PRELIMINARY AND INCOMPLETE WORKING DRAFT

"The American Textile Industry in the Nineteenth Century: Were the Workers Exploited?"*

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ABSTRACT

Much has been written about the history of labor relations and labor force utilization in the American cotton textile industry. For example, a comparison is often drawn between the paternalistic "Lowell System" which employed large numbers of single, native-born women in integrated mills located in planned communities, and the "Rhode Island System" which made greater use of foreign-born workers and the employment of whole families without the provision of much in the way of public and social amenities. The large scale employment of women and children within a patriarchal culture coupled with substantial documentary evidence that these workers were paid lower wages than men working in the same plants has led to efforts to explore the issue of whether female workers were "exploited" in a neoclassical sense (i.e., paid a wage less than the value of their marginal product). Two previous studies by David and Zevin found evidence of this, but a more detailed look by Vedder, Gallaway, and Klingaman found no such evidence.

Here, we use data from the censuses of manufacturing between 1820 and 1870 and from the 1832 survey commissioned by Treasury Secretary Louis McLane to reexamine this question. The data have been geocoded so that they can be linked to county-level data from the population and economic censuses, particularly data on urbanization and they are supplemented by county-level wage data from the Social Statistics schedules for 1850-1870 for some states.

Preliminary work indicates that male workers were paid roughly their opportunity cost and marginal value product (about $1.00 per day) while female workers were paid less (about $.50 per day – below their marginal value product of about $.75 per day but above their opportunity cost of about $.25 per day).

The American Textile Industry in the Nineteenth Century:

Were the Workers Exploited?

At the time of the Revolution, textile production in America was dominated by household manufacturing which met most family's needs (Tryon 1917). This was supplemented by imports of higher valued, finer cloth and fabric. "Home spun" was the norm. The rapid spread of innovation in cotton textiles in Great Britain was, however, already revolutionizing the industry. Despite Britain's best efforts to prevent the spread of this new technology beyond her shores, in a familiar story, Samuel Slater slipped out of the country in 1789 with the secrets of the water frame and, with financial underwriting from the Providence Rhode Island merchants Almy and Brown, successfully established the first mechanized spinning mill using these new principles in the fledgling United States in December 1790. Within just two or three decades, it dominated manufacturing industry and only relinquished its primacy in the waning years of the nineteenth century.

Although it is unclear how much of Alexander Hamilton's thinking in his *Report on Manufactures* was conditioned by cotton textiles—efforts to duplicate England's success were already underway before Slater emigrated and the Report appeared within a year of the commencement of work at Almy and Brown and two years prior to the opening of Slater's spinning mill—but the industry certainly fit the model. As Hamilton observed "to maintain between the recent establishments of one country and the long matured establishments of another country, a competition upon equal terms, both as to quality and price, is in most cases impracticable" and argued that "the extraordinary aid and protection of government" might be necessary to redress the balance (United States. Dept. of the Treasury. and United States. Congress House. 1791). More importantly for this paper, he also argued "the husbandman himself experiences a new source of profit and support from the encreased industry of his wife and daughters; invited and stimulated by the demands of the neighboring manufactories" (United States. Dept. of the Treasury. and United States. Congress House. 1791).

II

In Rhode Island where the industry first took root, family employment, and particularly the employment of young children, was the norm. For example, all 72 spindles in the original Slater mill were operated by seven boys and two girls (White and Woodbury 1836). By 1816, the mill employed 68 people, 56 of them from 13 families, eight of them from just one family (Ware 1931, p.199). But, as the industry spread northwards into Massachusetts, employment became more individual than family-based, particularly of young women per Hamilton's suggestion.

These early mills followed the English model. They concentrated upon spinning—the activity where most innovation to date had taken place—while the weaving of cloth was "put out" to independent contractors, many of them operating out of their homes with family labor. In 1814 the industry changed again when Francis Cabot Lowell opened the Boston Manufacturing Company in Waltham, Massachusetts, the first mill to integrate spinning and weaving under one roof and making use of his powered loom developed with the help of Paul Moody.

These integrated mills, with the financial support of commercial capitalists looking for more secure investment opportunities, most notably the Boston Associates(Jeremy and Merrimack Valley Textile Museum. 1981; Dalzell 1987, Part I), quickly became large scale establishments—indeed, they became among the largest manufacturing enterprises in America until the emergence of Standard Oil and U.S. Steel. For example, as early as 1820 the Boston Manufacturing Company had 264 employees operating 5,376 spindles and 175 looms too process 450,000 pounds of cotton (United States. Census office. 4th census 1820. and United States. Dept. of State. 1823, p. 8), while the biggest mills by 1860 employed around 2,000 workers and produced millions of yards of cloth.

The growth of the industry in the Boston area, however, was handicapped by the limited waterpower potential of the Charles River. Consequently, beginning in 1822, the industry relocated to the newly established industrial town of Lowell along the banks of the Merrimack River about 20 miles to the north and other suitable waterpower sites (Hunter, Eleutherian Mills-Hagley Foundation. et al. 1979). In the newly established town, the mills found labor in short supply. Efforts to attract more workers ran into the prejudice and perceptions that factory girls (without the immediate support of family members—especially fathers and brothers--working alongside them to protect them) were little better—if at all—than prostitutes. In an effort to dispel this perception, Lowell instituted a system of closely-monitored boarding houses with dormitory sleeping and compulsory church and Sunday school attendance. The ploy succeeded and, with a promise of cash remittances "the daughters of respectable farmers were readily induced to come into these mills for a temporary period" (Appleton 1858, pp. 15-16, quoted in Dalzell 1987, p. 33). Many came from relatively great distances to work in the mills. The agent at Boott mills for example determined that the average distance traveled by the first group of women listed on their payroll was 70 miles and that less than 9 percent of the 816 person workforce had a permanent address in Lowell. High transport costs and lack of family support network in the vicinity must have reduced the job mobility of these long distance, temporary residents (Ware 1931, p. 219). Moreover, when this supply eventually fell short and became better organized, they were supplemented and eventually replaced by immigrants, often single women (Ware 1931, p. 232; Lazonick and Brush 1985).

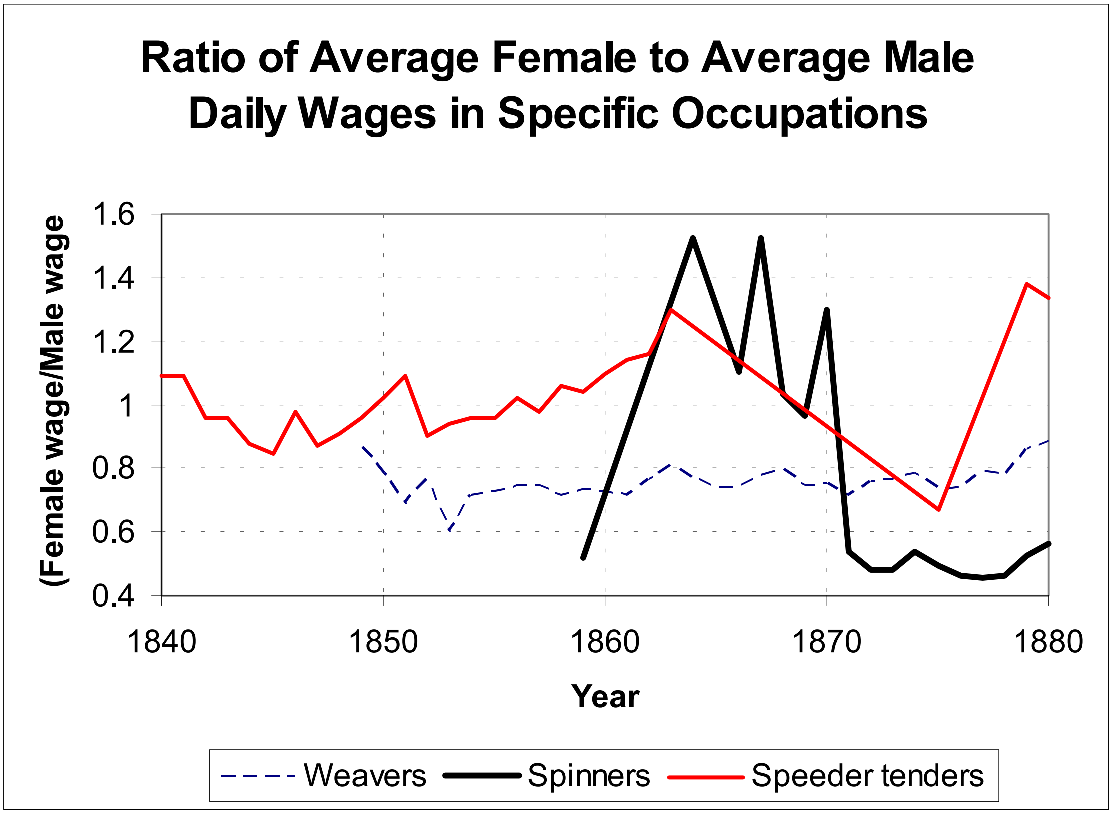
The rapid growth in textile output has been documented by Zevin, growing at better than 16 percent per year from 1815 to 1833 after which the rate of growth slowed to a more modest 5 percent or so through the outbreak of the Civil War (Zevin 1971). Employment grew more slowly thanks to labor productivity growth, some of which was the result of learning-by-doing and capital-deepening but some of which was the result of an intensification of work effort such as doubling the number of machines each employee tended (David 1975; Lazonick and Brush 1985). In 1811, it is estimated that about 4,000 hands were employed in the 87 mills then operating (United States. Census Office. and Edmunds 1990, xvii). By 1832, it had grown to more than 58,500 (sample count from McLane Report). Eight years later it was estimated to be over 72,000 (United States. Census Office. and Edmunds 1990, xix). At the 1850, almost 98,000 workers were reported for the industry and by 1860, employment was estimated at about 115,000(United States. Census Office. and Kennedy 1990, 43); (United States. Census Office. and Edmunds 1990, 735). Hidden behind these employment figures, however, are some important shifts in labor-force composition. In 1820, children made up 45% of the workforce in Massachusetts mills, 54% in Connecticut and 55% in Rhode Island. By 1832, child labor had declined to 21% in Massachusetts and 41% in Rhode Island (Ware 1931, p. 210). As the fraction of child labor declined, the percentage of workers who were female rose. In 1820 the Boston Manufacturing Company was employing 26 men, 225 women, and 13 children (United States. Census office. 4th census 1820. and United States. Dept. of State. 1823, p. 8). By 1832, the same factory was employing 96 men, 331 women, and no children. Similarly, in 1832, the Appleton Cotton Manufacturing Company used 50 men and 430 women; the Lowell Manufacturing Company employed 60 men and 230 women; the Merrimack Cotton Manufacturing Company had 312 men, 1,025 women, and 106 children p; and the Hamilton Cotton Manufacturing Company used 154 men and 672 women (U.S. Congress, 1833, Vol I, pp. 341-341, 372-373, 970-971).

By 1850, more than two-thirds of the Massachusetts cotton textile workers were women and nationwide they made up almost 64% of the workforce (United States. Census Office. and Kennedy 1990). As at earlier dates, the fraction of the workforce that was female in some firms was considerably higher that the average. At the Lawrence Manufacturing Company for example, 85% of the workforce was female in 1850. Eighteen fifty seems to represent the high tide in “feminization” of the industry as shares declined slightly at subsequent censuses.[1] Impressive as these numbers are, perhaps even more importantly cotton textiles accounted for about a quarter of all female industrial workers or about the same fraction as were employed in the “needles” trade (i.e. clothing) which is more commonly associated with female employment.

There have been efforts to explore the issue of whether these workers, particularly women and children, were "exploited" in a neoclassical sense. That is, were they were paid a wage less than the value of their marginal product? The question of exploitation, however, presupposes monopsony power in labor markets by individual firms, such as the classic "company town" model. Two previous studies by David (David 1970) and Zevin (Zevin 1977) have used individual firm data found evidence of exploitation. But a more detailed look by Vedder, Gallaway, and Klingaman (Vedder et al.1978) found no such evidence. Here, we take a new, first look at the issue, using somewhat different data from those used in earlier studies.

Evidence that women were often paid less than men is not hard to find (Goldin 1982; Goldin and Sokoloff 1984; Goldin 1990), although this was not always the case. For example, a study by the Bureau of Labor Statistics (U.S. Department of Labor. Bureau of Labor Statistics 1934) indicates that female spinners and speeder tenders earned about the same and during the Civil War significant more—40% plus—than men between 1860 and 1880 (Figure1). The pattern for weavers in Figure 1 is, however, more typical. Indeed, where we have found data for men and women employed in the same firm and with the same occupational title, women were paid less than men (Figure 2).

This, of course, does not mean that women were necessarily being "exploited." They may simply have been less productive for whatever reason.



Source: (U.S. Department of Labor. Bureau of Labor Statistics 1934).

FIGURE 1

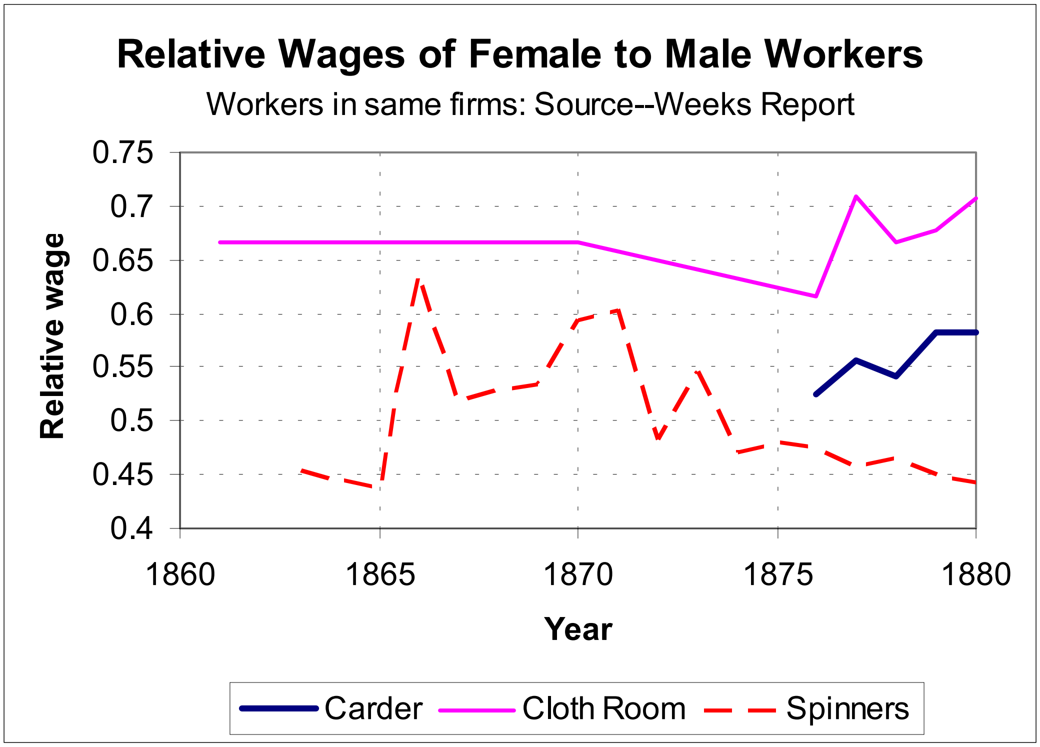


FIGURE 2

III

There are three distinct bodies of establishment level data underlying this study. The earliest data that we use are taken from Kenneth Sokoloff's sample from the 1820 Census of Manufactures . These data appear to be collected as a cluster sample from the microfilms of the 1820 Census and covers states in the Middle Atlantic and New England regions.

Regrettably there was no census of manufactures taken in 1830—an oversight that may have caused some regret as debate over the tariff question raged in Congress and between the states and federal government. In response to this contentious debate, Andrew Jackson's Secretary of the Treasury, Louis D. McLane, ordered a survey of manufacturing in an effort to document the extent of manufacturing in the country and to understand the ramifications of changes in tariff rates (United States. Dept. of the

Treasury. and McLane 1969). Perhaps in part for this latter reason it was much more complete and detailed in those areas closest to the port cities and/or with cheap, easy water access (e.g. Ohio via the Great Lakes and the Mississippi River system) where the impact of foreign competition would be greatest. As a survey and not a census, there was no legal obligation reply or penalty for failure. It is therefore even less complete than the censuses. Moreover, there was much less uniformity in responses. These problems notwithstanding, Michael Haines has collected the data for all of the textile firms that are separately identified in the McLane Report, and these data are more akin to a census than a sample.

Thirdly, we use the data collected by Bateman and Weiss from the censuses of manufactures for 1850, 1860, and 1870 as modified and supplemented by Atack and Bateman (Bateman and Weiss 1981; Atack and Bateman 1999). Some of these data were collected as random samples. Others were collected systematically from among the largest firms in each state. We compensate for this sampling scheme by use of appropriate weights reflecting the relative importance of cotton textiles in each state in each census year. We do not use the Atack-Bateman sample from the 1880 census as textiles were one of the "special agent" industries that were assigned to knowledgeable persons—experts on the industry. In the case of cotton textiles, the task was assigned to Edward Atkinson, a Boston-based economist and pamphleteer who had written several pamphlets and monographs about the industry.[2] Unfortunately, his report is brief, lacks any analysis of the data whose collection he supervised and generally falls short of expectations. More importantly though, the special agent enumerations were not deposited with the other census data, and the records have never been found.[3] Although some establishments in these special agent industries were collected—perhaps inadvertently—by the regular enumerators, none of the large textile mills in the leading textile producing states made it into our sample so we decided not to use the 1880 data at all.

TABLE 1										
Industrial Distribution of Textile Firms by Sample Year										
Year	Industry									
	221	222	223	224	225	226	227	228	229	Total
1820	143		81					31	14	269
1832	601	1	333		4		2	12	3	956
1850	184		163		1		14	92	43	497
1860	154		169		1		18	48	27	420
1870	119	3	152	2	1	1	26	21	17	342

The data have been geocoded so that they can be linked to the ICPSR county-level data from the population and economic censuses, particularly data on urbanization. These are be supplemented by county-level wage data from the Social Statistics schedules for 1850-1870 for some states collected by Robert Margo (Margo 2000). This would enable us to look at the effects of local area labor market conditions on individual firms.

Most firms in the samples produced cotton cloth (SIC 221) though by 1860 firms in the SIC 223 group began to dominate the samples. Firms in this group not only produced woolens and worsteds but it is also where we classified those firms that produced both cottons and woolens, often in the form of what was known as linsey, a durable fabric with a linen warp and cotton or wool weft. In nineteenth century America most seem to have been made with a cotton warp and wool weft. This product does not appear in the SIC Classification Manual, but Atack, Bateman, and Weiss in their coding grouped these under SIC 223 (United States. Office of Management and Budget. 1987). Since each 3-digit SIC group represents (by definition) a distinct technology and type of product, it is essential that these differences be taken into account in so far as they affect factor proportions, factor substitutability and productivity.

IV

The definition of exploitation in neoclassical economics is simple and straightforward. In purely competitive factor and product markets, profit-maximizing firms pay their workers a wage (*w*) that is equal to the value of their marginal product (*VMP*). This is equal to their marginal physical product valued at the price at which this marginal product is being sold. Under perfect competition in the product market, the firm is a price taker so that marginal revenue is the same as price. Exploitation occurs whenever a factor of production is paid less than the value of its marginal product. Building upon this definition it has become customary to define the rate of exploitation, *E*, in terms of the gap between the value of the marginal product (what a worker SHOULD be paid) and the wage (what they are ACTUALLY paid) as a percentage of what they should be paid:

$$E = \frac{VMP - w}{VMP}$$

We actually observe the wage, *w*, (or some facsimile thereof) so that the problem is estimating the value of the marginal product, *VMP*. To do this we turn to production theory. We have eschewed deriving everything from first principles so instead we may begin with a simple Cobb-Douglas production function:[4]

$$V = AL^{\alpha} K^{\beta}$$

Where V denotes value-added, L is the measure of labor input and K measures the capital input. The parameters α and β are the output elasticities with respect to labor and capital. The *VMP* for labor is:

$$\frac{\partial V}{\partial L} = \alpha \frac{V}{L}$$

Cobb-Douglas production functions usually estimated empirically in log-linear form:

$$\log V_i = \log A + \alpha \log L_i + \beta \log K_i + \varepsilon_i$$

Our objective is to test whether the marginal productivities of men and women differed and might justify the observed differences in wages. Therefore we have broken down the labor input by gender and estimate the following expanded Cobb-Douglas production function:

$$V = AM^{\alpha_M} F^{\alpha_F} K^{\beta}$$

where α_M and α_F are the output elasticities for male (M) and female (F) workers respectively. Empirically this would be estimated as:

$$\log V_i = a + \alpha_F \log F_i + \alpha_M \log M_i + \beta \log K_i + \varepsilon_i$$

The values of the marginal products may be defined analogously as:

$$\frac{\partial V}{\partial M} = \alpha_M \frac{V}{M} \text{ and } \frac{\partial V}{\partial F} = \alpha_F \frac{V}{F}$$

There are, however, several potential problems with this approach. First, by definition, the Cobb-Douglas production function assumes unit elasticity of substitution between factors of production. In the simple Cobb-Douglas production function, one can test empirically whether the assumption of unit elasticity of substitution is a reasonable approximation or not using the procedure suggested by Arrow, Chenery, Minhas and Solow (Arrow 1961):

$$\log\frac{Q_i}{L_i} = a\log\overline{w_i} + \varepsilon_i$$

where Q_i is the output of firm *i* and $\overline{w_i}$ is the average wage paid in firm *i*.

An alternative approach which removes the constraint is to estimate a constant elasticity of substitution (CES) production function:

$$V = A[\delta K^{-\rho} + (1-\delta)L^{-\rho}]^{-\frac{\mu}{\rho}}$$

Which has elasticity of substitution: $\sigma = \frac{1}{(1+\rho)}$ between capital and labor. For $\rho = 0$, that is $\sigma = 1$, this reduces to a Cobb-Douglas production function. The CES production function is most easily estimated empirically using Kmenta's approximation (Kmenta 1967):

$$\log V_i = a + \alpha\log L_i + \beta\log K_i - \frac{1}{2}\rho\alpha\beta[\log K_i - \log L_i]^2 + \varepsilon_i$$

The translog production function extends this approach by easing the hometheticity restriction in the CES function:

$$\log V_i = a + \alpha\log L_i + \beta\log K_i + \lambda_{11}[\log L_i]^2 + \lambda_{12}[\log K_i\log L_i] + \lambda_{22}[\log K_i]^2 + \varepsilon_i$$

The effect of these changes should be to improve our estimates of the parameters of the production. In particular, they ought to yield better estimates of the output elasticity.

Cox and Nye (Cox 1989) and, more recently, Carden (Carden 2004), have proposed estimating discrimination based upon a comparison between the ratio of the relevant output elasticities and the ratio of factor expenditures by the firm:

$$\log V_i = a + \alpha_F\log F_i + \alpha_M\log M_i + \beta\log K_i + \varepsilon_i$$

The hypothesis of "no exploitation/no discrimination" may then be tested using a F-test on:

$$\frac{\alpha_F}{\alpha_M} = \frac{w_F F}{w_M M}$$

where $w_F F$ is the firm's expenditure on female labor and $w_M M$ is the expenditure on male labor. The ratio of these may be taken directly from the 1850 and 1860 censuses of manufactures since enumerators were instructed to record the average monthly cost of male and female labor.

Even if one is willing to accept the proposition of unit elasticity of substitution between capital and labor, it is a much more difficult proposition to accept between male and female workers and between each group of workers and capital. Indeed, if men and women did different jobs—which appears to have been the typical case—then they were more likely complements than substitutes, especially if there were some rationale for the gender division of labor (e.g., nimbleness of fingers, slenderness of hand versus physical strength). In which case, the only option seems to be to use a nested CES production, which may be estimated using ordinary least squares. The technique derives from Sato (Sato 1967). The technique begins with the factors most likely to be complements. This could be either male and female labor if we accept the occupational segregation by gender argument, or males and capital if we believe that men are skilled workers who create and maintain the capital goods and which then embodies their skills for use by less skilled female workers. At the second level, we then determine the relationship between the more complementary factor combination and the other factor. [At the present time, we have yet to operationalize this approach.]

As written in the equation below, we have assumed that men and women are complementary factors and that labor and capital are substitutes. That is men and women are nested inside this CES production function:

$$V = A[\phi_1(\delta M^{-\rho_1} + (1-\delta)F^{-\rho_1})^{\frac{\rho_2}{\rho_1}} + \phi_2 K^{-\rho_2}]^{-\frac{1}{\rho_2}}$$

The estimating procedure is as follows:

a) Estimate

$$\log(\frac{K}{Y_{MF}}) = \sigma_2 \log(\frac{\phi_2}{\phi_1}) + \sigma_2 \log(\frac{P_{MF}}{P_K})$$

b) From this equation, estimate σ_1, ρ_1, δ, and (1-δ)

c) Based upon these estimates, construct the quantity and price indexes:

$$J = Y_{MF} = \left[\delta M^{-\rho_1} + (1-\delta)F^{-\rho_1}\right]^{-\frac{1}{\rho_1}}$$

$$P_J = P_{MF} = \left[\delta^{\sigma_1} P_M^{(1-\sigma_1)} + (1-\delta)^{\sigma_1} P_F^{(1-\sigma_1)}\right]^{\frac{1}{(1-\sigma_1)}}$$

d) Estimate:

$$\log(\frac{K}{Y_{MF}}) = \sigma_2 \log(\frac{\phi_2}{\phi_1}) + \sigma_2 \log(\frac{P_{MF}}{P_K})$$

e) From this equation, estimate σ_2, ρ_2, ϕ_1, and ϕ_2

V

Before we can turn to actually estimating our production functions and testing for the existence of exploitation, we have to discuss several data issues. First, in order to be included in our production function estimates, firms had to report non-zero fixed capital, at least one employee, a non-zero value for inputs and outputs and show a positive value-added, defined as the difference between the value of output less the value of inputs. By assumption, any production requires non-zero amounts of all factors of production and has to yield a non-zero output. Moreover, since the production functions are estimated in log-linear form, all values—including value-added and the number of male and female workers—have to be positive.

Second, there is an on-going debate regarding whether or not entrepreneurial labor was included in the enumerator's count of employees. In 1850 and 1860, the instructions to enumerators were quite explicit on this point that they were to be counted and a cost attributed to them if they contributed to production. These same instructions applied in 1870. We note that almost every firm reported having employees to whom wages were paid and that average wages did not change abruptly between one and two (or two and three) employees. With respect to the 1820 census and the McLane Report, Sokoloff is equally adamant that the owner-operator was not counted and so he adds one (male) to each firm's employment count. With respect to the current investigation we have done the same in 1820 and 1832 although in most cases the percentage change in employment was small.

Third, we have adjusted the reported fixed capital upward to reflect the exclusion of working capital from the factor inputs of each firm. Some firms surveyed for the McLane Report listed this separately. Where firms did so, we have estimated the production function with each adjustment separately. Our adjustment is based upon the gross value of each firm's output since inventories, goods in process, and goods sold on consignment were major components of working capital in the nineteenth century. Our parameters for these are derived on a state and industry basis from the 1890 published census which included a detailed analysis of the composition of capital.

Fourth, the regressions (and means) in 1850, 1860 and 1870 are weighted to adjust the sampling frequencies by state to those in the underlying parent population.

VI

THINKING OUT LOUD:

Observation: Women typically (almost universally) paid less than men.

What are our options for explaining this?

a) Nothing to explain. Women simply less productive. This MAY be the result of discrimination in access to education, experience etc.

b) Women exploited as a result of monopsony or patriarchal values and paid less than their productivity warrants

c) Women less productive because of discrimination which led to strict gender segregation by occupation.

Problem is in distinguishing between (a) and (c) which is an area in which Fred and I got into trouble many years ago.

TABLE 2

Production Function Estimates: SIC 22

Simple Cobb-Douglas Production Function

	Constant	Output Elasticity with respect to:					Dummies?		N	R^2
		Capital	Men	Women & Children	Women	Children	State	Industry		
1820	2.3105	0.4730	0.4310		0.1644	0.1759	no	no	54	0.68
	1.85	3.09	3.93		1.38	1.44				
	2.7155	0.4325	0.4809	0.2243			no	no	86	0.77
	3.77	4.52	5.8	2.62						
	1.9767	0.5281	0.4970		-0.0141	0.2067	yes	yes	54	0.71
	1.46	3.15	3.08		-0.07	1.35				
	1.9076	0.4970	0.3834	0.3021			yes	yes	86	0.79
	2.24	4.59	3.73	2.61						
1832	5.2792	0.1936	0.4339		0.3933	-0.0695	no	no	428	0.77
	12.62	3.54	9.53		10.06	-2.03				
	4.0764	0.3268	0.3782	0.2958			no	no	644	0.77
	12.14	7.01	10.07	7.28						
	5.1393	0.2159	0.3670		0.4222	-0.0372	yes	yes	428	0.79
	11.79	3.69	7.08		8.15	-0.94				
	3.9960	0.3591	0.3268	0.3134			yes	yes	644	0.8
	12.08	7.74	8.05	6.75						
1850	2.8653	0.4844	0.4017	0.0983			no	no	348	0.92
	8.04	10.19	7.87	2.88						
	2.1932	0.5603	0.3211	0.1026			yes	yes	348	0.93
	5.01	10.04	5.6	2.77						
1860	2.9460	0.5284	0.1289	0.2955			no	no	308	0.91
	7	9.26	1.8	7.37						
	1.8910	0.6394	0.0055	0.3282			yes	yes	308	0.93
	3.53	9.5	0.07	6.86						
1870	4.1485	0.4237	-0.0387		0.4343	0.1176	no	no	63	0.84
	3.79	3.63	-0.31		3.04	0.95				
	4.5673	0.3449	-0.0737	0.6316			no	no	75	0.86
	5.29	3.39	-0.67	4.96						
	4.0208	0.5038	-0.3126		0.6574	-0.0457	yes	yes	63	0.88
	2.01	2.34	-1.26		2.94	-0.26				
	4.9101	0.3496	-0.1852	0.6872			yes	yes	75	0.89
	3.7	2.14	-0.87	3.38						

TABLE 3

Production Function Estimates: Weaving and Integrated Cotton Mills (SIC 221)

Simple Cobb-Douglas Production Function (t-statistics)

	Constant	Output Elasticity with respect to:					Dummies?	N	R2
		Capital	Men	Women & Children	Women	Children	State		
1820	0.7370	0.6696	0.3591		-0.0138	0.1580	yes	38	0.74
	0.42	2.98	1.76		-0.05	0.86			
	1.0483	0.5690	0.3222	0.3696			yes	48	0.78
	0.85	3.32	2.4	1.68					
1832	5.1045	0.2351	0.2474		0.4434	-0.0122	yes	290	0.8
	11.72	4.04	5.19		8.28	-0.33			
	4.6324	0.2692	0.2563	0.4419				426	0.83
	12.7	5.17	6.39	8.45					
1850	1.9683	0.5843	0.3956	0.0137			no	171	0.87
	3.41	7.55	4.9	0.26					
	2.5160	0.5258	0.4172	0.0444			yes	171	0.89
	3.89	6.23	4.69	0.79					
1860	1.5830	0.7157	-0.1443	0.3264			no	143	0.91
	2.47	8.26	-1.31	4.02					
	1.7646	0.6955	-0.1773	0.3711			yes	143	0.92
	2.1	6.34	-1.44	4.01					

TABLE 4

Production Function Estimates: Woolen and Mixed Textile Mills (SIC 223)

Simple Cobb-Douglas Production Function (t-statistics)

	Constant	Output Elasticity with respect to:					Dummies?	N	R^2
		Capital	Men	Women & Children	Women	Children	State		
1820	2.1366	0.6073	0.3155	0.0535			yes	24	0.72
	0.82	1.78	1.07	0.19					
1832	6.1938	0.0338	0.7405		0.4097	-0.1027	yes	129	0.77
	5.86	0.24	5.21		3.59	-0.93			
	3.5769	0.4007	0.5022	0.1650			yes	200	0.77
	5.12	4.19	5	1.81					
1850	1.7345	0.6363	0.1504	0.1990			no	124	0.94
	2.54	7.17	1.41	2.38					
	1.6355	0.6309	0.1638	0.1995			yes	124	0.95
	1.9	5.9	1.35	2.25					
1860	3.1460	0.4834	0.2265	0.3081			no	122	0.92
	5.23	6.17	2.19	4.43					
	1.7339	0.6541	0.1159	0.2509			yes	122	0.94
	2.08	6.58	1.01	3.53					

TABLE 5

Value-Added per Worker by Type of Worker

	All (SIC 22)				SIC 221				SIC 223			
Data set	Men	Women & Children	Women	Children	Men	Women & Children	Women	Children	Men	Women & Children	Women	Children
1820	$ 850	$ 451	$ 1,177	$ 708	$ 1,138	$ 277	$ 1,007	$ 573	$ 681	$ 612	$ 1,607	$ 936
(σ)	672	406	1530	721	772	202	1283	776	511	466	2003	688
1832	$ 1,225	$ 621	$ 1,011	$ 2,750	$ 1,389	$ 406	$ 523	$ 2,738	$ 899	$ 1,073	$ 2,257	$ 2,803
(σ)	1117	1671	6217	3374	1072	323	517	3312	1126	2910	11706	3559
1850	$ 778	$ 1,165			$ 878	$ 1,108			$ 702	$ 1,178		
(σ)	609	2908			623	4236			504	931		
1860	$ 1,205	$ 1,676			$ 1,537	$ 1,116			$ 1,178	$ 1,952		
(σ)	1398	3672			2027	3392			1119	3046		
1870	$ 2,412	$ 1,509	$ 4,802	$ 4,823								
(σ)	5321	1779	20366	6804								

BIBLIOGRAPHY

Appleton, N. (1858). Introduction of the power loom, and origin of Lowell. Lowell, Mass., B.H. Penhallow.

Arrow, K. C. H. B. M. a. S., R. M. (1961). "Capital-Labor Substitution and Economic Efficiency." Review of Economics and Statistics **43**: 225-250.

Atack, J. (1976). Estimation of Economies of Scale in Nineteenth Century United States Manufacturing and the Form of the Production Function. Economics. Bloomington, Indiana University.

Atack, J. and F. Bateman (1999). "Nineteenth Century American Industrial Development Through the Eyes of the Census of Manufactures: A New Resource for Historical Research." Historical Methods **32**(4): 177-88.

Atkinson, E. and Boston Board of Trade. (1863). Report to the Boston Board of Trade on the cotton manufacture of 1862. [Boston, s.n.

Atkinson, E., Joseph Meredith Toner Collection (Library of Congress), et al. (1861). Cheap cotton by free labor. Boston, A. Williams & co.

Atkinson, E. and YA Pamphlet Collection (Library of Congress) (1876). Address of Mr. Edward Atkinson on the export of cotton goods, at the meeting of the New England cotton manufacturer's association, April 26, 1876. [n. p.

Bateman, F. and T. J. Weiss (1981). A deplorable scarcity: the failure of industrialization in the slave economy. Chapel Hill, University of North Carolina Press.

Carden, A. (2004). Unequal Pay for UNequal Work in Antebellum America. Department of EConomics, Washington University in St. Louis**:** 28.

Cox, D. a. N., John Vincent (1989). "Male-Female Wage Discrimination in Nineteenth Century France." Journal of Economic History **49**(4): 903-20.

Dalzell, R. F. (1987). Enterprising elite: the Boston Associates and the world they made. Cambridge, Mass., Harvard University Press.

David, P. A. (1970). "Learning by Doing and Tariff Protection: A Reconsideration of the Case of the Ante-Bellum U.S. Textile Industry." The Journal of Economic History **30**(3): 521-601.

David, P. A. (1975). Technical choice, innovation and economic growth: essays on American and British experience in the nineteenth century. London, Cambridge University Press.

Goldin, C. (1990). Understanding the Gender Gap. New York, Oxford University Press.

Goldin, C., and Kenneth Sokoloff (1982). "Women, Children, and Industrialization in the Early Republic: Evidence from the Manufacturing Censuses." The Journal of Economic History **42**(4): 741-74.

Goldin, C. and K. Sokoloff (1984). "The Relative Productivity Hypothesis of Industrialization: The American Case, 1820 to 1850." Quarterly Journal of Economics **99**(3): 461-87.

Hunter, L. C., Eleutherian Mills-Hagley Foundation., et al. (1979). A history of industrial power in the United States, 1780-1930. Charlottesville, Published for the Eleutherian Mills-Hagley Foundation by the University Press of Virginia.

Jeremy, D. J. and Merrimack Valley Textile Museum. (1981). Transatlantic industrial revolution: the diffusion of textile technologies between Britain and America, 1790-1830s. North Andover, Mass.

Cambridge, Mass., Merrimack Valley Textile Museum;
MIT Press.
Kmenta, J. (1967). "On EStimation of the CES Production Function." International Economic Review **8**: 180-9.
Knowlton, E. H. (1948). Pepperell's progress; history of a cotton textile company, 1844-1945. Cambridge, Harvard Univ. Press.
Lazonick, W. and T. Brush (1985). "The "Horndal Effect" in Early U.S. Manufacturing." Explorations in Economic History. January **22**(1): 53-96.
Margo, R. A. (2000). Wages and labor markets in the United States, 1820-1860. Chicago, University of Chicago Press.
Sato, K. (1967). "The Two Level Constant Elasticity of Substitution Production Function." Review of Economic Studies **34**(2).
Tryon, R. M. (1917). Household manufactures in the United States, 1640-1860. Chicago, University of Chicago Press.
U.S. Department of Labor. Bureau of Labor Statistics (1934). History of Wages in the United States from Colonial Times to 1928, G.P.O. **Bulletin of the United States Bureau of Labor Statistics No. 604. Revision of Bulletin No. 499 with Supplement, 1929-1933**.
United States. Census office. 4th census 1820. and United States. Dept. of State. (1823). Digest of accounts of manufacturing establishments in the United States, and of their manufactures. Made under direction of the Secretary of State, in pursuance of a resolution of Congress, of 30th March, 1822. Washington, Printed by Gales & Seaton.
United States. Census office. 10th census 1880. [from old catalog] (1883). [Census reports] Tenth census. Washington, Govt. print. off.
United States. Census Office. and J. M. Edmunds (1990). Manufactures of the United States in 1860: compiled from the original returns of the eighth census, under the direction of the Secretary of the Interior. New York, N.Y., Norman Ross Publ.
United States. Census Office. and J. C. G. Kennedy (1990). Manufactures in the several states and territories for the year ending June 1, 1850: abstract of the statistics of manufactures, according to the returns of the seventh census, condensed from the digest completed under the direction of the Secretary of the Interior, in conformity with the first section of the act of June 12, 1858. New York, N.Y., Norman Ross Publ.
United States. Dept. of the Treasury. and L. McLane (1969). Documents relative to the manufactures in the United States. New York, A. M. Kelley.
United States. Dept. of the Treasury. and United States. Congress House. (1791). Report of the secretary of the Treasury of the United States, on the subject of manufactures
Presented to the House of Representatives, December 5, 1791. [Philadelphia], Printed by Childs and Swaine.
United States. Office of Management and Budget. (1987). Standard industrial classification manual. Springfield, Va., For sale by National Technical Information Service.

Vedder, R. G., Lowell and David Klingaman (1978). Discrimination and Exploitation in Antebellum American Cotton Textile Manufacturing. Research in Economic History. P. Uselding. Greenwich, JAI Press. **3:** 217-62.

Ware, C. F. (1931). The early New England cotton manufacture; a study in industrial beginnings. Boston, New York, Houghton Mifflin company.

White, G. S. and L. Woodbury (1836). Memoir of Samuel Slater: the father of American manufactures: connected with a history of the rise and progress of the cotton manufacture in England and America, with remarks on the moral influence of manufactories in the United States. Philadelphia, [s.n.].

Williamson, H. F. (1934). Edward Atkinson; the biography of an American liberal, 1827-1905. Boston, Old Corner Book Store.

Zevin, R. B. (1971). The Growth of the Cotton Textile Production after 1815. The Reinterpretation of American Economic History. R. W. F. a. S. Engerman. New York, Harper and Row**:** 122-47.

Zevin, R. B. (1977). The Use of a "Long Run" Learning Function: With Application to Massachusetts Cotton Textile Firm, 1823-1860. New York, Arno Press.

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[1] This statement is qualified in so far as child labor was not separately reported at the 1850 and 1860 censuses and may have been included among the women.

[2] See, for example,
Atkinson, E., Joseph Meredith Toner Collection (Library of Congress), et al. (1861). Cheap cotton by free labor. Boston, A. Williams & co,
Atkinson, E. and Boston Board of Trade. (1863). Report to the Boston Board of Trade on the cotton manufacture of 1862. [Boston, s.n,
Atkinson, E. and YA Pamphlet Collection (Library of Congress) (1876). Address of Mr. Edward Atkinson on the export of cotton goods, at the meeting of the New England cotton manufacturer's association, April 26, 1876. [n. p,
Williamson, H. F. (1934). Edward Atkinson; the biography of an American liberal, 1827-1905. Boston, Old Corner Book Store.

[3] Delle Donne, “Federal Census Schedules”.

[4] Much of the following is elaborated in Atack
Atack, J. (1976). Estimation of Economies of Scale in Nineteenth Century United States Manufacturing and the Form of the Production Function. Economics. Bloomington, Indiana University. and, more recently, in Vedder, Gallaway and Klingaman.
Vedder, R. G., Lowell and David Klingaman (1978). Discrimination and Exploitation in Antebellum American Cotton Textile Manufacturing. Research in Economic History. P. Uselding. Greenwich, JAI Press. **3:** 217-62.