Child Labor and the Division of Labor in the Early English Cotton Mills

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Revised

Abstract

The share of children employed in English cotton factories fell significantly before the introduction of effective child labor legislation in the early 1830s. The early factories employed predominantly children because adults without factory experience were relatively unproductive factory workers. The subsequent growth of the cotton industry fostered the development of a labor market for productive adult factory workers. This effect helps account for the shift towards adults in the cotton factory workforce.

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The elaboration of the division of labor has long been linked to economic development.* According to Adam Smith (1776), the expansion of trade promoted the division of labor that in turn boosted productivity and stimulated further expansion of trade. In Smith's now classic image of the pin factory, the separation of tasks and the specialization of workers promoted dexterity, reduced set-up time, and encouraged technical advance. Smith, however, failed to mention an aspect of the division of labor that was obvious to contemporaries and that is central to historical accounts of the factories -- the employment of women and children. The division of tasks promoted the division of laborers: the factory manager could assign to each task the lowest cost type of worker -- man, woman, or child -- able to perform that task.

While Smith presented economic progress as the progressive elaboration of the division of labor, the share of children in the cotton mill workforce actually fell sharply in the half century before significant legislative restrictions on child labor. In a survey in 1788, "children" made up two-thirds of the workforce on powered equipment in 143 water mills in England and Scotland (Colquon n.d.). A survey of 982 mills in England and Scotland in 1835, before the Factory Act of 1833 had fully taken effect, indicated that 43% of the workforce was under eighteen (Factory Reports 1835). Other local data support this downward trend. The share of cotton mill workers under eighteen in surveys in Manchester, Stockport, and Preston in 1816-9 were 47%, 58%, and 65% respectively, while by 1835 the corresponding figures had fallen to 39%, 36%, and 47%.[1]

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[1]The earlier figures for Manchester (27 firms, 10096 workers) and Preston (24 firms, 2772 workers) are from BPP (1816), pp. 374, 261. The earlier figure for Stockport (6 firms, 823 workers) is from the BPP (1819), App. no. 1-6. An alternative figure for Manchester (12 firms, 6638 workers) from BPP (1818) and BPP (1819), is 51% of workers under 18. The figures for 1835 are from BPP (1836b) and sample size is as follows: Manchester, 123 factories, 35,841 persons; Stockport, 64 factories, 21,093 persons; Preston, 25 factories, 5819 persons. Workers under eighteen are considered here as a category because

This paper argues that the share of children employed in factories fell in part because the maturing of cohorts of child factory workers fostered the development of a labor market for productive adult factory workers. Work in mechanized factories required regular attendance and consistent effort, respect for tools and machinery used but not owned, tolerance for close supervision, a willingness to work under non-personal contract, and the ability to work in close quarters with a large number of persons. In late eighteenth century Britain, these were largely new kinds of skills. As Landes (1972) put it, work in mechanized factories "required and eventually created a new breed of worker." Other scholars have made similar points (Gerschenkron 1962; Pollard 1968; Mokyr 1993) and have also noted the transition to relatively greater employment of adults. Nonetheless, the literature contains remarkably little systematically analyzed evidence to support the often-told story of the cotton factories producing, in addition to cloth, a new workforce.

This paper provides such evidence. Section 1 analyzes a survey of factory managers and shows that factory managers considered child labor in the factory to be important training for future factory work. Section 2 uses data on migrants to show that children's wages reflected such a training effect: wages were significantly higher for experienced young factory workers than for inexperienced migrants. Moreover, as Section 3 establishes, most adult factory workers worked in factories as children. Thus the first three parts of this paper indicate the importance of child labor in the factories for shaping the size and characteristics of the pool of future adult factory workers. Section 4 shows that the employment of children relative to men in cotton factories was significantly lower in towns with a larger cotton industry. This evidence supports the view that the development of local labor markets for effective adult factory workers helps account for the shift over time towards adults in the division of labor.

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that was the only category available across these data sets. I define children subsequently in a richer data set as persons under sixteen.

1. The Views of Factory Managers

The image of dark Satanic mills consuming children is a central image of the Industrial Revolution. Life for a child laborer in the early English factories was brutal. Nonetheless, some children not only endured but went on to become adult factory workers. How much significance did factory managers attach to child factory workers going on to become adult factory workers?

The Factory Queries of 1833 (BPP 1834) provide direct evidence. That survey included the following question:

> What is the difference in skill and general character of those employed in the works who have been employed from infancy, as compared with those who have been taken into employment at later periods; refer to names of those persons on the annexed lists whom you can adduce as instances?

One hundred and ninety-four cotton mill managers from Cheshire, Derbyshire, and Lancashire responded to this question.

A significant share of managers apparently did not feel a need to make up answers to justify their employment of children. In response to the above question, 17% of the respondents didn't answer or asserted that they were unable to answer. Those who were unable to answer and offered an explanation almost unanimously stated that they had little comparative evidence. Here are some typical explanations from mill managers who were unable to answer the question:[2]

[2] The comments cited in this section are from the following respondents: Hugh Shaw and Co., p. 249; Leigh Slater, p. 228; M'Connel and Co., p. 196; R. Schofield, p. 245; T. Hardman, p. 286; B. Nicholls, p.

- There are so few that we have now but what have been employed from infancy.
- Cannot give a very confident opinion as I conceive that few enter the business after they are grown up.
- We adhere as much as possible to the practice of teaching from childhood those we employ, and seldom engage others who have not been so taught. We are, therefore, not competent to estimate the difference.

In addition to indicating frank, thoughtful responses, these answers suggest that relatively few workers entered the mills as adults.

Among the respondents expressing a view, 84% asserted that workers employed from "infancy" were preferable. Another 13% saw no difference, and 3% gave ambiguous responses. Some of the respondents who stated that child labor was unimportant for producing better workers offered plausible explanations:

- Skill, in my opinion, depends upon their own natural ability and ingenuity.
- We see no difference; the work is so easily and soon learned.
- ...all depends on their own abilities and good disposition.

On the other hand, supporting the weight of the summary statistics given above were a fair number of detailed, factual responses.

- Those employed from early life are the most competent (see James Foster on the list, who has risen to be manager, Hugh Boltons, head carder, Samuel Rostrow, Thomas Holt, Henry Foster, Joshua Border, and William Hamer, overlookers.)
- Those who have been employed on the premises by childhood are decidedly the best hands in the mills; all the overlookers are instances, having raised themselves by degrees to their present situations.

234;, Joseph Wilkinson, p. 27; Taylor, Hindle, and Co., p. 164; J. Spear Heron, p. 289; Mosely and Howard, p. 38; Clogg and Norris, p. 194; Hardy and Andrews, p. 71; J. Adshead, p. 22; G. Wilkinson, p. 178, and T. Robinson, p. 80.

- Children are most expert, active, and complete when taken young, and a decided preference is given to them afterwards.

The question posed to the mill managers was ambiguous as to the entrance ages associated with employment "from infancy". Those mill managers who elaborated upon entrance ages differed as to how early children should enter the mills. Some argued that children should begin work under age 12.

- ...when they commence at an early age they are more useful, and ready to be put to better employment sooner than if only commencing at twelve years.
- We do not require children under twelve years of age, but a child at ten years will sooner learn its work than one of twelve; and such as are intended for spinners would never be so active did they not begin piecing before twelve years of age.
- ...when children are not sent to work early, they get into bad company and idle habits which they seldom get rid of.

Others suggested that as long as children began work before 15, they could be made into effective workers. Many mill managers claimed that poor parents pressed them into accepting children under 12, while others acknowledged the advantage of the low wages of very young children.

In responding to the Factory Queries of 1833, factory managers were quite clear in distinguishing between apprenticeship and child labor. When asked if they employed apprentices, almost all responded that they did not, while a few mentioned the existence of apprentices to their mechanics. Nonetheless, factory managers presented child labor in the factory as functioning as a form of apprenticeship.

2. Factory Experience and Children's Wages

To the extent that factory work trained children to be better factory workers, one would expect to see children's wages rise with their factory experience. The literature

documents rising wages with age for children working in cotton factories (Boot 1995), but only one scholar has analyzed children's wages while controlling for the effect of age (Nardinelli 1984). This section uses evidence on migrants to illustrate the recruiting process and estimate the extent to which experienced young factory workers earned higher wages than inexperienced workers of the same age.

In the early 1830s factory owners and government officials noted that there was a labor shortage in the northern counties and a pool of unemployed laborers in the South. The Poor Law Commissioners created an agency to assist families in the South to migrate north to take up factory jobs. At least one mill owner urged that families simply be sent north where they could be housed temporarily while they considered the job possibilities (BPP 1835, App. C 5 (d)). The migration officers pushed the employers to provide migrants with a three-year labor contract before they moved. Such a contract, which was adopted, assured migrants of a job and decreased the chance of them returning to their home parish.

While employers retained the right to dismiss workers, employers were nonetheless very concerned about worker quality. The Boards of Guardians who suggested workers to the migration officers had to provide detailed information regarding the quality of potential migrants. They were required to specify a worker's "character as a workman" and "Moral Character," and also "Names and Descriptions of Persons, able from their own knowledge, to certify to the Character of each Person." There was a special "Form of Certificate as to Character" in which a reference, stating his name, calling, and residence, certified that, based on his personal knowledge, the potential migrant was "a person of honest, industrious, sober, and peaceable character, whom I myself would be willing to employ if I stood in need of labour which [insert name] is capable of performing." (BPP1836, pp. 413,425)

In spite of this elaborate screening mechanism, few if any adult male or female migrants received jobs in the factories. Adult males were typically given 10s for work as a laborer, and adult females were expected to work within the home. Migrants' children received jobs in the factories, but at wages below those of the children currently working there.

Analysis of the time profile of migrants' wage contacts shows that migrants earned a significant return on their factory experience. Figures 1 and 2 show age-wage profiles for children in families that migrated to Lancashire. These profiles reflect wages specified in the labor contracts drawn up before migrants began work. The age-wage profiles for migrants with two years of experience recognize that the migrants will then be two years older. Hence one controls for age by comparing wage profiles at a given age. For male migrants ages 11-15, two years of experience raised wages on average 18% after controlling for age. The corresponding figure for female migrants ages 11-15 is 26%. Thus the migrant data suggest that work experience raised children's wages 9-12% per year, at least for the first two years of work.

There is some evidence that the increases in contractual wages underestimate the economic value of training. Referring to migrants employed in their factory, Henry and Edmund Ashworth wrote (BPP 1835, App C 5(e)):

> All the children who are of the legal age are employed in our works; the teaching of them is attended with a good deal of trouble, although they are mostly diligent and tractable; and in order that they may repay us for the advantages of their skill when acquired, they have undertaken to remain with us for three years, at a rate of wages progressively increasing every year.

Thus the Ashworths assumed some of the training costs, and hence decreased the slope of the age-wage profile. The Ashworths also raised the wages of some migrants above the contract level because of "good conduct and skill." These raises may not have been

simply a matter of paternalistic generosity; wage norms within the mill might have also played a role. In any case, the raises suggest that contract wages underestimated the value of skills acquired.

Figure 1
The Value of Experience
(male migrants)

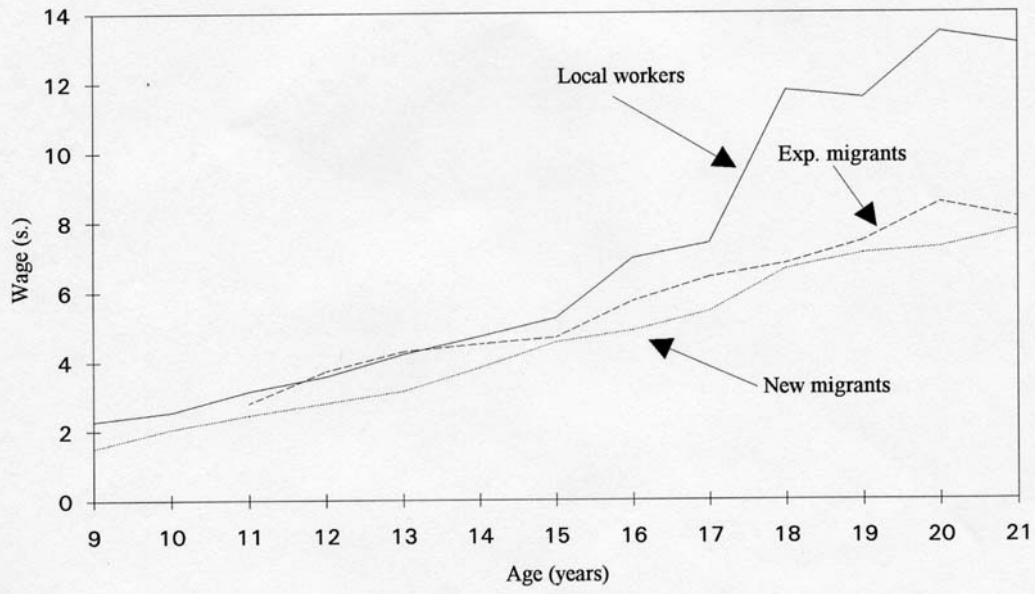
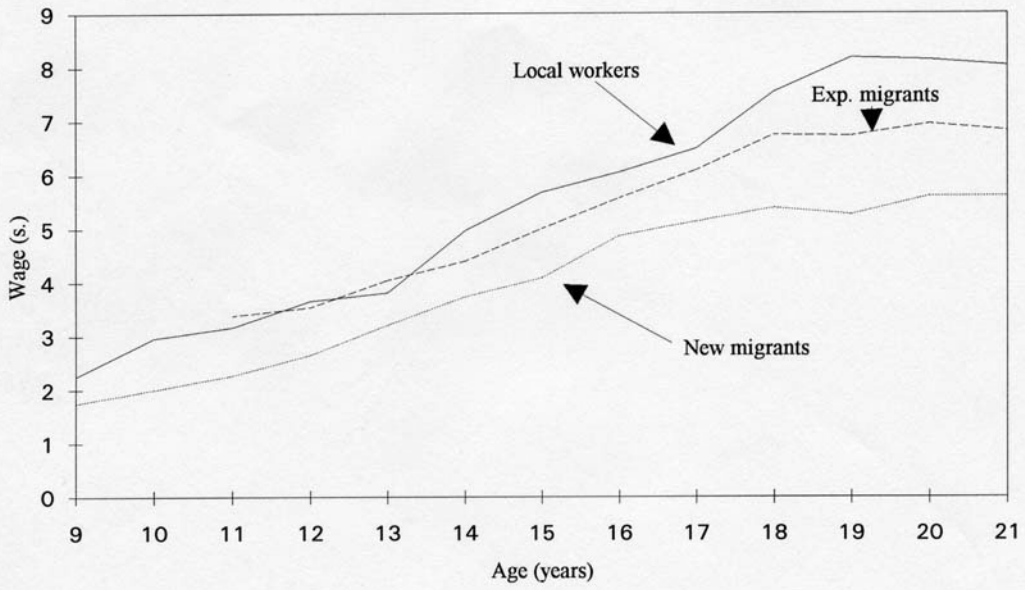


Figure 2
The Value of Experience
(female migrants)



Comparing migrants' wages to wages of local workers of the same age gives another estimate of the value of experience.[3] I focus on the age group 19-21 since that age group provides the sharpest contrast between the work experience of locals and migrants. Data from the Lords Reports of 1818 and 1819 (BPP 1818; BPP 1819) indicate that local males ages 19-21 averaged 10.6 years of factory experience and local females 8.4 years. Wages for local male workers ages 19-21 were 58% higher than those for migrants with two years of experience. These figures suggest a return to experience of 5.5% per year between 2 and 10.6 years of experience, while the wage contracts indicate a return to experience of 7% per year for the first two years of work. Wages for local

[3] The age-wage profiles for local workers in Figures 1 and 2 represent Mitchell's compilation of returns from cotton factories in 1833 (BPP 1834, p.21). The Factory Act of 1833, enacted after Mitchell's data was collected, put upward pressure on children's wages. In addition, the cotton trade was booming between 1833 and 1836, and the expansion of old mills and the construction of new ones also put upward pressure on children's wages. Mill owners proposed and endorsed the migration scheme largely because of such market conditions. Thus Mitchell's sample almost certainly underestimates wages for local workers in 1836.

females ages 19-21 were 19% higher than wages for migrants of the same age and with two years of experience. This evidence suggests a return to experience of 2.7% per year between 2 and 8.4 years of experience while the wage contracts indicate a return to experience of 12% per year for the first two years of work. For comparison, Nardinelli (1984) found 4-6% per year return to experience among males under 14 years of age who worked in a variety of industries around England.

The calculations above assume that migrants' skills were valued at going rates in the local labor market. If migrants were used to undercut wages of local workers, migrants would have received a hostile reception from their neighbors and co-workers. Migrants themselves reported no such hostility, and they did not complain about the level of their wages. Thus the difference between migrant children's wages and local children's wages is probably a good measure of the return to children's work experience in cotton factories.

3. Life-Cycle Patterns in the Factory Labor Market

The role of child labor in training factory workers indicates that child labor in the early English factories had more significance for the factories than just a "use and dispose" labor scheme. Examination of worker experience profiles and life-cycle patterns of work re-enforces this point. Such evidence shows that child labor was the primary entry point into the labor market for the early English cotton mills and that most adult workers, even in relatively early mills, had experience as child laborers. This evidence suggests that the return to adult factory experience, for adults who did not work in the factories as children, was relatively low. The worker age distribution also shows that, if the age distribution was maintained over time, a significant share of child workers could not find jobs in the factories as adults.

Most workers in the early English cotton factories started working in the factories as children. Table 1 gives the distribution of the starting age of work for workers in a sample of factories in Manchester and Stockport in 1818 and 1819 (BPP 1818; BPP 1819). The distribution indicates that about 50% of workers started working in the factories when they were less than ten years old. Another 28% started work under fourteen years of age. Only 7.8% of workers began work in the mills at twenty-one years of age or older. Morever, the small share of workers starting work as adults does not merely reflect the small share of adults employed. As Table 1 shows, 37% of workers were twenty-one or older.

Child work experience was particularly important for fine spinners, who were the best-paid non-supervisory workers in cotton factories. In a sample from Manchester in 1832, 837 fine spinners with an average age of 32 years began work in the factories on average at 9.8 years of age (Shuttleworth 1842). Given that few workers began work in the factories at younger than eight years of age, the distribution of starting ages was probably skewed rightward. Hence the share of fine-spinners who began work under 10 years of age was probably considerably greater than the 50% figure for all workers presented above.

Table 1
Age Distribution in Cotton Factories
(Manchester and Stockport Cotton Factories, 1818-9)

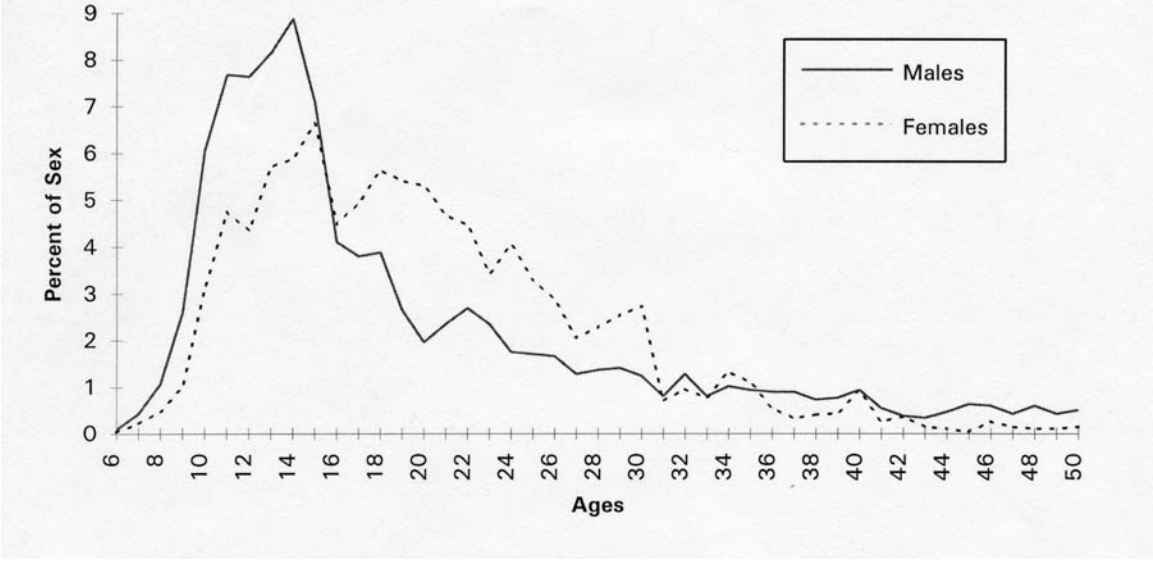
	Starting Age in Factories		Current Age	
Age Group	%	cum %	%	cum %
under 10	49.9	49.9	3.9	3.9
10-13	27.9	77.8	25.3	29.2
14-17	10.3	88.1	22.1	51.3
18-20	4.1	92.2	11.8	63.1
21 & over	7.8	100	36.9	100
sample size	7142		7888	

Source: BPP (1818) and BPP (1819)

Since the division of labor in the factories involved the employment of a large number of children relative to adults, the aging of children had important implications for their job opportunities. There were three possibilities. First, firms could shift the division of labor over time toward older workers and thus create more adult jobs for former child workers. Another possibility was for the growth of existing firms or the entry of new firms to expand employment opportunities. The third possibility was for children to exit the cotton industry as they grew older.

Exit behavior for male children differed significantly from that of female children. Figure 3 shows the age distribution of cotton workers in Manchester in 1818. The number of eighteen year old males employed in the factories was only one-half to one-third of the number of thirteen year old males, while the number of females aged thirteen was roughly equal to the number aged eighteen. In Manchester between 1815 and 1841, employment in cotton factories grew at an average rate of 4.9% per year. This growth rate, combined with the employment profile in Figure 3, implies that 36-58% of thirteen year old males left the cotton industry, net of a small number of new entrants. The age profile does not imply any net exit for females between ages thirteen and eighteen; instead, the size of female age cohorts gradually decreased from age twenty onwards.

FIGURE 3
AGE DISTRIBUTION OF COTTON WORKERS



Workers recognized that child laborers represented future competition for adult jobs. This was particularly a concern among mule-spinners, who held the best-paid jobs in the mills. In 1829 John Doherty, the secretary of the Manchester mule-spinners, proposed that only piecers who were sons or brothers of mule-spinners should be taught to spin. Bolin-Hort (1989) has argued that spinners sought to preserve their privileged position by controlling children's work experience:

> The solution was to employ children from other working-class families as piecers, but only for a very limited period of time.... In this way, recruitment to the profession could be kept under control. This meant that the piecer group was really divided into two distinct parts: the sons of the spinners who were expected to stay on and in time take over a couple of "wheels" of their own, and the children from other working-class backgrounds who were simply used as "free" wage labour for a limited period of time (Bolin-Hort, pp. 50-1).

Mill rosters in the Lords Reports of 1818 and 1819 (BPP 1818; BPP 1819) offer relevant data for testing this theory. From the order of workers on the rosters one can identify spinner-piecer teams. Table 2 presents piecers grouped by age and sex, and by whether the piecer's surname corresponded to that of the spinner under whom the piecer worked. Piecers working under women spinners have been excluded. Spinners hired a relatively larger share of older male piecers among male piecers with whom they shared a surname ("relatives"), as Bolin-Hort's theory suggests. For female piecers the pattern is different: there was a larger share of piecers over sixteen within the group of non-relatives. One might well speculate that a different kind of interest motivated male spinners' employment of older non-related female piecers.

Table 2
Family Relations and Piecer Age Distributions

	Males		Females	
Age group	Relatives (%)	Non-rel.'s (%)	Relatives (%)	Non-rel.'s (%)
10 & under	25	28	22	21
11-13	34	48	37	38
14-16	27	17	32	21
over 16	14	7	9	21
sample size	73	557	68	385

Source: Spinner-piecer teams identified in BPP (1818) and BPP (1819).

More important for this paper is that growing up affected child workers' job prospects. A generation of child workers competed for adult jobs in the cotton factories, and some got them. Others didn't, and they were released into the local labor market to seek other work. This effect was much more dramatic for male workers in their late teens than for female workers of the same ages. The flow of former child factory workers into a local labor market was proportional to the number of factory jobs in the town, and the size of the reserve pool of factory trained adults grew over time. Both a greater flow and stock of former child factory workers fostered the development of the factory labor

market by giving factory managers the ability to hire, quickly and at prevailing wages, new, effectively trained adults.

4. Determinants of the Division of Labor: An Econometric Analysis

This section considers whether the development of local labor markets for adult factory workers affected the shares of children, women, and men in the factory workforce. Recent work that noted the fall in the share of children employed before the 1830's attributed it to the shift from water power to steam power, the development of the self-acting mule, and increases in family income (Nardinelli 1980). Using data on the cotton factory workforce in towns in England in 1838, this section provides new evidence on the factors that affected the division of labor among children, women, and men. The size of the local cotton industry, linked to the development of the local factory labor market through the maturing of child laborers, turns out to be significant.

Theoretical framework

Assume that cotton factories' production function is:

$$Y= Z (L_c^{\beta} L_w^{\delta} L_m^{1-\beta-\delta})^{\alpha} K^{1-\alpha} \quad (1)$$

where Z, K, L_c, L_w, and L_m are respectively a constant, capital, the employment of children, the employment of women, and the employment of men. Given wages of children, women, and men (w_c, w_w, and w_m), and a cost of capital r, a necessary condition for minimizing the cost $C=w_cL_c+w_wL_w+w_mL_m+rk$ of producing output Y is

$$L_c = \beta\alpha\, rK/(w_c(1-\alpha)) \quad (2)$$

A key aspect of this equation is that the demand for children depends only on children's wages and the capital stock. Technological change affecting the relative employment of children is represented by variation in β. Unmodeled variation in demand or the effects of model mispecification can be incorporated as a multiplicative error term in equation (2).

The supply of children to the cotton factories depends on the number of children in the local labor market, the demand for children in non-cotton factories, and the factory wage. As Lyons (1989) shows, there are other factors, such as parental unemployment, that affect the supply of children to factories, but these factors are left as part of the unmodeled variation in labor supply. Thus the supply of children to cotton factories is

$$L_c = v\, n^{\phi}\, o^{\eta}\, w_c^{\gamma} \qquad (3)$$

where v is unmodeled variation, n is the number of children in the local labor market, and o is an index of labor absorption by non-cotton factories (see below). Solving equations (2) and (3) for L_c gives a reduced form equation for children employed

$$\log(L_c) = c + \varphi_1 \log(K) + \varphi_2 \log(\beta) + \varphi_3 \log(n) + \varphi_4 \log(o) + \varepsilon \qquad (4)$$

where c is a constant, $\varphi_1=\varphi_2=\gamma/(1+\gamma)$, $\varphi_3=\phi/(1+\gamma)$, $\varphi_4=\eta/(1+\gamma)$, and ε represents unmodeled variation. Equations analogous to (4) also hold for the employment of women and men. Since the parameters in (3) are different for children, women, and men, there are no cross-equation restrictions among these employment equations.

Note that if children's labor supply is perfectly elastic, then equation (3) doesn't apply. In this case employment is

$$\log(L_c) = c + \log(K) + \log(\beta) + \varepsilon \qquad (5)$$

where c is a constant and ε represents unmodeled variation. Analogous equations hold if labor supply for women and labor supply for men are perfectly elastic.

Data

The sample is a cross-section of English towns in 1838. It includes towns that contained cotton factories and for which data were available on the age distribution of both the cotton factory workforce and the population. The sample covers 1353 factories and 187,537 workers and thus includes 85% of English cotton factories and 86% of workers

covered in a comprehensive 1838 survey (BPP 1839). All the variables describe below are drawn from that survey unless otherwise noted.

The definition of children, women, and men, categories that are often taken for granted, requires careful consideration. Children have been defined as workers under sixteen, since before this age neither employment profiles nor wages differ greatly among males and females. Men and women are then defined as male workers sixteen and over and female workers sixteen and over, respectively. In forming the aggregates for children, women, and men, I assume that, within these categories, workers of different ages earn wages in proportion to their category-specific skills. The number of male and female factory workers in each town in the sample is known for each year of age up to age 20, with ages 21 and over being the remaining group. Wage data (BPP 1834, p. 21) for these age groupings were used to compute wage-weighted aggregates for children, women, and men.

A wage-weighted aggregate for workers of different ages within a given category is merely a rescaling of the simple aggregate (sum of workers in that category) if the age distribution of workers did not vary within the category or if age-based wage variations within the category were unimportant. The latter is certainly not true, as Figures 1 and 2 show. Age distributions within categories were, however, relatively constant: the standard deviations of the ratio of the wage-weighted aggregates for children, women, and men to their simple aggregates are 10%, 3%, and 10% of the means, respectively. The same assumption about the substitutability of workers of different ages within each category is needed to justify a wage-weighted aggregate or a simple aggregate. This assumption may not hold completely. I use the wage-weighted aggregates in the analysis below because at least they recognize the differences in wages among different age workers within each category.

Total horsepower employed in a given town's cotton factories is used as a proxy for capital in equation (4). Capital investment in a town's cotton factories, and total horsepower employed in these factories, depended mainly on location-specific factors outside the labor market, such as the development of warehousing and trading infrastructure, the availability of coal, the personal preferences and wealth of entrepreneurs, and shifts in cotton product market demands given location-specific product specialization. Such factors were probably much more significant determinants of the total horsepower employed in a town's cotton factories than variations in the wages of children, women, and men. Thus I take total horsepower employed to be exogenous in the employment equations estimated below.

The share of steam horsepower in total factory horsepower (steam horsepower plus water horsepower) is incorporated to test its significance for the division of labor. In equation (4), $v_1+v_2\log(s)$, where s is the share of steam horsepower in total horsepower and v_1 and v_2 are (unidentified) parameters, is used as a model for $\log(\beta)$. The smallest positive steam share is 0.125, while about 16% of the towns have a steam share of zero. For these later observations, log(s) is set equal to zero and a water-power-only indicator, otherwise zero, is set to one.

The regressions include evidence on labor supply. Data from the Census of 1841 (BPP 1843) identify the number of children, women, and men in each town in the sample. The Census provides data for the number of males and females grouped into five-year age categories. The local pool of potential factory workers is taken to be persons ages 9-39. The number of children is defined as the total of one-fifth the number of persons ages 5-9 (an estimate of the number of nine year olds), all persons ages 10-14, and one-fifth the number of persons ages 15-19 (an estimate of the number of 15 year olds). The number of women is taken to be the total of four-fifths the number of females ages 15-19 and all the females ages 20-39. The number of men is defined analogously to the number of women.

There are significant differences between the composition of labor supply and the composition of the factory workforce. Table 3 compares the share of the simple aggregates of children, women, and men in total factory employment with the share of children, women, and men in the local pool of potential factory workers, as defined above. This table shows that, relative to the local labor pool, cotton factories employed a relatively large number of children and women.

Table 3
Worker Share Distributions

	First Quartile	Median	Third Quartile
Children in factories	0.29	0.34	0.39
Children in labor market	0.28	0.29	0.30
Women in factories	0.34	0.40	0.49
Women in labor market	0.33	0.34	0.35
Men in factories	0.15	0.21	0.31
Men in labor market	0.35	0.37	0.39

Note: The labor market pool is as defined in the text. The shares given in the table are relative to all children, women, and men in factories or to all in the labor market.

Table 4
Employee/Horsepower Ratios

	Children	Women	Men
Cotton	1.41	1.58	1.17
Flax	2.27	2.17	1.01
Silk	4.24	3.16	1.60
Woollen	1.00	0.34	0.88
Worsted	1.75	1.60	0.35

The employment of workers in factories other than cotton factories affects labor supply for the cotton factories. The index of employment in factories other than cotton factories (variable o in equation (4)) is based on horsepower employed in these factories and average horsepower/worker ratios for children, women, and men. As Table 4 shows, the horsepower/worker ratios differ significantly across different types of factories. Using the average horsepower/worker ratios and the number of horsepower employed in each type of factory, I constructed for each town an index of the expected employment of children, women, and men in factories other than cotton factories. Assuming that horsepower employed is exogenous to the market for cotton factory workers, the index of non-cotton-

factory employment is also exogenous. This index enters equation (4) in logarithmic form (log(o)). For the 51% of observations for which the index equals 0, log(o) is set to zero and an indicator, otherwise zero, is set to one.

Table 5 summarizes the data used in the econometric analysis.

Table 5
Descriptive Statistics for Regression Data
(English Towns, 1838)

	First Quartile	Mean	Third Quartile
Cotton factory horsepower	30	669	322
Steam power share	0.36	0.68	1.00
Children in cotton factories	42	940	639
Children in other factories	0	349	307
Children in labor pool	764	4162	5628
Women in cotton factories	53	1055	617
Women in other factories	0	249	180
Women in labor pool	871	5213	7197
Men in cotton factories	20	784	422
Men in other factories	0	156	89
Men in labor pool	969	5947	6972
Cotton factories in town	1	21	13

Note: Children, women, and men in cotton factories are wage-weighted aggregates, formed as described in text. Children, women, and men in other factories are indices based on horsepower employed and average horsepower/employment ratios, as described in text. The number of towns in the sample is 63.

Estimation and Results

The weighting of the observations (towns) in the regressions is potentially an important issue. While coefficient estimates are consistent under any weighting, an incorrect weighting produces standard errors that are not consistent, and estimation is not efficient. Across factories and towns, variation in horsepower employed explains most of the variation in employment. Without changing the variance structure of the error term, equation (4) could be rewritten as a regression of employment per horsepower on horsepower and the other independent variables. Employment per horsepower in a town is a function of employment and horsepower averaged across factories within the town.

Thus, given unmodeled, uncorrelated, factory-specific effects on employment, the variance of total employment per total horsepower falls as the number of factories in a town increases. This means that town observations that encompass more factories should receive more weight in estimating equation (4). On the other hand, there is also likely to be a town-level component of the error variance, and it is incorrect to weight this error component by the number of mills in the town.

Table 6
Cotton Factory Employment Regressions

	Factory-Weighted OLS			Heterskd.-Robust LS		
	Childrn	Womn	Men	Childrn	Womn	Men
Log(cotton factory horsepower)	0.891 (.024)	0.895 (.030)	1.10 (.033)	0.925 (.029)	0.910 (.036)	1.14 (.055)
Log(steam share)	0.18 (.13)	0.36 (.15)	0.30 (.18)	0.39 (.11)	0.20 (.14)	(0.40) (.21)
Indicator: steam share=0	-0.32 (.24)	-0.04 (.28)	-0.50 (.34)	-0.61 (.15)	0.12 (.19)	-0.33 (.28)
Log(size of labor pool)	0.17 (.048)	0.20 (.062)	.034 (.051)	0.071 (.056)	0.21 (068)	0.086 (.096)
Log(other factory emp.)	-0.072 (.034)	-0.078 (.040)	-0.074 (.041)	-0.023 (.048)	-0.095 (.057)	-0.11 (.088)
Indicator: other factory employment = 0	-0.32 (.20)	-0.37 (.21)	-0.17 (.22)	-0.16 (.27)	-0.40 (.30)	-0.29 (.43)
Constant	0.12 (.25)	-0.11 (.32)	-0.59 (.34)	0.50 (.39)	-0.27 (.49)	-1.2 (.75)
Root MSE (weighted)	0.19	0.22	0.28	0.26	0.35	0.53

Note: Column headings give the category of factory employment that forms the dependent variable. The number of observations is 63 (62 for women). The figures in parentheses are the standard errors of the above regression coefficients.

Table 6 presents estimation results for the employment of children, women, and men. The first set of results are OLS regressions with observations weighted by the number of factories in each town. The second set of results are Huber-White heteroskedasticity robust regressions. Unweighted OLS regressions, not reported here, produce results similar to those in Table 6, but with larger standard errors.

There is little evidence that the source of power affects the division of labor. The steam share is significantly different from zero in the robust regression for the employment of children, but the coefficient is nearly the same as the (imprecisely estimated) coefficient for the effect of steam share on the employment of men. Moreover, the same equations show that towns with cotton factories powered only by water had significantly lower employment of children relative to men, holding other factors constant. In the weighted OLS regressions, the coefficient on steam share is significantly different from zero in the employment equation for women, but again the coefficients for women and men are similar relative to their standard errors. These results show that comparing the unconditional mean of child labor in water-power-intensive towns to steam-power-intensive towns, as Nardinelli (1980) apparently did, overlooks the effect of other significant factors that are detailed below.

There is some evidence that supply-side shifts mattered for the division of labor. In the weighted OLS regressions, an increase in the number of local children and women raised the factory employment of children and women, while there was no such effect for men. Similarly, an increase in the employment possibilities for children and women in factories other than cotton factories significantly reduced the employment of children and women in cotton factories. In this case the effect for men was of similar magnitude but not statistically significant. With the exception of the labor pool effect for women, these supply side effects do not come through in the robust regression.

Note that a labor supply shift is a factor common across factories in a town. There might, however, be variance in factories' responses to differences in labor supply. As Table 6 shows, the root mean squared error (RMSE) for the weighted regression is significantly smaller than the RMSE for the robust regression. The question of whether the weighted regressions are more informative than the robust regressions hinges on whether the town observations that encompass more factories provide more information

on factories' responses to labor supply differences. More sophisticated econometric analysis, not explored here, might be able to address that question.

Other evidence in Table 6 indicates that labor supply was highly elastic but not perfectly elastic. Consider the coefficient on horsepower. If labor supply were perfectly elastic, this coefficient would equal one. In each equation the hypothesis that this coefficient equals one can be rejected with a significance level less than 0.5%. Interpreted in terms of equation (4), the employment equations for children and women imply a labor supply elasticity about 9.0, while the coefficient in the employment equation for men implies a slightly downward sloping labor supply curve.

More important for this paper is the result that the scale of a town's cotton industry had a significant effect on cotton factories' division of labor between children, women, and men. The differences in the coefficients on horsepower imply that as the scale of the local industry increased, all else held constant, the employment of children relative to men and women relative to men fell. As Table 3 shows, the share of women and children employed in cotton factories was larger than their share in the pool of potential factory workers. Thus, all else equal, an expansion of cotton factories would put more pressure on labor supply, and hence on wages, for children and women than for men. A rise in wages for children and women relative to men can explain part of the increase in employment of children and women relative to men. However, the increase in the employment/horsepower ratio for men with an increase in industry scale suggests that additional factors matter.

The life-cycle patterns described in Section 3 of this paper imply that towns with a greater number of factory jobs had a larger number of former child factory workers for whom, under a stable division of labor, adult factory jobs did not exist. As noted earlier, the flow out of factories was more pronounced for males than females, and females probably also had a greater rate of withdrawal from the labor force as they grew older.

Workers who left a factory may have been, on average, less effective workers than those who stayed (Galbi 1994). Nonetheless, the first two sections of this paper indicate that workers with child labor experience had significantly more productive potential in factories than workers who had no childhood factory experience. The growth in the number of former child workers would have made it easier for factory managers to recruit new, effectively trained adults.

Table 7
Manchester and Stockport, 1818-9 to 1838
(Ratios – levels in 1838 to levels in 1818-9)

	Manchester	Stockport
Cotton factory horsepower	2	4
Cotton factory steam share	1	3
Labor pool of children	1.7	1.5
Labor pool of women	2.1	1.6
Labor pool of men	2.8	2.1

Note: Labor pools are as defined in text and estimated from Census data.

The effect of cotton industry scale on the division of labor, measured in the 1838 cross-section of towns, is significant relative to the growth of the cotton industry and the changes in the division of labor observed over time. Table 7 shows estimated changes in horsepower, the share of steam power, and the employment of children, women, and men in Manchester and Stockport between 1818-9 and 1838. The coefficients for the robust regressions in Table 6 along with the data in Table 7 predict about half the actual fall in the children/men and women/men employment ratios. See Table 8. The result for the women/men ratio in Stockport is anomalous, but more generally the employment pattern for women is more similar to that of children than to that of men.

Table 8
Predicted Shifts in the Division of Labor
(Manchester and Stockport, 1818-9 to 1838)

	Manchester		Stockport	
	Childrn/men emp. Ratio	Womn/men emp. Ratio	Chldrn/men emp. Ratio	Womn/men emp. Ratio
Predicted change	-18%	-9%	-29%	-39%
Actual change	-45%	-12%	-58%	-7%
Predicted rel. to actual	40%	69%	50%	584%

Note: Calculations based on Table 6 and 7, and BPP (1818) and BPP (1819).

Differences in the cotton industry's growth rate in different towns may have caused the cross-section coefficients to underestimate industry scale effects on the division of labor. Towns with greater cotton industry employment in 1838 tended to have experienced faster cotton industry growth from 1818 to 1838. Towns with faster cotton industry growth would have experienced tighter labor markets for adults and hence relatively greater use of children. Thus the effects of labor market scale in the cross-section may have been partially offset by differences in time patterns of development among towns.

Other factors might also account for the greater impact observed over time than in the cross section. The shift to self-acting mules and the income effects that Nardinelli (1980) pointed to might be part of the explanation, although self-acting mules only began to become important in late 1830's and the existence of a rise in family income in the first third of the nineteenth century is highly contentious (Brown 1990; Horrell and Humphrey 1992). As noted earlier, the Factory Act of 1833 took effect after a significant decline in child labor had already occurred, hence this law cannot explain a major part of the decline in child labor analyzed in this paper. The Factory Acts may have been important for the decline in child labor after 1835. Some have argued that a rent-seeking motivation for reducing child labor explains the Factory Acts (Marvel 1977; Anderson and Tollison 1984); the evidence here indicates that if such a motive was important, it occurred in the

context of other economic developments that were independently creating a reduction in child labor.

5. Conclusion

From an initial division of labor strongly skewed toward children, the factories produced a new adult workforce from their child workers. The growing up of a generation of child factory workers improved the quality of adult factory workers and created a reserve pool of adults with factory experience. This process of local labor market development was particularly significant for men. Over the late eighteenth and early nineteenth centuries the development of local labor markets helps account for the observed shift toward men in the division of labor in the early English cotton factories.

The role of child labor in the early English cotton mills indicates the distinctiveness of the work that the Industrial Revolution engendered. Recent scholarship has shown that national product and industrial output grew much more slowly in late eighteenth and early nineteenth century Britain than had been previously thought (Crafts and Harley 1992). This scholarship has led some to question the meaning of the period traditionally identified as the Industrial Revolution (Landes 1993). The relatively extensive use of child labor in the early cotton factories, and the decline of child labor with the maturing of generations of child workers, indicate the extent of the difference between traditional work and factory work. The nature of work is a dimension in which the Industrial Revolution was unquestionably revolutionary.

References

Official Publications

BPP (1816) Select Committee on the State of Children employed in Manufactories in the U.K. Sessional Papers, House of Commons, vol. 3

BPP (1818) Minutes of Evidence on the Health and Morals of Apprentices and others employed in Cotton Mills and Factories. Sessional Papers, House of Lords, vol. 96, appendix

BPP (1819) Minutes of Evidence on the State and Condition of the Children employed in Cotton Factories. Sessional Papers, House of Lords, vol. 110, appendix

BPP (1834) Factories Inquiry Commission Supplementary Report Part I. Sessional Papers, House of Commons, vol. 19

BPP (1835) First Annual Report of the Poor Law Commissioners. Sessional Papers, House of Commons, vol. 35

BPP (1836a) Second Annual Report of the Poor Law Commissioners. Sessional Papers, House of Commons, vol. 29

BPP (1836b) Factory Inspectors' Reports May 1835. Sessional Papers, House of Commons, vol. 45

BPP (1839) Factory Inspectors' Reports for year ending 30 June 1838. Sessional Papers, House of Commons, vol. 42

BPP (1843) Census of Great Britain. Sessional Papers, House of Commons, vol. 23

Books and Articles

Anderson GM, Tollison RO (1984) A Rent-Seeking Explanation of the British Factory Acts. In: Colander DC (ed) *Neoclassical Political Economy*. Ballinger Publishing Co., Cambridge 120-47

Bolin-Hort P (1989) *Work, Family, and the State*. Lund Univ. Press, Lund, Sweden

Boot HM (1995) How skilled were Lancashire cotton factory workers in 1833. *Economic History Review* 48(2):283-303

Brown J (1990) The Conditions of England and the Standard of Living: Cotton Textiles in the Northwest, 1806-1850. *Journal of Economic History* 50(3): 591-614

Colquon P (n.d.) *Memorandum on Cotton Manufacture in Great Britain*. Manuscript E-46, Kress Library, Harvard

Crafts NFR, Harley CK (1992) Output Growth and the British Industrial Revolution: a restatement of the Crafts-Harley view. *Economic History Review* 45(4): 703-730

Galbi DA (1994) The Perpetuation of Gender. Centre for History and Economics Working Paper, King's College, Cambridge

Gerschenkron A (1962) *Economic Backwardness in Historical Perspective.* Belknap Press, Cambridge

Horrell S, Humphries J (1992) Old Questions, New Data, and Alternative Perspectives: Families' Living Standards in the Industrial Revolution. *Journal of Economic History* 52(4): 849-80

Landes DS (1972) *The Unbound Prometheus.* Belknap Press, Cambridge
Landes DS (1993) The Fable of the Dead Horse; or, the Industrial Revolution Revisited. In Mokyr J (ed) *The British Industrial Revolution: An Economic Perspective.* Westview Press, Boulder 132-70
Lyons JS (1989) Family Response to Economic Decline: Handloom Weavers in Early Nineteenth-Century Lancashire. In Ransom RL, Lindert PH, Sutch R (eds) *Research in Economic History*, Vol. 12. JAI Press, Greenwich and London 45-92
Marvel HP (1977) Factory Regulation: A Reinterpretation of Early English Experience. *Journal of Law and Economics* 20(2): 379-402
Mokyr J (1993) Editor's Introduction: The New Economic History and the Industrial Revolution. In: Mokyr J (ed) *The British Industrial Revolution*. Westview Press, Boulder 1-131
Nardinelli C (1980) Child Labor and the Factory Acts. *Journal of Economic History* 40(4): 739-55
Nardinelli C (1984) The Productivity of Corporal Punishment. *Explorations in Economic History* 21(2): 224-8
Pollard S (1965) *The Genesis of Modern Management*. Harvard Univ. Press, Cambridge
Shuttleworth J (1842) Vital Statistics of Piecers and Spinners. *Journal of the Statistical Society of London* 5: 268-73
Smith A (1776) *An Inquiry into the Nature and Causes of the Wealth of Nations*. Cannan E (ed) 6'th edition (1961) Metheun, London