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The New England Textile Industry, 1825–60: Trends and Fluctuations

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I. Introduction

Many studies of the growth of the American economy during the first three-quarters of the nineteenth century have suffered both from the diffusion of their focus and from the weakness of their statistical foundations. Reliance on the federal Census returns necessitates estimating the underreportings that plague those volumes and, perhaps more important, limits the study to benchmark years—a limitation that excludes any discussion of fluctuations between those years. Moreover, these studies have frequently attempted to draw economy-wide conclusions from data indicative of conditions in only a local area or, conversely, to describe each area in terms of a national average. Thus, there have been frequent attempts to apply technical coefficients or economic relations derived from one area to another region characterized by an entirely different technology or subject to very different market forces.

For most of the period before 1870, no national market existed for many industries. In this period it appears almost useless to study the economy as an integrated whole rather than as a sum of various quite heterogeneous parts. Any national figures, almost by definition, blur the local characteristics; and, all too frequently, marginal changes (changes that are small, but possibly of crucial importance for growth) in local figures get lost in the national totals. Ideally, it would be best to study every industry in every region; however, because of the scarcity of source material, it is improbable that this goal can be achieved. What is more possible, however, is a study of the important industries in each region during those periods when the industry was changing rapidly (either

expanding or contracting). Since almost all industries that play a significant role in the process of economic growth could be included in this more restrictive study, such an approach seems fruitful despite the narrowing of focus. At the same time, insofar as it is possible to estimate output from all industries in all regions, studies of aggregate income will not be hampered. In fact, even these broader studies may be improved, since a comparison of local firm records with Census reports may provide a better measure of underreporting than anything previously available.[1]

Furthermore, from the point of view of economic theory, a certain economy is achieved in studying those sectors that are undergoing rapid change. Moreover, since rapidly changing industries or those heavily concentrated (geographically) tend to leave business records and other economic artifacts which may substitute for the Census as a source of statistical data, there is an additional incentive to adopt this regional methodology.

II. The Estimates

THE DATA

The cotton textile industry provides a fine example of what can be done with a regional approach (in fact, the example may be too good). The industry was heavily concentrated in New England and, within New England, the growth of the industry after 1820 was associated with the rise of a particular group of firms. Fortunately there exist today, at various museums and libraries on the East Coast, the original business records of a significant proportion of these firms.[2]

[1] The records of some of the textile mills, for example, include copies of the Census enumerators' reports as well as their mill records—which show quite different totals. The following table shows the discrepancies for six mills reporting to the 1859 Census (in millions of yards).

	Total	*Merrimack*	*Hamilton*	*Suffolk*	*Tremont*	*Lawrence*	*Massachusetts Cotton*
Reported	96.0	20.8	12.2	8.0	11.9	18.7	24.4
Actual	96.4	22.1	11.6	8.5	11.0	18.6	24.6

These six firms are a sample; all errors exceed 5 per cent, but they appear random with mean equal to zero. There is, of course, no guarantee of the randomness of the errors. More important objections to use of the federal Census after 1820 for the textile industry flow from (1) constantly changing definitions (e.g., establishment); (2) the paucity of information gathered and reported vis-à-vis the Massachusetts Census (especially the failure to report yards of output in 1839); (3) the lack of a local breakdown in 1850; and (4) the number of different "official" versions.

[2] The materials for this paper were gathered from various textile collections deposited at the Baker Library, Harvard, the Merrimack Valley Textile Museum, and the Manchester Historical Society Museum. There are to the knowledge of the authors other collections in the possession of local historical and academic units; in fact, the problem

There were two principal types of textile firms in New England.[3] The firms of the Massachusetts type, modeled after the Boston Manufacturing Company, were located on the major rivers of northern New England. They were typically multifacility operations (sometimes with bleacheries or printworks) and generally capitalized in excess of $500,000. From the beginning, these firms were integrated producing units heavily concentrated in the low-count goods. Existing alongside the Massachusetts-type operations were a much larger number of small proprietary single-mill firms located on the streams of lower New England. These so-called Rhode Island-type mills were small, often specialized, and tended to produce medium grades of cloth (particularly printing cloths).[4] During the mid-1840's the structure of the industry in lower New England changed, and thereafter the Rhode Island mills began to resemble their northern counterparts more closely.

Table 1 lists the firms whose records were used in this study. The distribution of firms is not wholly geographical. Firms of the Rhode Island type were located in Massachusetts as well as in Rhode Island and Connecticut. Moreover, although Metacomet was located in New Bedford and resembled the larger firms, it was really representative of the post-1845 mills springing up in lower New England, and was therefore included as a Rhode Island-type mill.

The company records for at least sixteen of the Massachusetts-type mills exist for at least some part of the period prior to the Civil War. The journals, semiannual accounts, and treasurer's reports give sufficient information to ascertain the amount of cloth produced by each firm.[5] Generally, the output by six-month periods is available, but for certain years the output of Nashua and Jackson was only given on a yearly basis.

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of data is not its insufficiency but rather its overabundance. In choosing the particular data used in this paper, preference was given to those records that were complete and continuous for long periods, and reasonably intelligible.

[3] The relative contributions of the two families of firms to the growth of the New England textile industry might be seen from the county returns in Massachusetts. Middlesex and Hampden counties included the large mill centers of Chicopee and Lowell; Bristol and Worcester counties were always centers of the smaller enterprises. The number of spindles (in thousands) follows:

	1820	*1837*	*1855*
Middlesex-Hampden	10	233	635
Bristol-Worcester	18	240	508

[4] The best discussion of the two types of enterprise is found in Caroline Ware's *The Early New England Cotton Manufacture*, Cambridge, Mass., 1931.

[5] In some cases it was necessary to add yards sold to the change in inventory for a period, since output figures were not always present whereas sales and inventory values were more common.

TABLE 1

SAMPLE MILLS, 1815-60

Firm Name	Years for Which Records Were Examined
MASSACHUSETTS TYPE	
Boston	1815-60
Merrimack	1824-60
Hamilton	1828-60
Suffolk	1832-60
Tremont	1832-60
Lawrence	1833-60
Massachusetts Cotton	1840-60
Naumkeag	1848-60
Lancaster	1847-60[b]
Dwight[a]	1834-60
Lyman[a]	1850-60
Nashua	1826-60
Jackson	1832-60
Amoskeag[a]	1837-60
Laconia	1845-60
Pepperill	1851-60
RHODE ISLAND TYPE	
Rampo	1821-33
Slater	1826-34
Slater and Tiffany	1827-37
Sutton	1830-59
Metacomet	1848-60

[a]Records are available for different groups of mills operated by these companies.

[b]Includes the records of the Cabot and Perkins Companies which were merged into Dwight in 1856.

For the Rhode Island-type firms, output could be estimated from either weaving ledgers or consignment books.[6] Typically, these data were available on a monthly basis.

ADJUSTMENTS TO A UNIFORM ACCOUNTING PERIOD

Reporting techniques differed greatly from mill to mill. Every month represented the closing of at least one company's accounts. Moreover, companies changed their final closing date from time to time. To make the data comparable, each mill's output was allocated uniformly over the months covered by the accounting period. Uniform allocation was

[6] The use of the consignment books introduces a sequence of lags, since there is no way of dating consignments in terms of the time elapsed between production and shipment. In the case of Slater and Tiffany, pounds of cloth produced were known but not yards.

TABLE 2

QUARTERLY OUTPUT OF SELECTED FIRMS OF THE MASSACHUSETTS TYPE, 1821–60
(thousand yards)

Year	Jan. 1–Mar. 31	April 1–June 30	July 1–Sept. 30	Oct. 1–Dec. 31
1821	337	363	370	384
1822	403	439	420	380
1823	408	465	454	433
1824	451	487	483	865
1825	1,044	886	813	774
1826	783	988	1,138	1,168
1827	1,193	1,442	1,659	1,658
1828	2,414	2,688	2,858	2,746
1829	2,569	2,681	2,702	2,711
1830	2,711	3,032	3,354	3,282
1831	3,701	3,899	4,036	3,956
1832	4,094	4,604	5,799	6,091
1833	6,956	7,481	7,975	8,052
1834	8,570	9,050	9,001	9,038
1835	9,971	10,920	11,282	11,196
1836	11,534	12,328	12,642	12,186
1837	12,690	12,620	12,063	11,746
1838	12,610	13,884	14,241	14,028
1839	14,461	15,080	14,961	14,540
1840	14,471	13,877	13,406	14,083
1841	14,734	15,088	16,020	16,234
1842	16,888	16,913	16,404	16,047
1843	15,727	15,868	16,697	16,958
1844	17,878	17,916	18,783	18,596
1845	19,622	19,994	21,163	21,296
1846	21,747	21,863	21,718	21,882
1847	22,271	22,474	22,593	22,923
1848	24,073	25,680	27,260	26,786
1849	28,030	28,229	28,994	29,827
1850	27,782	27,604	29,129	28,022
1851	28,249	28,799	31,452	32,832
1852	34,427	35,246	37,102	37,272
1853	34,580	31,172	35,938	36,509
1854	35,198	35,241	35,993	36,446
1855	35,976	36,018	35,396	35,956
1856	37,316	37,258	38,132	38,570
1857	34,638	33,929	31,451	29,474
1858	33,561	35,984	39,373	40,840
1859	40,962	41,350	42,889	43,430
1860	43,084	43,229	40,881	40,447

Source: Company records of Boston, Merrimack, Hamilton, Suffolk, Tremont, Lawrence, Naumkeag, Lancaster, Dwight, Lyman, Nashua, Jackson, Amoskeag, Laconia, and Pepperill.

selected for a number of reasons. First, it has been generally inferred that the short-run marginal cost curves were steep about some "capacity" level.[7] Second, the data required to construct a monthly deflating index were not available. What data exist are generally of poor quality because they represent only the history of the Rhode Island-type mills, whose output was often curtailed in response to a freshet or to install new equipment. These conditions were not characteristic of the rest of the industry. Third, a monthly index constructed from Rhode Island data, Nashua reports, and consumption of cotton in Cabot mill number 1 (where monthly data were available), with adjustments made for floods, replacement of equipment, and other local events, is not significantly different from the results achieved by uniform allocation. The monthly figures were summed to standard quarters and calendar years. Annual output by firm may be found in Table A-1, while the quarterly output of selected Massachusetts firms will be found summed in Table 2.

CHOICE OF OUTPUT MEASURE

The output reported in these tables is in terms of yards. The company books described output variously—in pieces, pounds, and yards. Yards were, however, the most common; they were available in all but a single case. Pieces, a widely varying metric, were the least common. Pounds of output, when not reported, could usually be estimated from the weight of cotton inputs corrected for the mill's waste factor or from the yards of output, if the weight per yard ratios were available for the full range of product. Yards were used as the measure for this study because they represented a more meaningful unit of demand, because they were more generally available, and because they appear to be a more useful tool in comparing input and output ratios.[8] Despite these advantages, yards are not a perfect measure. Because of the lack of homogeneity arising from changing width and count patterns, they too may be criticized. However, tests suggest that for this sample at least the bias injected by nonhomogeneity may not be too significant.[9]

[7] See R. C. O. Mathews, *A Study in Trade-Cycle History*, Cambridge, Eng., p. 130.

[8] Robert Layer (in *Earnings of Cotton Mill Operatives, 1825-1914*, Cambridge, Mass., 1955) feels that pounds are a superior measure. Nominally, pounds ignore width differentials but not count differences. Since yards and standard yards appear to have a relatively stable relationship on the aggregate level, the question of unit recedes in significance. Output in yards or pounds would differ by a scale factor. There are, however, certain marginal considerations which make yards preferable. In estimating production functions, the marginal products of labor, cotton, and capital can be ascertained by using yards as a measure of output; if, on the other hand, pounds were used, the rather constant proportion between cotton input and cloth output (regardless of the quality of output) does not allow the other parameters to have significant coefficients.

ADJUSTMENT TO REGIONAL LEVELS

Table 3 shows the relationship between sample output and the output of various regions as they appeared in the Census. The relationships are rather stable except for the initial change in the thirties. This jump may

TABLE 3

RATIO OF OUTPUTS OF SAMPLE FIRMS TO CENSUS OUTPUT TOTALS, SELECTED YEARS, 1831–59

Year	Rhode Island, Connecticut	Massachusetts	Maine, New Hampshire	New England
1831	.04	.16	.10	.11
1837		.29		
1839[a]	.01	.30	.40	.22
1845		.28		
1849	.04	.23	.32	.19
1855		.29		
1859	.03	.26	.29	.20

Source: 1840, 1850, 1860, federal Censuses; 1831, from Survey of Friends of Domestic Industry; 1837, 1845, 1855, Massachusetts Censuses.

[a]Ratio based on estimate of textile output.

be explained in terms of the development of Lowell and the later textile centers in Manchester and Springfield. In Massachusetts, the sample shows a gain of three firms between 1832 and 1834 (Suffolk, Tremont, and Lawrence), while eighteen were actually incorporated. During the period 1828–30, however, only Hamilton enters the sample while twenty-four firms were incorporated. A portion of the fall in relative output recorded in 1860 is a result of firms leaving the sample in that year.

The movements in the sample output series may be used to provide an index of cyclical movements in textile output. Moreover, when inflated to approximate total production they furnish a measure of total output between benchmark years. Their usefulness, however, depends on the

[9] For those mills that reported both yardage and pounds, it was possible to compensate for quality and width differences by converting their output into standard yards. Therefore, the thirty-nine mills with data on both yardage and pounds were divided into two classes, those producing mostly low-count (under 16) goods and those producing finer quality (over 18) cottons. The output of the former class were then converted into standard 14s × 14s, 48 × 48, 36″ wide brown sheeting; and the latter's output into 22s × 22s, 40, 36″ wide sheeting. Apart from the late twenties, when the sample size was small (only thirteen mills), the relations between standard and recorded yards was extremely stable (see Table A-2); and both series tend to move together. In the thirties, for example, there was first a movement toward heavier goods and then a movement toward lighter ones. If, however, total standard yards (the sum of the standard columns) is compared with total recorded yards, a slight trend toward the coarser cloth is evident.

validity of two assumptions: that the sample of firms is representative of the entire industry, and that the Census provides adequate estimates of total output in the benchmark years. As to the first, the evidence suggests that the sample of Massachusetts-type firms was quite representative of the entire universe, but that the sample of Rhode Island firms was probably less so. As to the second, the Massachusetts inflations based on the state Census probably provide a more trustworthy measure of activity in the benchmark years than the New Hampshire-Maine and New England inflations based on the federal Census do.[10]

The results of such inflations are presented in Table 4. The Massachusetts mills were inflated on a straight-line basis between the Census years 1831, 1837, 1845, and 1855. The series was extrapolated to 1860 according to the 1845–55 increments; and backward extrapolation from 1831 to 1825 was based on an incremental change of zero. This latter extrapolation probably overstates output in the earlier years (since it appears that the sample size increased relative to the universe in the period) but, in the absence of any benchmark, it remains the best alternative.

The Maine and New Hampshire inflation was based on the federal Census and the survey of 1831. The same basic procedure used in the Massachusetts inflation was followed, but the 1825–31 period was treated in the same manner as the 1831–39 interval. Rhode Island and Connecticut were treated in the same manner as Maine and New Hampshire; however, the changing sample size during the intercensual period created additional problems. Even if these could be solved, however, the smallness of the Rhode Island and Connecticut sample, particularly in the 1839–47 period, argues against attaching great significance to the inflated series.

Two different estimates of total New England output suggest themselves. First, it is possible to sum up the inflated series for the three state groups; second, one could inflate, in a manner similar to the treatment of New Hampshire and Maine, the output figures from all mills for which the data were of good quality. The difference between the two series is much greater than can be explained by the exclusion of Vermont from the first variant. Unfortunately, the former series is also subject to wide fluctuations induced by the inclusion of the poor-quality series from Rhode Island. As a result, the second technique is almost certainly a better indicator of textile activity in New England, and it is a series so constructed that is included on Table 4.

[10] Because of omissions in the 1840 Census, it was necessary to estimate textile output and this procedure injects another element of bias into the inflation based on the federal Census.

TABLE 4

OUTPUT BY REGION, 1826–60
(thousand yards)

Year	Sample			Inflated			
	Rhode Island, Connecticut	Massa-chusetts	Maine, New Hampshire	Rhode Island, Connecticut	Massa-chusetts	Maine, New Hampshire	New England
1826	770	3,757	321	27,018	23,475	3,211	37,072
1827	1,337	4,920	1,031	37,100	30,753	10,313	54,107
1828	1,427	8,768	1,939	35,731	54,797	19,386	97,327
1829	1,050	8,313	2,350	32,194	51,957	23,501	96,937
1830	1,536	9,895	2,484	42,715	61,845	24,838	112,536
1831	2,035	12,637	2,955	47,212	79,231	30,810	141,727
1832	1,813	14,730	5,858	44,167	81,832	41,841	175,961
1833	1,605	22,434	8,029	45,650	106,828	50,183	245,672
1834	1,240	27,558	8,092	47,391	111,482	44,954	272,129
1835	1,125	35,262	8,107	44,642	130,598	40,533	314,262
1836	1,489	38,531	10,159	58,421	132,866	46,178	335,797
1837	1,014	35,453	13,667	69,926	118,175	56,944	323,151
1838	1,190	39,675	15,088	99,083	134,449	58,030	359,868
1839	893	42,714	16,328	85,769	147,288	58,316	369,014
1840	372	40,900	14,938	80,870	143,509	53.349	371,012
1841	710	44,876	17,201	151,064	160,272	61,431	432,476
1842	235	45,526	20,726	48,750	165,548	74,023	437,005
1843	993	44,936	20,520	198,400	175,756	73,303	426,125
1844	741	48,332	24,842	145,098	179,000	88,721	465,593
1845	778	48,434	33,643	149,231	179,958	120,152	497,640
1846	711	51,752	35,461	133,962	190,097	126,649	527,120
1847	834	54,849	35,417	151,455	203,150	126,487	532,422
1848	5,157	65,790	38,642	117,740	240,988	138,007	589,217
1849	6,346	68,233	46,848	148,271	242,902	145,989	600,318
1850	6,143	72,210	40,320	146,962	262,583	127,032	585,179
1851	4,245	73,513	48,741	103,790	266,350	155,276	634,098
1852	5,612	86,440	57,609	140,652	312,058	185,596	745,210
1853	6,168	85,195	55,417	158,154	306,452	180,570	725,552
1854	5,989	88,627	54,255	157,605	316,521	178,823	735,368
1855	5,731	91,647	51,603	154,474	328,482	172,067	735,370
1856	6,142	97,437	53,840	170,139	347,990	181,769	774,588
1857	5,812	86,445	43,048	165,114	308,732	147,072	661,353
1858	7,464	93,840	56,510	218,246	347,555	195,401	765,920
1859	7,456	105,192	63,440	225,939	404,580	222,051	856,362
1860	6,130	104,570	63,172	245,200	402,192	224,332	850,188

III. Analysis of Fluctuations in Textile Output

Recently there has been some controversy over business fluctuations in the antebellum decades, and the textile series cast some light on the dating of the so-called cycles.[11]

[11] The question of specific cycles was recently raised by J. R. T. Hughes and N. Rosenberg in "The United States Business Cycle before 1860: Some Problems of Interpretation," *Economic History Review*, 1963; and some questions of long swings were discussed by L. E. Davis in "The New England Textile Mills and the Capital Markets: A Study of Industrial Borrowing, 1840-1860," *Journal of Economic History*, March 1960.

SPECIFIC CYCLES

The strong trend element and the discrete entry of firms into the sample somewhat complicate the analysis of the fluctuations of textile activity; however, Table 5 presents two series that throw some light on the subject; and Table 6 contrasts the textile series with the National Bureau turning points. Column 1 of Table 5 shows changes in the output of the sample firms of the Massachusetts type after correction for lumpiness of entry. To correct for lumpiness, change in output for any pair of years was calculated by summing the differences in production for only those firms which operated throughout both years. This corrected series indicates four years (1825, 1832, 1842, and 1850) when total sample output increased, but the level of production by established firms contracted. Column 2 presents the first differences for the inflated New England series previously presented in Table 4.

The first cycle apparently reached its peak during the last quarter of 1824 and the first quarter of 1825. Output increased until that date for both sample firms and fell for the next three quarters. Inventories were accumulated during the second half of 1824 and remained at substantial levels until mid-1826. Real sales fell during 1824, recovered during the first three quarters of 1825, subsided again until the fourth period of 1826 and the first of 1827. These fluctuations are somewhat at variance with the standard cycle that shows contraction to 1824, recovery during 1824, and contraction again in 1825-26.

All indexes show an increase in textile activity until 1828; however, output increases stopped in the third quarter of that year and did not reach the same level until mid-1830. Inventories increased in the first quarter of 1829 and fell only in the second half of 1830, but real sales fell after mid-1828 and rose again in late 1829. These movements seem to be in accord with measures of general business activity.

The recovery continued until mid-1831, and at that time output peaked for each of the operating companies. Large inventories were, however, accumulated during the next year, and sales fell for the entire sample in 1832. Complete recovery was evident in 1833. It is an open question whether this dip was a product of the smoothing process (since it is not noticeable in the second series) or actually represented a decrease in industry activity. However, additional evidence appears to support the latter conclusions. The standard works on business fluctuations show a general contraction during 1831–34; the Cole and Smith volume-of-trade index shows a drop in 1832; and, perhaps most important, the Rhode Island sample (containing a constant number of firms

TABLE 5

ANNUAL CHANGES IN TEXTILE OUTPUT, 1821–60

Year	Massachusetts, Corrected (thous. yards) (1)	New England (mill. yards) (2)
1821	194	
1822	187	
1823	119	
1824	137	
1825	-188	
1826	236	
1827	1,164	17
1828	1,037	43
1829	-454	0
1830	1,582	16
1831	2,742	29
1832	-305	34
1833	1,439	70
1834	55	27
1835	7,704	42
1836	3,270	21
1837	-3,079	-13
1838	4,223	37
1839	3,038	9
1840	-1,813	2
1841	3,524	61
1842	-3,039	5
1843	-589	-11
1844	3,396	39
1845	102	32
1846	3,317	29
1847	2,961	5
1848	4,957	57
1849	2,544	11
1850	-855	-15
1851	977	49
1852	10,292	11
1853	-1,247	-20
1854	3,433	10
1855	3,020	0
1856	5,791	39
1857	-10,992	-113
1858	7,394	105
1859	11,353	90
1860	-723	-6

Source: Col. 1 from Table A-1; col. 2 from Table 4.

TABLE 6

OUTPUT TURNING POINTS, TEXTILE SERIES AND NBER ESTIMATES, 1825-58

Trough		Peak	
Textile	NBER	Textile	NBER
1825	1826	1828	1828
1829	1829	1831	
1832		1833	1833
1834	1834	1836	1836
1837	1838	1839	1839
1840		1842	
1843	1843	1844	1845
1845		1846	
1847	1846	1848	1847
1850	1848	1852	1853
1853	1855	1856	1856
1857	1858	1858	1860

Source: Textile series from Table 5; NBER series from W.C. Mitchell, *Business Cycles, The Problem and Its Setting*, New York, NBER, 1927, pp. 425-427.

during this period) shows a decrease in output and a substantial fall in profits.[12]

Textile output increased from 1833 to 1836; however, the rate of growth of output and sales fell substantially during middle and late 1834. After the peak of the third quarter of 1836, output stagnated at a lower level for a year. In the last half of 1837, sales fell sharply, output less rapidly, and inventories accumulated. The severity of the contraction was limited to the third and fourth quarters of 1837. Recovery was immediate and continued sporadically through 1838 and 1839, but the rate of increase was lower in the latter year. Late 1839 and 1840 witnessed a fall in output and sales, and inventories tended to accumulate during the first and third quarters of 1840. The year 1841 marked a moderate recovery in sales and output but only a slight reduction in inventories. The peak of this moderate recovery was reached in the second quarter of 1842, and was followed by three quarters of contracting output. Sales fell during the same period but not as rapidly as production, and as a result inventories were reduced. The trough was reached by the second quarter of 1843. These movements do not coincide precisely with the accepted series. The National Bureau marks 1838 as the trough, but textile activity increased

[12] Arthur H. Cole and Walter B. Smith, *Fluctuations in American Business, 1790-1860*, Cambridge, Mass., 1935.

throughout most of that year. Similarly, the NBER figures do not show the recovery of 1841 and fall in 1842. The troughs of 1843, however, do coincide. The Cole and Smith series also shows no recovery in 1838, but it does reflect the contraction-expansion-contraction phases of 1840, 1841, and 1842.

The middle and late 1840's witnessed a period of sustained increase in both output and sales of cotton cloth. Inventories were reduced to virtually nothing in 1846, but accumulated during the later forties. The industry's growth rate accelerated rapidly during this period through the expansion of existing mills, the entry of new firms at existing sites (the sample added nine new mills built by the old firms and four by new firms), and the development of new sites (for example, Lawrence and New Bedford). The expansion slackened after mid-1848 and ended in the first quarter of 1850, when sales and output fell. Inventories peaked in the fourth quarter, and the trough was reached by the first quarter of 1851. After that date all indexes showed continued improvement until 1853 when output in the first half fell but immediately recovered. This brief drop in production and the concomitant fall in sales were borne entirely by the firms producing finer goods. Output continued to grow during the years 1854, 1855, and 1856. This pattern differs substantially from the general cycle pattern of the National Bureau. Although the Massachusetts data suggest a mild contraction in 1845 and the New Hampshire mills cut back production in late 1847, the Bureau's dates are noticeably out of phase with the fluctuations of textile activity during the 1845–48 period. The textile depression of 1850 seemingly occurred at a time of relative prosperity. Thereafter, however, throughout the mid-1850's textiles appear to have led the economy.

The dominating economic event of the late 1850's was the panic of 1857. Sales and output began to erode early in that year but dropped swiftly during the last half. The year-end inventories were almost twice the level of 1856. Recovery was evident with the new year; predepression levels of sales and output were attained in the third quarter of 1858. Inventories were parred by over 35 per cent but were still substantially above the 1856 level. Output and sales reached a prewar peak in 1859; inventories dropped below the 1856 levels; and profits attained their highest level since 1846. Again, the textile industry apparently led the economy.

LONG SWINGS

The data also appear to cast some light on the existence of long swings in the American economy during the antebellum decades. Cole has observed an apparent long swing during the 1840's and 1850's. In his examination

TABLE 7

THREE-YEAR MOVING AVERAGES OF CHANGE IN TEXTILE OUTPUT, 1822-59

Year	Massachusetts (thous. yards) (1)	New England (mill. yards) (2)
1822	167	
1823	148	
1824	23	
1825	62	
1826	404	
1827	812	
1828	582	20
1829	722	20
1830	1,292	15
1831	1,341	26
1832	1,294	44
1833	398	44
1834	3,068	46
1835	3,678	30
1836	2,633	17
1837	1,473	15
1838	1,396	11
1839	1,818	16
1840	1,585	24
1841	441	23
1842	33	18
1843	76	11
1844	971	20
1845	2,273	33
1846	2,128	22
1847	3,747	30
1848	3,489	24
1849	2,217	18
1850	890	15
1851	3,473	15
1852	3,342	13
1853	4,161	0
1854	1,737	-3
1855	4,083	16
1856	725	-28
1857	733	10
1858	2,587	27
1859	6,010	-66

Source: Table 5.

of the period, he found a trough in 1843 and another in 1858 and concluded "there evidently were forces which, acting slowly, gave decade-long sustaining power to values."[13] A similar swing was found in interest rates of the period.[14] The textile series also show such a swing and, in addition, suggest that the 1843–58 swing was not unique. Table 7 presents three-year moving averages of the changes in textile output. These series indicate a trough in 1843-44, an intervening peak in 1847–49, and a trough in 1856-57. Moreover, they show an earlier swing with an apparent trough in 1824-25 and a peak in 1834-35.

IV. Productivity Change

Table 8, constructed from the spindleage, payroll, and output records of the Tremont, Suffolk, Hamilton, Lawrence, Boston, and Nashua mills, provides some measure of the increase in productivity realized by the Massachusetts-type firms during the antebellum period.[15] Column 1 shows average output per man-day and column 4 average output per spindle in the six mills. Columns 2 and 5 present a three-year moving average of the raw data, and columns 3 and 6 five-year moving averages chosen to smooth the effect of short-term fluctuations.

The series presented in columns 4, 5, and 6 show an increase in output per spindle of almost 50 per cent during the 1830's. Thereafter, the series decline slightly, but the fall is merely a reflection of a reduction in the hours of work and implies no decrease in productivity. (When the series are adjusted to a common workday, they display no significant change after 1840.) The labor figures (columns 1, 2, and 3) also indicate a substantial increase in productivity during a part of the period. These latter series display a monotonic increase until about 1850; thereafter, however, output per worker remained relatively constant.

A comparison of the two series with each other and with the usual indexes of business activity produces only tenuous results. Despite what one might think a priori, the two do not move together in the short run. In the long run, the upward trend of labor productivity and the change in the direction of the capital index about 1840 might suggest that innovation before 1840 was capital-saving as well as laborsaving, while thereafter the laborsaving, capital-using innovations appear to have been more prevalent. The short-cycle behavior also displays no consistent patterns,

[13] Cole and Smith, *Fluctuations*, pp. 126–127.

[14] Davis, "The New England Textile Mills," p. 13.

[15] The hourly and daily data for the last four mills was originally gathered by Robert Layer. He generously allowed us to use his worksheets.

TABLE 8

OUTPUT PER MAN-DAY AND OUTPUT PER SPINDLE-YEAR, 1821-60

Year	Yards Per Man-Day			Yards Per Spindle-Year		
	Raw (1)	3-Year Moving Average (2)	5-Year Moving Average (3)	Raw (4)	3-Year Moving Average (5)	5-Year Moving Average (6)
1821						
1822						
1823						
1824						
1825						
1826						
1827				130		
1828				161	166	
1829				206	195	191
1830				219	222	213
1831	40.07			241	229	243
1832	35.56	35.15		228	264	249
1833	30.02	34.66	37.23	323	262	254
1834	38.59	36.93	37.25	235	267	258
1835	42.19	40.62	39.45	244	246	262
1836	40.07	42.88	42.64	260	251	255
1837	46.39	44.13	44.40	249	265	273
1838	45.94	46.91	45.13	287	287	287
1839	48.39	46.77	46.39	326	309	294
1840	45.88	46.88	47.26	314	311	301
1841	46.38	47.66	48.18	294	297	299
1842	50.72	50.04	50.52	283	285	292
1843	53.03	53.46	52.32	277	284	285
1844	56.62	54.82	53.14	293	283	284
1845	54.82	53.97	53.22	278	287	287
1846	50.47	52.13	54.48	290	288	293
1847	51.09	53.63	55.39	295	298	291
1848	59.33	57.20	57.61	309	296	293
1849	61.19	62.17	60.73	284	294	286
1850	66.00	64.41	63.94	289	276	280
1851	66.05	66.22	65.48	255	269	270
1852	66.62	66.40	66.20	263	260	279
1853	66.53	65.98	65.78	261	280	274
1854	64.80	65.07	64.79	316	285	276
1855	63.88	63.27	62.78	277	285	272
1856	61.14	63.28	65.69	262	261	270
1857	63.83	66.60	67.74	245	252	265
1858	74.82	71.22	66.98	250	262	272
1859	75.01	69.97		292	285	
1860	60.12			313		

Source: Company records of Tremont, Suffolk, Hamilton, Lawrence, Boston, and Nashua.

although, as Layer has indicated, the labor productivity fell during the boom of 1846 and increased significantly during the depression of the early 1840's. Moreover, the long swings in productivity usually noted in studies of the long cycles of the post-Civil War economy are notably absent from the textile data.[16]

It has been frequently argued that the American textile industry underwent a revolutionary transformation in the decade between 1814 and 1824, but that thereafter technical progress was relatively slow. Certainly the industry during the decade following the War of 1812 was marked by many obvious changes. In terms of industrial organization, the integrated mill, so successfully pioneered by the Boston Manufacturing Company, was widely introduced. Moreover, there were also important developments in machine technology. The decade saw the invention and widespread innovation of the power loom, the Waltham dresser, the double speeder and filling frame, the self-acting loom temple, and a number of pickers and openers.[17]

These developments, admittedly of an almost revolutionary character, antedate this study. The study does, however, cast some light on the developments after 1824. The case for relative stagnation in the latter period rests, not on any quantitative evidence, but only on the observation that the changes that did occur do not appear particularly important when contrasted with the developments in the previous period.[18] Gibb, working from the records of the textile machinery firm, has argued that techniques continued to improve rapidly after 1824, and the productivity figures from the Massachusetts mills bear out his conclusions. True, there were no revolutionary changes in industrial organization, but there were developments in textile machinery. The twenty years after 1824 saw the development of the cap spinner and an imperfect ring spinner, the self-acting mule, and improvements in the roving frames. These developments almost certainly contributed to a steady increase in per worker productivity during the 1830's and 1840's. Moreover, new machines do not tell the

[16] The relationships between output and wages are discussed in Robert Layer, *Earnings*, pp. 24–27.

[17] For a detailed account of these developments, see George S. Gibb, *The Saco Lowell Shops*, Cambridge, Mass., 1950.

[18] In discussing the technology, most works on American history describe the early contributions of Slater and the Waltham system, but fail to emphasize the long-run revolutionary impact of the succession of gradual changes which characterized the period between 1825 and 1850.

At times the authors emphasize innovations which were not widely adopted before the 1860's. (See, for example, H. Faulkner, *American Economic History*, New York, 1960, p. 248.) In other cases, they single out the period after 1850 and gloss over the middle period. (See R. Russel, *A History of the American Economic System*, New York, 1964, p. 179).

entire story. More important, throughout the period new refinements were worked out in the machine shop and then were incorporated in the latest models of the old machine.

Also contributing to the rise in per worker productivity and certainly the prime cause of the increasing output per spindle, reflected in the figures in Table 7, was the great rise in spindle speed associated with the innovation of the belt drive. Even if machine technology had not changed, the output of the existing capital stock would have risen significantly because of the much higher operating speeds which could be attained with the new drive system. Before 1828 mechanical problems inherent in the English gear drive (problems that multiplied rapidly in the imperfect American copies of the drive) severely limited operating speed. In that year, however, Paul Moody in building the Appleton mills introduced the belt drive principle to textile production. Thereafter, the new principle was widely imitated and American mills greatly increased their speed of operation.[19]

The increase in speed meant that output per spindle rose by almost 50 per cent. The number of spindles has been used typically as an index of textile capital, but the increase in output per spindle implies that such a measure cannot be reliably employed in any study spanning the period before and after the innovation of the belt drive.[20]

Finally, Table 9 compares the productivity of the six firms with the average productivity of the entire industry. The United States figures are drawn from the federal Censuses and, therefore, may be distorted. However, since even the Massachusetts figures based on the fairly reliable state Census show lower productivity, it seems unlikely that the weakness of the Census fully explains the difference. The sample firms, although not on the average producing a coarser cloth, show remarkedly higher output-to-labor and output-to-spindle ratios even though the figures on output per man-year for the sample firms have been deliberately underestimated (the data in Table 9 are based on an average 265-day work

[19] Gibb, *Saco Lowell Shops*, pp. 76–80.

[20] This is also true in the period after the introduction of belt drive, even though Taussig claims that spindles are "the best single indication of the extent and growth of such an industry as cotton manufacture" (Taussig, *Some Aspects of the Tariff Question*, Cambridge, Mass., 1915, p. 265).

It is easy to cite examples in which the use of the number of spindles as a measure of output leads to error:

Example 1. With use of the spindle figures, the estimated output for the U.S. in 1839 would be 412 million. If the value of output in 1839 were deflated by a price index and then converted into yards (on the basis of 1840), the estimate would be 357.

Example 2. Between 1890 and 1910, spindle speed increased by 11 per cent, spindles by 93 per cent, and consequently expected output by 112 per cent. Actual output increased by 108 per cent.

year).[21] An examination of the six sample firms indicates that they were substantially larger than the average.[22] Therefore, insofar as economies of scale exist, they probably account for part of the differences between the sample and the average.

TABLE 9

MEASURES OF TECHNICAL EFFICIENCY IN COTTON TEXTILE PRODUCTION FOR SAMPLE, UNITED STATES, AND MASSACHUSETTS (yards)

	Output Per Spindle Per Year			Output Per Man Per Year		
Year	U.S.	Massa-chusetts	Sample	U.S.	Massa-chusetts	Sample
1820[a]	142		234	2,000		
1831	185	233	241	3,707	5,938	10,618
1837		224	260		6,395	12,823
1845		215	278		8,483	14,437
1849	217	232	284	7,796	10,399	16,215
1855		207	277		9,055	16,928
1859	219	248	292	9,410	10,800	19,878

Source: 1820, 1850, and 1860 for Mass. and U.S., from Censuses; 1831, from survey of that year; 1837, 1845, and 1855 Mass. figures, from state censuses.

[a]Based on a sample of firms which reported yardage produced.

Moreover, as Anne Grosse has shown, there are usually significant differences between the technically "best practice" and the normal mill practices in the textile industry. Management is not omnipotent and

[21] A further bias may be introduced against the tentative conclusion by assuming that the proportion of inputs used in the production of intermediate products (batting, thread, yarn, etc.) was the same as the proportion of cotton used in each. Also it may be assumed that at least 10 per cent of the employees were not in the four major departments. The Census data ratios would then be increased by 14 per cent for the U.S and 12 per cent for Massachusetts. The only case in which the relative values would be changed is 1831 for which the Massachusetts capital ratio would exceed the sample ratio.

[22] The number of spindles per mill was as follows:

	Sample	*Mass.*	*U.S.*
1831	6,073	1,359	1,567
1837	7,164	2,011	
1839	6,794	2,145	1,842
1845	6,842	2,707	
1849	8,370	6,048[a]	3,284[a]
1855	8,403	5,168	
1859	9,912	7,711[a]	4,799[a]

[a] The Census reported only firms. Many firms were multimill operations.

even if it were, it must utilize both old and new equipment.[23] Since the sample mills were the industry leaders or large mills with machine shops, which actually developed new machines and improved existing ones, it seems reasonable to assume that their technology was closer to "best practice" than was that of the average mill. The histories of the mills seem to indicate that the equipment of the leading firms was continually modified by their shop crews, while firms without shop connections had to buy complete new machines. These latter purchases could not be made until the entire new machine was available and, under any conditions, would not have been made until the total cost of the new machines' output was below the variable cost of the old machines' product. In fact, the average of 21 per cent, by which spindle productivity in the sample mills exceeded productivity in all Massachusetts during 1831–55, is not very far from Mrs. Grosse's 25 per cent estimate for the excess of best over average practice in the United States in 1941–46.[24]

A comparison of the figures presented in Table 9 and Mrs. Grosse's work shows at least one marked difference. In the more recent period, Mrs. Grosse has shown that average practice tends to approach best practice (i.e., the divergence between average output per spindle and best practice output tends to fall over time). No such convergence is apparent in Table 9. Although it is not possible to explain this difference with certainty, one partial answer suggests itself. In the period covered by the Grosse study, best-practice techniques were fairly constant. (Her best-practice estimates were constant from 1926 to 1935 and from 1936 to 1949.) In the earlier period, on the other hand, there was a continual improvement in best-practice techniques until the late 1840's. During this period, therefore, it is possible that average mills continually adopted newer practices but were still unable to close the gap between themselves and the leading firms. Even this answer, however, fails to explain the lack of convergence in the 1850's, when best-practice techniques showed little improvement. As for best practice relative to spindles (as opposed to labor), however, the early textile data do show the Massachusetts figures closing on the sample data.

[23] Anne Grosse, "The Technological Structure of the Cotton Textile Industry," in *Studies in the Structure of the American Economy*, W. Leontief, ed., New York, 1953, pp. 360–420.

One should also mention T. Y. Shen's thesis, "Technological Change in the Cotton Textile Industry," a best-practice study. This work has been reported in T. Y. Shen, "Job Analysis and Historical Productivities in the American Cotton Textile Industry," *Review of Economics and Statistics*, May 1958.

[24] Grosse, "Technological Structure," p. 410.

V. Summary

The records of business firms represent a relatively untouched resource for studies of the American economy in the nineteenth century. In this study, based on the records of a number of cotton textile firms, we have attempted to provide some information on the fluctuations in industrial output between the Census benchmark years. Firm records can also serve as a basis for studies of fluctuations in inventories, sales, costs, profits, and other variables for which we have only benchmark data. If studied regionally, firm records may be able to yield quantitative evidence regarding interregional differences in relative costs and techniques. In addition, an analysis based on firm records can yield some estimates of productivity changes and their causes and can, perhaps, suggest some ways by which these changes are transmitted through the economy.

TABLE A-1

ACTUAL OUTPUT STANDARDIZED WITH TABLE 3 TREATMENT, BY MILLS, 1815-60
(thousand yards)

Date	Boston	Merrimack	Hamilton	Suffolk	Tremont	Lawrence
1815	76					
1816	189					
1817	261					
1818	530					
1819	996					
1820	1,262					
1821	1,456					
1822	1,643					
1823	1,762					
1824	1,899	389				
1825	1,711	1,807				
1826	1,785	1,971				
1827	1,862	3,057				
1828	1,967	3,988	2,810			
1829	1,813	4,357	2,141			
1830	1,879	5,778	2,236			
1831	2,003	6,358	4,275			
1832	1,982	6,244	3,490	2,396	615	
1833	1,674	6,673	3,526	4,294	5,161	1,104
1834	2,090	6,948	3,926	3,839	4,578	6,173
1835	2,420	9,026	4,171	4,329	6,182	9,130
1836	2,450	9,961	4,612	4,579	6,661	10,265
1837	2,703	9,047	4,061	3,566	6,848	9,224
1838	2,820	9,998	5,104	4,520	6,713	10,518
1839	2,862	11,711	5,528	4,857	6,735	11,018
1840	2,580	9,922	5,606	5,118	7,123	10,549
1841	2,705	12,488	5,447	5,132	7,089	11,561
1842	2,488	12,625	5,212	4,807	6,314	10,858
1843	2,190	12,612	5,215	4,532	6,083	10,339
1844	2,683	13,299	5,828	5,061	6,624	10,480
1845	2,559	13,320	5,445	5,553	6,642	10,604
1846	2,477	13,052	6,343	5,689	6,584	12,816
1847	2,936	13,193	7,074	5,843	6,748	13,476
1848	3,172	14,729	8,953	5,732	7,401	14,199
1849	3,416	14,635	9,024	6,155	7,515	13,607
1850	3,472	17,663	10,208	4,656	5,666	11,128
1851	2,788	19,602	10,338	4,695	4,235	10,859
1852	2,724	19,989	11,696	6,420	7,715	13,696
1853	2,968	17,862	12,058	6,935	8,706	14,743
1854	3,154	17,354	11,658	6,709	10,021	13,726
1855	3,310	18,553	11,724	7,109	8,755	14,187
1856	3,698	19,765	11,218	8,049	10,797	15,927
1857	3,538	19,029	10,508	6,523	9,602	14,696
1858	3,497	19,680	10,336	7,361	8,552	16,371
1859	4,166	22,103	11,592	8,507	11,003	18,627
1860	4,573	22,447	12,917	8,455	11,169	19,183

(continued)

TABLE A-1 (continued)

Date	Naumkeag	Lancaster	Dwight I	Dwight II	Dwight III	Lyman I
1815						
1816						
1817						
1818						
1819						
1820						
1821						
1822						
1823						
1824						
1825						
1826						
1827						
1828						
1829						
1830						
1831						
1832						
1833						
1834						
1835						
1836						
1837						
1838						
1839						
1840						
1841			407	44		
1842			1,654	1,565		
1843			1,403	2,558		
1844			1,563	2,791		
1845			1,555	2,515	236	
1846			1,445	2,386	956	
1847		327	1,553	2,607	1,087	
1848	4,877	1,422	1,510	2,558	1,231	
1849	5,394	3,192	1,523	2,373	1,393	
1850	5,458	4,058	1,461	2,185	1,418	4,831
1851	5,614	4,102	1,528	1,787	1,384	6,574
1852	5,701	4,369	1,543	2,356	1,306	8,595
1853	5,294	4,026	1,572	2,444	1,440	4,172
1854	5,112	3,869	1,486	2,521	1,361	8,202
1855	5,460	4,678	1,679	2,486	1,403	8,289
1856	5,392	5,039	1,447	2,546	1,519	8,110
1857	4,925	4,612	1,284	2,885	1,154	4,240
1858	4,868	4,636	1,789	2,139	1,204	8,955
1859	5,366	5,340	1,930	2,485	1,342	8,553
1860	5,539	5,309	1,776	3,503	1,449	4,309

(continued)

TABLE A-1 (continued)

Date	Lyman II	Nashua	Jackson	Laconia	Pepperill	Amoskeag I
1815						
1816						
1817						
1818						
1819						
1820						
1821						
1822						
1823						
1824						
1825						
1826		321				
1827		1,031				
1828		1,938				
1829		2,350				
1830		2,483				
1831		2,954				
1832		3,347	2,510			
1833		3,721	4,308			
1834		3,706	4,385			
1835		3,646	4,460			
1836		5,591	4,567			
1837		6,560	4,975			1,272
1838		7,755	4,997			1,407
1839		9,033	4,980			1,453
1840		7,690	5,173			1,126
1841		8,203	5,321			1,077
1842		7,582	4,803			1,102
1843		7,814	4,867			1,148
1844		8,485	5,368			1,160
1845		11,041	5,473	1,974		1,189
1846		11,133	5,250	3,093		1,190
1847		10,479	4,980	5,509		540
1848		11,767	5,219	8,355		
1849		12,445	5,115	10,787		
1850		12,548	4,339	8,111	755	
1851		9,535	3,713	10,937	7,174	
1852	324	10,529	4,162	12,296	10,624	
1853	2,969	11,005	4,818	10,569	9,919	
1854	3,446	11,975	5,000	9,571	9,794	
1855	4,006	12,840	5,098	3,811	10,707	
1856	3,923	11,689	6,474		13,291	
1857	3,440	10,430	6,103		10,946	
1858	4,446	11,834	6,843		14,768	
1859	4,172	13,881	8,441		14,976	
1860	3,834	15,265	8,568		15,792	

(continued)

TABLE A-1 (concluded)

Date	Amoskeag II	Amoskeag III	Rampo	Slater	Slater and Tiffany	Sutton	Metacomet
1815							
1816							
1817							
1818							
1819							
1820							
1821			149				
1822			181				
1823			317				
1824			350				
1825			245				
1826			281	488			
1827			320	678	338		
1828			261	643	604		
1829			305	458	546		
1830			336	608	589	1	
1831			271	696	662	405	
1832			247	619	610	335	
1833			119	461	572	452	
1834				393	365	479	
1835				247	374	503	
1836				415	600	473	
1837	857			620	61	331	
1838	927			506		683	
1839	860			509		383	
1840	946					372	
1841	884	1,714				710	
1842	914	6,322				234	
1843	507	6,182				992	
1844	1,050	8,777				740	
1845	1,242	12,719				776	
1846	1,549	13,242				710	
1847	1,537	12,369				833	
1848		13,299				403	5,020
1849	498	17,999				845	5,500
1850	1,568	12,996				842	5,303
1851	1,564	15,816				875	3,370
1852	1,700	18,295				955	4,656
1853	1,458	17,646				998	5,170
1854	1,452	16,460				757	5,232
1855	1,423	17,721				1,286	4,445
1856	1,411	20,972				1,000	5,141
1857	544	15,024				511	5,300
1858	504	22,559				1,645	5,820
1859	1,900	24,240				1,800	5,656
1860	1,681	21,863					6,130

TABLE A-2

COMPARISON OF STANDARD AND RECORDED YARDS, BY COUNT, 1825-60
(thousand yards)

	Producers of Low-Count Goods[a]			Producers of Medium-Count Goods[b]		
Year	Number of Mills	Estimated Standard Output	Recorded Output	Number of Mills	Estimated Standard Output	Recorded Output
1825	3	1,586	1,711	3	2,349	1,801
1826	5	1,629	2,106	3	2,562	1,971
1827	5	2,669	2,893	3	3,975	3,057
1828	7	6,787	6,717	3	5,185	3,988
1829	7	6,282	6,305	3	5,664	4,357
1830	8	6,588	6,600	5	7,512	5,778
1831	8	9,492	9,233	6	8,266	6,358
1832	11	14,361	14,343	6	8,117	6,244
1833	15	24,224	23,790	6	8,674	6,673
1834	15	31,127	28,700	6	9,032	6,948
1835	17	36,094	34,341	7	12,118	9,323
1836	17	39,271	38,729	7	14,980	11,657
1837	17	37,759	37,940	7	12,554	9,944
1838	18	42,823	42,429	8	16,050	12,350
1839	18	45,921	45,016	8	18,713	14,393
1840	18	45,022	43,842	8	19,504	13,016
1841	18	47,218	45,460	9	20,218	15,952
1842	18	43,948	42,066	9	21,645	18,264
1843	18	42,782	41,043	9	20,240	17,227
1844	18	47,263	44,531	9	23,094	19,205
1845	21	52,362	49,295	10	25,249	19,435
1846	22	57,126	53,388	10	26,936	20,598
1847	24	60,901	57,048	10	25,797	19,937
1848	24	73,018	69,679	10	27,755	21,757
1849	24	77,505	73,463	10	27,008	21,755
1850	24	68,311	66,346	10	31,373	24,829
1851	24	73,055	69,893	10	32,481	26,245
1852	24	91,907	85,568	10	34,105	27,555
1853	24	90,909	87,019	9	30,330	24,317
1854	24	88,982	86,725	9	26,567	23,824
1855	24	87,353	83,006	9	31,573	25,411
1856	24	91,798	86,540	9	34,671	26,428
1857	24	81,018	77,276	9	31,372	24,896
1858	24	89,255	84,433	9	32,168	26,914
1859	24	102,670	96,562	9	37,801	30,119
1860	24	107,829	101,466	9	36,060	29,604

[a]Boston, Hamilton, Suffolk, Tremont, Lawrence, Naumkeag, Jackson, Nashua, Pepperill.

[b]Merrimack, Dwight.

COMMENT

Paul F. McGouldrick, Board of Governors, Federal Reserve System

In estimating the annual output of the New England textile industry between 1825 and 1860, Davis and Stettler assumed that their sample was representative of established companies with respect to percentage changes in output and that additions to output by new companies occurred evenly between benchmark dates. The first of these assumptions is supported broadly by my analysis of much the same group of companies which shows a very low variance of company output changes around mean output changes.[1] My comparison of the output of these companies with the raw cotton consumed annually in the United States after the Civil War showed a steeper upward trend, as would be expected from the entry of new companies, particularly those in the Fall River-New Bedford area and the South. But the contours of both series around their respective trends do not disprove the hypothesis that the companies in the Baker Library manuscript collection represented the established component of the industry in their output decisions.

But the second assumption made by Davis and Stettler—that output of new companies can be distributed evenly between benchmark dates—is purely arbitrary. Specifically, plant and equipment spending of my own sample of companies shows very pronounced cycles from 1835 to the Civil War and thereafter. It would be astonishing if similar or even more pronounced cycles did not occur in the formation of new companies.[2] An index reflecting the number of new firms beginning operations year by year would certainly improve the estimates of this component of the output series. Such an index could be derived from the annual Massachusetts data on the incorporation of new companies by identifying textile companies among these from listings in trade directories available for the early 1870's. Lags between incorporation and output could be estimated from manuscripts in the Baker Library at Harvard University and applied

[1] After adjusting for entry of new companies but *not* for gross or net investment. The analysis is in my unpublished Ph.D. dissertation for Harvard University.

[2] All contemporary and present-day literature on the industry shows that orders for textile machinery fluctuated sharply in a cyclical fashion (George Gibb's *The Saco Lowell Shops* and Thomas Navin's *The Whitin Machine Works* might be referred to). Erastus Bigelow complained bitterly about the very uneven pace of textile company formation, asserting that what we would call information lags and desires of promoters to keep projects going, even in the face of declining markets, caused large amounts of excess capacity to appear when prices and profits were falling (Harris-Gastrell report on American cotton manufacturers, H.M. Stationers Office, London, 1873).

to textile company incorporations. The index constructed in this way could then be used to raise the percentage changes of the established companies to industry output between benchmark dates. It would also serve as a check on the reliability of the benchmarks.

In my opinion, the authors are correct in using yards instead of pounds of cloth as a measure of output. My own Laspeyres and Paasche index tests among companies over time show that the differences between the unweighted and the weighted output estimates were small enough to make weighting unnecessary for nearly every purpose. But the procedure for converting actual yards to standard yards is not clearly specified in the paper, nor are reasons given for not converting all output to the standard-yard equivalent.

In the last section on capital and labor productivity, the authors use the spindle as an index of capital. My work shows a large decline in the constant-dollar cost of structures and equipment per spindle for a standard mill producing a homogeneous output (in constant dollars) between the 1820's and the 1860's. Hence, the spindle has a strong upward bias over time as a capital index. Furthermore, the productivity of spindles and that of other textile capital goods changed at different times and at different rates. Thus these two biases affect not only long-run but also decade-to-decade comparisons.

The authors' estimates of labor productivity agree with mine. Labor productivity not only rose after 1840 but rose as rapidly as before, despite the substitution of unskilled and largely illiterate immigrant labor for the celebrated New England farm girls.

Data on inventories and imports would help the interpretation of the output series. Changes in cloth inventories can be obtained, in value and in physical terms, for a subsample of the companies in Davis' and Stettler's sample. Inventory cycles could illuminate changes in general economic conditions as well as those in output and prices of this industry. While the authors concentrated on the regional industry, imports competed strongly with home output of standard cloth types before the Civil War.

REPLY *by Davis and Stettler*

Paul McGouldrick calls attention to two assumptions in our paper and takes exception to the second. Unfortunately, he has slightly misunderstood the argument. We have not assumed that additions to output resulting from the entry of new firms occur evenly over the intercensual period; rather, we have assumed that the change in the sample proportion occurs evenly between benchmarks. This change occurs for three reasons: existing sample mills expand output more or less rapidly than nonsample

mills; existing sample firms add new facilities more or less rapidly than nonsample firms; and firms enter the sample at a rate other than the entry rate for the industry.

We well realize the difficulties associated with the even allocation technique and considered a number of alternatives; however, the more complicated hypotheses are underpinned by some equally tenuous assumptions.[1] McGouldrick suggests that we construct an index based on the differences in the rate of entry into the cotton industry. Such an index could simply assume that the yearly change in the sample proportion equals the difference between the benchmark ratios multiplied by the ratio of entry since the first benchmark to entry between benchmarks. Entry could be defined as a lagged function of incorporations in Massachusetts. If one wishes to take into account entries into the sample, the ratio of incorporations could be deflated by a similar ratio using yearly sample entries.

There are a number of unstated assumptions underlying such indexes. First, it is assumed that the number of investment projects consummated by production is proportional to the number of incorporations. This assumption is hardly justified. The ratios of net entry to incorporations appropriately lagged (given below) vary widely for six- and eight-year periods. Second, the proposed index assumes a lag invariant with respect

Period	*Lag of 0 Years*	*Lag of 1 Year*	*Lag of 2 Years*
1831–37	.36	.46	.67
1837–45	.43	.32	.22

to the business cycle and other disturbances. For the textile firms listed on the Boston Stock Exchange in the pre-Civil War era, the average lag between the year of incorporation and the commencement of operations is 1.25 years; however, the variance of the distribution is 1.58 years. In

[1] Changes in the weighting system induce considerable changes in the intercensual estimates. Massachusetts output estimates for 1832–36 using various inflation techniques are presented below:

			Cumulative Inc. Lagged		*Cumulative Inc. Corrected and Lagged*	
Year	*Sample*	*Even All.*	*1 Year*	*2 Years*	*1 Year*	*2 Years*
1832	14	82	98	105	113	105
1833	22	107	131	149	173	125
1834	28	111	153	138	212	125
1835	35	131	176	160	176	141
1836	39	133	183	160	183	160
1837	35	118	118	118	118	118

A particular difficulty arises in a number of instances with the last two indexes on an arithmetic count—division by zero.

addition to the lag between charter and start up, there is a shake-down period before normal levels of output are achieved. For the sample firms, the average is 6.0 quarters; for individual mills the figure is 2.9; the variances are 6.44 and 1.36 quarters, respectively. Use of a constant-lag index is questionable in the light of the high variances associated with the distributions. McGouldrick has observed that variability of the investment-output lag dampens the cycle in output. Third, the indexes based on entry or investment tacitly assume that changes in the productivity occur in proportion to entry. During the middle 1830's, the sample firms' output per spindle rose 8 per cent, while the Massachusetts figure fell 4 per cent; output per sample worker increased 20 per cent, while the Massachusetts workers' output rose only 8 per cent. It is of interest that the largest increases in sample output per worker occurred in 1834-35, the end of a three-year period of low entry.