continued)

Standard Industrial Classification Grouping	Industry	1870	1880
39	Manufacturing not elsewhere classified	10.59	10.81
76	Blacksmithing	11.18	11.30

Note: See text for method of computation. Only industries with more than 15 observations are reported.

Source: Computed from the national samples of manufacturing establishments collected by Jeremy Atack and Fred Bateman and available from http://www.vanderbilt.edu/Econ/faculty/ Atack/atackj.htm

TABLE 3

Estimates of the Average Number of Days of Operation per Year in Massachusetts Manufacturing Industry

SIC Code	Industry	Federal Census of Manufacturing (Range for 95% Confidence Interval)		State BLS data **1875(B)** (1871-1882 range, excluding 1875)
		1870	1880	
175	Carpentry		255 (13)	**251** (219-281)
204	Flour Milling		211 (57)	
205	Bakeries		309 (0)	**295** (295-307)
231	Men's Clothing		270 (30)	**263** (273-294)
242	Lumber Milling	170 (56)	214 (39)	**227** 295
251	Machinery		279 (41)	**283** (256-303)
273	Printing (books)		283 (29)	**296** (300-312)

TABLE 3 (continued)

SIC Code	Industry	Federal Census of Manufacturing (Range for 95% Confidence Interval) 1870	1880	State BLS data **1875(B)** (1871-1882 range, excluding 1875)
311	Leather tanning		263 (48)	**286** (183-310)
314	Boots and Shoes	269 (22)	255 (16)	**239** (163-281)
352	Agricultural implements		281 (31)	**272** (256-291)
769	Blacksmith		290 (20)	**280** (257)
	All Manufacturing	261 (13)	268 (6)	**267**

1871: (Massachusetts. Bureau of Labor Statistics. 1872)

1875A: (Massachusetts. Bureau of Labor Statistics. 1876)

1875B: (Massachusetts. Bureau of Labor Statistics 1879)

1882: (Massachusetts. Bureau of Labor Statistics 1879)

TABLE 4

WEEKS OF OPERATION BY OHIO MANUFACTURING ENTERPRISES

(Estimates weighted by employment)

Figures in parentheses represent 95% Confidence Interval Range

SIC Code	Industry	Federal Census data		State BLS estimate
		1870	1880	
175	Carpentry	41.6 (4.4)	42.9 (3.2)	
204	Flour Milling	41.9 (5.4)	40.3 (3.7)	51.0
205	Bakeries		50.0 (3.4)	52.0
212	Cigars	50.2 (3.0)	50.8 (2.2)	52.0
231	Men's Clothing	47.3 (4.6)	49.4 (2.5)	
242	Lumber Milling	31.6 (3.6)	32.1 (3.1)	
243	Planning Mills		47.1 (1.6)	47.3
244	Cooperage	49.2 (3.3)	43.6 (5.2)	41.7

TABLE 4 (continued)

SIC Code	Industry	Federal Census data		State BLS estimate
		1870	1880	
251	Furniture	51.2 (1.5)	51.1 (1.2)	50.5
311	Leather Tanning	46.6 (4.6)		49.7
314	Boots and Shoes	50.5 (1.1)	47.6 (1.2)	45.3
352	Agricultural Implements	50.4 (3.5)	50.5 (5.0)	48.4
379	Carriages and Wagons	51.5 (1.0)	49.9 (1.8)	46.3
769	Blacksmithing	50.2 (1.5)	50.2 (1.3)	
	All Manufacturing	46.2 (0.9)	44.2 (0.8)	44.4

TABLE 5 Reduced Form Wage Equations (Standard errors) Dependent Variable = log(monthly wage per worker)						
Independent variable	1870			1880		
	(1)	(2)	(3)	(4)	(5)	(6)
Months of operation	-0.01112** (0.00458)	-0.02034** (0.00404)	-0.01532** (0.00448)	-0.01546** (0.00331)	-0.01544** (0.00299)	-0.02124** (0.00320)
% male	0.58211** (0.06938)	0.50156** (0.05967)	0.58406** (0.06767)	0.61470** (0.04924)	0.43496** (0.04162)	0.64104** (0.04731)
Constant	2.97496** (0.08393)	3.22768** (0.09042)	3.17561** (0.09908)	2.68799 (0.05861)	3.19723** (0.05706)	3.03304** (0.06494)
State Dummies	No	Yes	Yes	No	Yes	Yes
Industry Dummies	Yes	No	Yes	Yes	No	Yes
R^2	0.092	0.094	0.149	0.082	0.104	0.160
Number of observations	3946	3946	3946	7403	7403	7403

** Significant at the 1% level or better.

TABLE 6 The Relationship between Months of Operation and establishment Size and Location in Lumber Milling, 1870 Dependent variable: Months of Operation				
Independent Variable	Coefficient.	Standard Error	95% Confidence Interval	
			Lower bound	Upper bound
Output (in $100,000)	1.496	0.387	0.736	2.257
Alabama	-1.215	2.413	-5.955	3.524
District of Columbia	(dropped)			
Florida	-2.039	2.605	-7.157	3.079
Georgia	(dropped)			
Kentucky	-4.357	2.497	-9.262	0.548
Louisiana	(dropped)			
Maryland	(dropped)			
Mississippi	-2.564	3.114	-8.681	3.553
North Carolina	-4.608	2.346	-9.216	-0.001
South Carolina	-1.785	3.113	-7.899	4.330
Tennessee	-2.923	2.322	-7.485	1.638
Texas	-2.091	2.605	-7.208	3.026
Virginia	-4.962	2.356	-9.590	-0.335
West Virginia	-4.105	2.498	-9.012	0.802
Illinois	-3.477	2.462	-8.314	1.360
Indiana	-4.179	2.246	-8.591	0.233
Iowa	-4.255	2.394	-8.959	0.448
Kansas	-6.585	2.697	-11.883	-1.286
Michigan	-4.368	2.239	-8.766	0.030
Minnesota	-4.031	2.542	-9.024	0.963
Missouri	-2.501	2.296	-7.011	2.009
Nebraska	(dropped)			

TABLE 6 (continued)				
Independent Variable	Coefficient.	Standard Error	95% Confidence Interval	
			Lower bound	Upper bound
Ohio	-4.279	2.242	-8.684	0.126
Wisconsin	-4.206	2.327	-8.778	0.366
Connecticut	-3.644	2.380	-8.319	1.030
Delaware	(dropped)			
Maine	-3.302	2.300	-7.821	1.217
Massachusetts	-4.029	2.412	-8.768	0.710
New Hampshire	-5.037	2.395	-9.741	-0.334
New Jersey	-0.909	2.435	-5.692	3.875
New York	-3.332	2.236	-7.725	1.061
Pennsylvania	-4.345	2.227	-8.719	0.030
Vermont	-2.156	2.328	-6.730	2.418
California	-2.362	2.378	-7.034	2.309
Oregon	-1.210	2.696	-6.506	4.087
Washington	(dropped)			
Constant (Arkansas)	10.515	2.204	6.186	14.845
Adjusted R^2 = 0.0657		Number of observations = 570		

TABLE 7

The Impact of Less Than Year Round Operation on Rates of Return, 1850-60.

	Adjusting for distribution of months			Assuming year round operation by all establishments
	Median	Range: 1^{st} –99^{th} percentile	Range: 5^{th} –95^{th} percentile	Median
1850				
By establishment	20.3%	-91.8 – 189.3%	-26.6 – 105.6%	14.2%
Weighted by capital	11.2%	-28.8 –127.1%	-11.1 – 60.4%	8.2%
1860				
By establishment	19.9%	-82.7 – 174.2%	-23.4 – 101.9%	14.3%
Weighted by capital	15.2%	-60.9 – 116.4%	-10.6 – 66.9%	12.2%

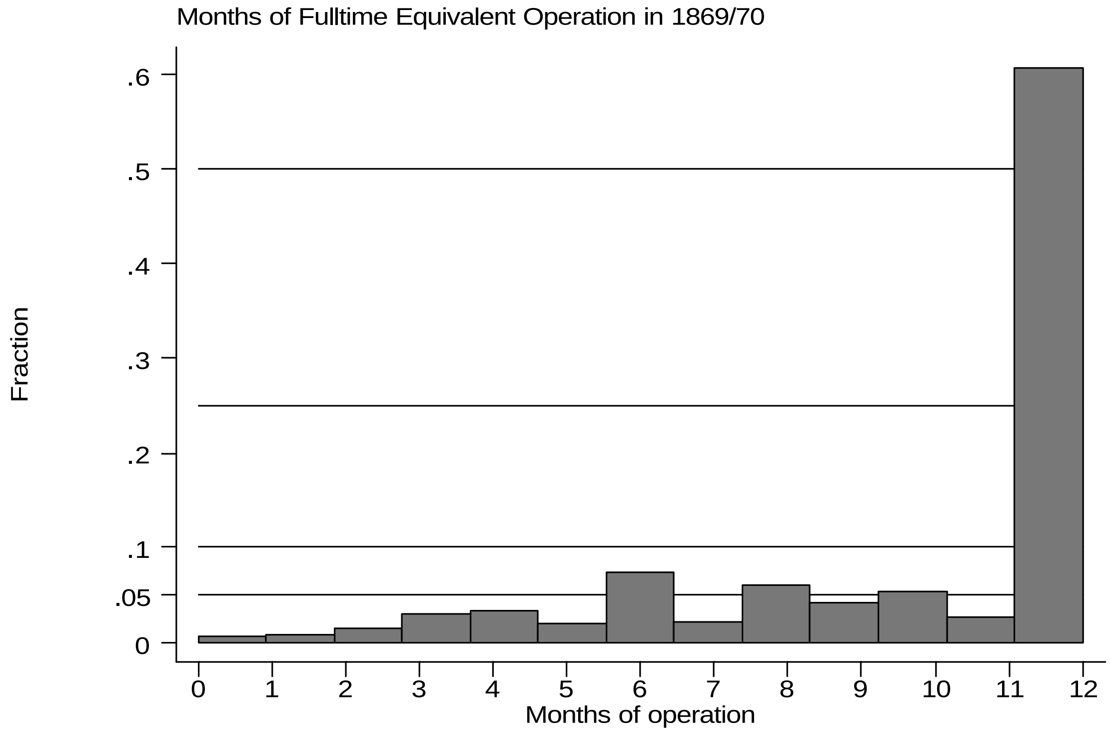

FIGURE 1

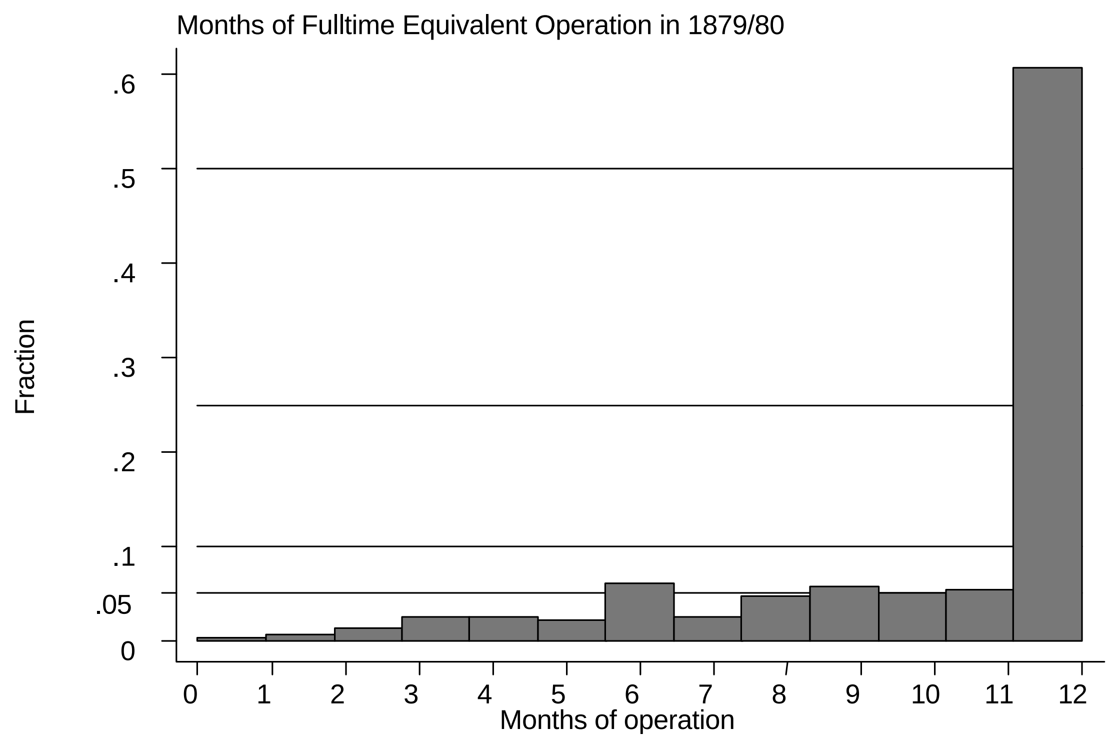

FIGURE 2

APPENDIX A

Average Months of Operation by State and Census Year

(State samples)

Figures signed "±" represent the range for the 95% confidence interval = ±1.96 times the standard error

	1870	1880
Alabama	9.75	8.36
	±0.38	±0.34
Arkansas	9.12	8.20
	±0.47	±0.43
District of Columbia	11.57	10.90
	±0.23	±0.23
Florida	7.86	8.62
	±0.46	±0.47
Georgia	Not available	9.15
		±0.42
Kentucky	9.81	9.72
	±0.39	±0.35
Louisiana	Not available	7.88
		±0.38
Maryland	Not available	10.49
		±0.30
Mississippi	8.73	8.39
	±0.41	±0.38
North Carolina	8.26	9.11
	±0.42	±0.35

APPENDIX A (continued)		
	1870	1880
South Carolina	8.46	8.05
	±0.49	±0.51
Tennessee	8.88	9.00
	±0.71	±0.37
Texas	9.07	8.37
	±0.44	±0.38
Virginia	10.06	9.60
	±0.37	±0.41
West Virginia	9.61	9.28
	±0.42	±0.44
Illinois	10.50	10.42
	±0.22	±0.22
Indiana	9.18	9.71
	±0.41	±0.30
Iowa	9.77	10.59
	±0.33	±0.29
Kansas	9.15	10.13
	±0.41	±0.34
Michigan	9.16	10.39
	±0.33	±0.27
Minnesota	10.13	10.06
	±0.41	±0.34
Missouri	9.95	9.88
	±0.27	±0.35
Nebraska	Not available	9.97
		±0.34

APPENDIX A (continued)		
	1870	1880
Ohio	9.93	10.22
	±0.24	±0.18
Wisconsin	10.26	10.02
	±0.39	±0.30
Connecticut	10.11	10.66
	±0.41	±0.30
Delaware	10.79	10.17
	±0.29	±0.34
Maine	9.83	9.41
	±0.44	±0.33
Massachusetts	10.13	10.42
	±0.51	±0.22
New Hampshire	7.56	9.77
	±0.68	±0.32
New Jersey	10.66	10.49
	±0.31	±0.28
New York	10.39	10.50
	±0.19	±0.14
Pennsylvania	10.34	10.39
	±0.18	±0.16
Vermont	10.33	10.02
	±0.40	±0.33
California	10.03	10.49
	±0.47	±0.32

APPENDIX A (continued)		
	1870	1880
Oregon	9.91	9.41
	±0.45	±0.40
Washington	Not	9.26
	available	±0.35

APPENDIX B

Average Number of Days in Operation During the Census Year by Industry Group

(National sample. Weighted by Employment)

SIC code	Industry	1870		1880	
		Mean	95% Range	Mean	95% Range
7	Agricultural Services	91	±15	114	±19
13	Oil	292	±23		
17	Construction Services	249	±7	269	±4
20	Food Processing	247	±7	225	±5
21	Tobacco Products	272	±11	291	±5
22	Textiles	301	±6	266	±18
23	Clothing	295	±5	295	±4
24	Lumber Products	226	±6	229	±5
25	Furniture	302	±4	287	±6
26	Paper	297	±12	283	±10
27	Printing and Publishing	306	±5	303	±5
28	Chemicals	283	±15	267	±10
31	Leather Products	286	±3	281	±2
32	Stone, Brick, and Clay Products	187	±13	215	±9
33	Primary Metals	279	±9	273	±15
34	Fabricated Metal Products	270	±12	296	±4
35	Machinery	279	±12	293	±4
37	Transportation Equipment	299	±4	298	±4

APPENDIX B						
SIC code	Industry	1870		1880		
		Mean	95% Range	Mean	95% Range	
38	Precision Instruments			308	±3	
39	Miscellaneous Manufacturing	293	±9	287	±7	
49	Gas and Coke	305	±10	297	±17	
76	Blacksmithing	290	±4	291	±3	
	All Manufacturing Industries	277	±2	272	±1	

Months converted to days at a rate of 25.75 days per month with the results rounded UP to the nearest whole day. Range describes (approximately) the 95 % confidence interval around this mean as we have rounded the bounds up to whole days.

ENDNOTES

[1] For resistance to changing the customary hours of work, see Atack, J. and F. Bateman (1991). Whom Did Protective Legislation Protect? Evidence from 1880. NBER Working Paper Series on Historical Factors in Long Run Growth. Cambridge.; Atack, J. and F. Bateman (1992). "How Long Was the Workday in 1880?" Journal of Economic History **52**(1): 129-60.; and Whaples, R. M. (1990). The Shortening of the American Work Week: An Economic and Historical Analysis of its Context, Causes, and Consequences. Economics. Philadelphia, University of Pennsylvania**:** 499.. Moreover, months of operation and daily hours were positively correlated (R=0.088) in 1880 suggesting that they were complements rather than substitutes.

[2] These are available from http://www.vanderbilt.edu/Econ/faculty/Atack/atackj.htm.

[3] 1832 estimate based upon data from the McLane Report (United States. Dept. of the Treasury. (1969). Documents relative to the manufactures in the United States. New York,, A. M. Kelley.) provided by Kenneth Sokoloff whom we thank for sharing these data.

[4] See Weiss, T. (1994). Economic Growth before 1860: Revised Conjectures. American economic development in historical perspective. T. Weiss and D. e. Schaefer. Stanford, Stanford University Press**:** 11-27. and U.S. Bureau of the Census (1975, Series D75-77 and D152 and 153).

[5] For women, these fractions were reversed for the two seasons. See Engerman, S. and C. Goldin (Ibid.). Seasonality in Nineteenth-Century Labor Markets**:** 99-126..

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[6] See, in particular, the Seventh Annual Report Massachusetts. Bureau of Labor Statistics. (1876). Seventh Annual Report. Boston, Wright & Potter. and the Tenth Annual Report Massachusetts. Bureau of Labor Statistics (1879). Tenth Annual Report. Boston, Rand, Avery & Co. both of which used data collected for the 1875 Massachusetts state census.

[7] We differ in that the Massachusetts BLS converted months to days, assuming 308 working days in a year, whereas for reasons discussed below, we assume 309 days per year.

[8] Some of these may, in fact, be newly established firms just getting into operation but ,absent any specific note on the census manuscripts, we cannot distinguish them from those establishments which chose to shutdown for part of the year. However, since the population of business establishments was growing over time, new start-ups typically exceeded permanent closures.

[9] Unfortunately, most reported a non-zero output for the year which seems inconsistent with their reported months of operation though it may reflect sales from inventory. At the same time most establishments reporting zero output for the census year reported non-zero months of operation. Consequently, it seems unwise to use zero output as an indicator for an idled plant.

[10] Just shy of 60 percent (59.94%) reported 11.5 or more months of operation per year during the 1880 census year.

[11] The t-statistic (-3.19) testing that there was no difference between the two means leads to the rejection of the hypothesis at greater than the 99.5% confidence level.

[12] Contemporaries generally report between 308 and 310 working days per year. We have used 309 days both because it splits the difference and because the arithmetic works

out more nicely with 25.75 working days per month as opposed to 25.666 (recurring) or 26.833 (recurring). The picture is further complicated because 1880 was actually a leap year.

[13] As already noted, the Fourth Annual Report of the Massachusetts Bureau of Labor Statistics uses a working year of 308 days. In the Seventh Annual Report, they appear to use 310 days. See Massachusetts. Bureau of Labor Statistics. (1873). Fourth Annual Report. Boston, Wright & Potter. and Massachusetts. Bureau of Labor Statistics. (1876). Seventh Annual Report. Boston, Wright & Potter.

[14] See http://www.nber.org/cycles.html

[15]

1870: Omitted Dummies: Northeast Region, SIC 20 (Food)			
Independent Variable	Coefficient	Standard Error	t-statistic
Midwest	-0.41681	0.085902	-4.852
Pacific	-0.65742	0.264968	-2.481
South	-0.61322	0.119714	-5.122
SIC 7	-5.16158	0.412353	-12.517
SIC 13	1.566216	0.870469	1.799
SIC 17	0.070753	0.173878	0.407
SIC 21	1.478219	0.248908	5.939
SIC 22	0.733334	0.315379	2.325
SIC 23	1.926041	0.198708	9.693
SIC 24	-1.45868	0.142479	-10.238
SIC 25	2.241282	0.264398	8.477
SIC 26	1.29512	0.567423	2.282
SIC 27	2.29846	0.354897	6.476
SIC 28	-0.53083	0.322776	-1.645
SIC 30	-0.03378	1.93299	-0.017
SIC 31	1.901863	0.144412	13.17
SIC 32	-1.89043	0.258938	-7.301
SIC 33	1.171758	0.292823	4.002
SIC 34	1.502827	0.234674	6.404
SIC 35	0.909111	0.282608	3.217
SIC 36	0.278825	1.369032	0.204

SIC 37	1.777018	0.196113	9.061
SIC 38	1.174622	1.932667	0.608
SIC 39	1.300276	0.273556	4.753
SIC 49	1.428634	0.526881	2.711
SIC 76	1.938235	0.153503	12.627
SIC 99	0.624058	0.511328	1.22
Constant	9.533784	0.114164	83.51
n	5065		
r2	0.226		

1880: Omitted Dummies: Northeast Region, SIC 20 (Food)

Independent Variable	Coefficient	Standard Error	t-statistic
Midwest	-0.02902	0.067243	-0.432
Pacific	-0.40738	0.176287	-2.311
South	-0.53156	0.082634	-6.433
SIC 7	-5.05344	0.357063	-14.153
SIC 17	0.49634	0.123546	4.017
SIC 21	1.209715	0.17712	6.83
SIC 22	0.331397	0.365832	0.906
SIC 23	1.153363	0.157565	7.32
SIC 24	-1.26629	0.100881	-12.552
SIC 25	1.563318	0.186857	8.366
SIC 26	1.023553	0.353681	2.894
SIC 27	1.991047	0.225592	8.826
SIC 28	0.62829	0.241826	2.598
SIC 29	2.33585	2.617544	0.892
SIC 30	2.306828	1.51237	1.525
SIC 31	1.543434	0.105007	14.698
SIC 32	-2.0707	0.175243	-11.816
SIC 33	0.346176	0.296877	1.166
SIC 34	1.64379	0.158701	10.358
SIC 35	1.410471	0.150576	9.367
SIC 36	0.806828	1.07072	0.754
SIC 37	1.319252	0.183997	7.17
SIC 38	2.285805	0.482941	4.733
SIC 39	1.180052	0.193226	6.107
SIC 49	1.615705	0.561972	2.875
SIC 76	1.732762	0.111597	15.527
Constant	9.693172	0.074964	129.304
n	8127		
r2	0.189		

[16] In 1870, the t-statistic for no difference between the South and the Midwest (the region with the next lowest average number of months of operation) was –3.90. For 1880, the test statistic was –8.43. The hypothesis of no difference is not accepted with better than 99.5% certainty.

[17] See Jeremy Atack and Fred Bateman, "The Working Year in the Late Nineteenth Century: Some New Evidence," (working paper).

[18] The t-statistic testing for equality between the means is rejected at better than the 99 percent level for flour mills (t=5.47) and at the 95 percent level for cigar making (t=2.35)

[19] In 1870, the t-statistic for no difference between the Northeast and the Midwest was 4.60. For 1880, the test statistic was 2.55. The hypothesis of no difference is not accepted with better than 99% certainty.

[20] Unfortunately our Massachusetts data for 1870 is very limited because our student helpers who collected the original data 30 years ago neglected to write down the information on months of operation—a fact we only recently caught since we, like the original census enumerators, paid little attention to this particular piece of information. We plan on correcting this oversight in the near future.

[21] Indeed, none of the unemployment surveys provides <u>any</u> information about the employers.

[22] In the Third Annual Report (reporting data from 1871), the maximum number of days reported in the text and tables is 312 days (in Printing) Massachusetts. Bureau of Labor Statistics. (1872). <u>Third Annual Report</u>. Boston, Wright & Potter.; in 1875, 310 days Massachusetts. Bureau of Labor Statistics. (1876). <u>Seventh Annual Report</u>. Boston, Wright & Potter.; and in 1882, 307 days Massachusetts. Bureau of Labor Statistics.

(1883). Fourteenth Annual Report. Boston, Wright & Potter.. In subsequent work with the 1875 state census the Massachusetts BLS explicitly assumed a working year of 308 days Massachusetts. Bureau of Labor Statistics (1879). Tenth Annual Report. Boston, Rand, Avery & Co.. Our measure can simply be transformed between these different assumptions by use of the appropriate multiplier.

[23] Hours were only reported in 1880.

[24] The precise outputs of establishments in 1880 are not identified making price correction difficult except at the most aggregated level.