Volume Title: Changes in Labor Cost During Cycles in Production and Business

Volume Author/Editor: Thor Hultgren

Volume Publisher: NBER

Volume ISBN: 0-87014-388-3

Volume URL: http://www.nber.org/books/hult60-1

Publication Date: 1960

Chapter Title: Production and Man-Hours per Unit of Product

Chapter Author: Thor Hultgren

Chapter URL: http://www.nber.org/chapters/c1713

Chapter pages in book: (p. 6 - 32)

2

Production and Man-Hours per Unit of Product

Changes in man-hours and labor cost in any industry may be compared with changes either in the production of that industry or in the level of general business activity. This chapter is concerned with the first kind of comparison. As an initial step, we seasonally adjust the aggregate production figures and chart them. Inspecting the curve, we judge that peaks in production occurred in some months and troughs in others. The interval from any trough to a following peak is called an expansion, that from any peak to a following trough a contraction. An expansion or a contraction is termed a phase, and any two consecutive phases (which of course have opposite characters) a cycle.

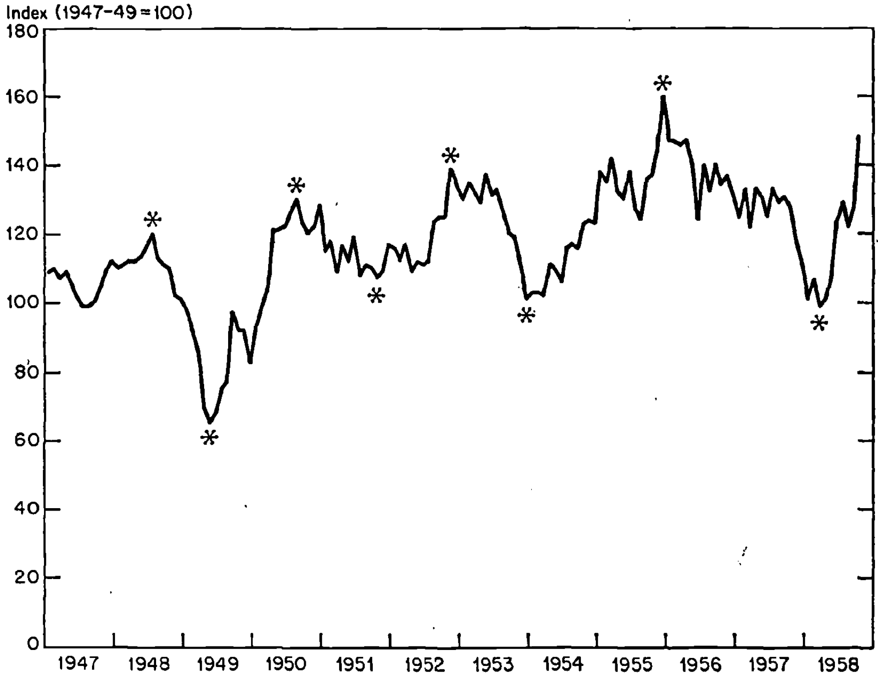
Chart 1, which depicts production of aluminum and copper mill shapes, from 1947 to 1958, illustrates the process. As often happens, there are numerous minor month-to-month ups and downs in the curve. We disregard these, but try to pick out the larger swings. A helpful rule in this connection, and one that we follow, is that nothing shall be recognized as a cycle unless the up-and-down swing lasts for at least fifteen months. Production of mill shapes reached a peak in July 1948. After that there was a downswing, reaching a trough in May 1949. This was followed by an upswing, which reached a peak in August of 1950, and so on. Asterisks indicate the dates of peaks and trough. Our worksheets include similar charts for all of our industries.

Hours per Unit Usually Fall When Production Rises, and Vice Versa

Having identified the turning points in production, we can determine, in each expansion in each industry, whether man-hours per unit were higher or lower at the peak of output than at the preceding trough, and whether

CHART 1

Aluminum and Copper Mill Shapes: Federal Reserve Index of Production, January 1947–October 1958



they were higher or lower at each trough in production than at the preceding peak. In answering such a question, we prefer not to depend on the figure for a single month, but take an average of hours per unit in the month preceding each peak, the actual peak month, and the following month. Likewise, we take an average for each group of three months that has a trough month in the middle.

Mill shapes is one of the industries for which we use index numbers. Computing three-month averages, we find that the index of hours per unit (1947-49 = 100) was 91.3 at the 1948 production peak and 116.0 at the 1949 trough. In this contraction of production, hours per unit of product increased. At the 1950 peak the figure is 94.8; therefore, in the 1949-50 upswing, hours per unit declined.

So far, it looks as though hours per unit were inversely related to production in this industry. But we have data on only three completed contractions and only two completed expansions, perhaps not enough to justify a generalization about this particular industry. We do feel, however, that by pooling our data for this and other industries we obtain something more significant. In one industry or another, at one time or another, we have data on ninety expansions of production and ninety-nine contractions. In eighty-three, or 92 per cent, of the ninety expansions, there was a net decline in hours per unit. In seventy, or 71 per cent, of the ninety-nine contractions, there was a net rise in hours per unit. The pooled data suggest a strong tendency toward an inverse relation between hours per unit and total output. When one goes up the other goes down, and vice versa. This means that man-hours in the aggregate usually do not rise and do not fall by as great a percentage as output.

These conclusions are based on monthly figures for a limited number of industries over limited periods of time. We have annual data for industries not included in our list of twenty-three, and for some of the industries in that list for periods of time not covered by the monthly data. If we can trust these annual figures to convey the same impression as monthly figures, we can greatly broaden the base of our finding. We can test their value by inquiring what impression we would get from annual figures if we relied on them in the periods for which we do have monthly figures. To make this test, we have examined the annual data for each industry, beginning with the year before our earliest monthly turning point and ending with the year after our latest turning point, and have noted the expansions and contractions they indicate. For example, the earliest turn in anthracite coal is a trough in June 1932 and the latest a peak in May 1944. We therefore examined annual anthracite production data from 1931 to 1945.

An investigator who depended on annual figures only would not find any hint of some of the expansions and contractions that we find in the monthly figures. For example, the monthly data show that consumption of raw cotton (which we use as an indicator of the production of cotton textiles) increased from a trough in December 1937 to a peak in December 1939, declined a little to a trough in April 1940, and then rose to a peak in May 1942. The annual data, however, indicate only a continuous rise from a trough in 1938 to a peak in 1942. On the other hand, our limited investigator would have recognized some phases that we do not recognize: he would have found three in production of iron and steel between 1949 and 1953, while we recognize only a continuous expansion in that period.

Although the peaks and troughs in the annual data do not correspond, item by item, with the monthly peaks and troughs, they do lead to the same general conclusions with respect to the net change in hours per unit (h/p) during expansions. There are seventy-seven instances of net fall in h/p from a trough to a peak in production, and only ten rises. Whichever set of data we use, declines in h/p preponderate over increases.

But in contractions the annual do not agree with the monthly data. The yearly figures indicate rises in h/p in thirty-eight declines of production, but falls in fifty-six. Annual data show a preponderance of declines, monthly figures a preponderance of rises. On first thought, therefore, it would seem that annual figures, where we have nothing else, tell nothing about what the monthly figures for contractions would indicate, if we had them. But this is too pessimistic an inference; for even in the annual data, declines in h/p are less common in the falling than in the rising phases of production. They occur in 89 per cent of the expansions, but only in 60 per cent of the contractions. The narrower majority of declines in contraction suggested by the annual data corresponds to a predominance of actual rises as disclosed by the monthly data.

Why should the two kinds of figures differ? Because man-hours per unit are influenced not only by the cyclical level of production but by technological progress. Producers in one establishment or another are constantly introducing new and improved plants, machines, and operating techniques. The innovations tend to reduce labor requirements not only in expansions of output but also in contractions. Wherever there is an inverse relation between h/p and volume, technological change tends to reinforce the effect of rising volume and to oppose the effect of declining volume. Annual figures tend to minimize the influence of volume, without correspondingly minimizing the influence of technical improvement. A comparison of the top with the bottom three months of a swing in production covers almost the whole of the swing. The figure for a peak year, on the other hand, reflects more months of less than peak production, and that for a trough year more months of greater than minimum production. In contractions, therefore, annual data tend to show more frequent declines in h/p than monthly data. But the adverse influence of declining volume on efficiency is not wholly concealed even in such data; it shows up in the difference in frequency as compared with expansions.

In the area for which we have no monthly data, we find a similar difference in the annual data (Table 2). They show declines in 169 of 202, or 84 per cent, of the expansions, and in 128 of 224, or only 57 per cent, of the contractions. It seems likely that if we had monthly data for these areas they too would show a preponderance of rises in contractions. In other words, the expansions and contractions in Table 2 really broaden the empirical basis for our conclusion that h/p is usually inversely related to production.

Similar Inverse Relation Found in Most Individual Industries with Enough Data

One cannot safely generalize about what happens during production cycles from evidence for a few phases, and for many industries we have evidence for less than half a dozen. Until now, therefore, we have combined

TABLE 2

Direction of Change in Man-Hours per Unit of Product, Based on Annual Data for Which There Are No Corresponding Monthly Data

	Period Covered by Expansions and Contractions	Number of Expansions in Which Hours per Unit		Number of Contractions in Which Hours per Unit	
		Increased	Decreased	Increased	Decreased
Iron mining	1917-54	0	9	10	0
Copper mining	1933-54	0	4	3	1
Lead and zinc mining	1937-51	1	2	1	2
Anthracite coal	1901-33	6	3	5	5
Bituminous coal	1903-37	1	8	0	9
Meat	1921-32	1	2	2	1
Canned milk	1942-49	0	1	1	1
Ice cream	1920-46	0	6	2	4
Canning and preserving	[a]	2	6	5	4
Grain products	1920-47	3	5	3	4
Grain products and feed	1950-57	1	1	0	2
Bakery products	1924-39	1	1	1	1
Cane sugar [b]	1920-39	1	3	3	1
Beet sugar	1940-48	1	1	3	0
Cane and beet sugar	1948-55	0	2	1	1
Confectionery	1926-38	0	2	0	3
Beverages	1948-54	0	2	0	3
Malt liquors	1940-47	1	1	0	1
Cigars	1920-42	1	4	1	4
Cigarettes	1919-32	0	1	1	1
Other tobacco	1921-39	1	4	2	3
Cotton	1921-32	1	2	0	3
Silk and rayon fabrics	1920-39	0	5	2	2
Wool	1920-32	3	2	0	5
Knit goods	1948-58	1	2	0	4
Floor coverings	1948-51	0	1	1	1
Lumber	1921-38	1	3	1	3
Wood containers	1949-58	0	2	1	1
Furniture and fixtures	[c]	0	6	2	5
Paper	1920-32	0	2	0	3
Newspapers and periodicals	1920-38	0	3	4	0
Chemicals	1920-38	0	3	3	1
Organic chemicals	1948-58	0	3	1	3
Rayon and nylon yarn	1931-49	0	3	0	4
Paints and varnishes	[d]	0	5	3	3

TABLE 2 (*Continued*)

Direction of Change in Man-Hours per Unit of Product, Based on Annual Data for Which There Are No Corresponding Monthly Data

	Period Covered by Expansions and Contractions	Number of Expansions in Which Hours per Unit		Number of Contractions in Which Hours per Unit	
		Increased	Decreased	Increased	Decreased
Fertilizer	[e]	0	3	0	5
Petroleum refining	1929-38	0	1	0	2
By-product coke	1919-49	0	7	5	2
Beehive coke	1919-49	1	7	7	1
Tires and tubes	1928-32	0	0	0	1
Other rubber	1928-38	1	1	2	1
Leather	1921-39	0	4	0	3
Footwear	1921-36	2	3	1	3
Glass	1920-38	0	4	1	4
Glass containers	1938-49	0	1	1	0
Cement	1920-33	0	1	0	2
Structural clay	1920-58	1	7	5	4
Steel	1919-32	0	4	2	2
Nonferrous smelting and refining	1921-47	0	5	3	1
Agricultural implements	[f]	1	5	3	4
Motor vehicles	1920-38	0	4	2	3
Railroads	1915-21	0	2	1	1
Total manufacturing		25	141	75	110
Total all industries		33	169	95	128

NOTE: Man-hours of production workers only.
[a] 1924-1948, 1951-1957.
[b] Does not include one contraction in which there was no change in *h/p*.
[c] 1921-1938, 1948-1958.
[d] 1920-1938, 1949-1958.
[e] 1920-1938, 1953-1954.
[f] 1922-1939, 1948-1958.

the information on all industries for which we have any material at all. But in an industry where we have a record for eight or more phases, we are willing to hazard a conclusion.

For each of eleven industries we have enough monthly data to meet our minimum requirement. One of these provides a perfect example of an inverse relation between hours per unit and production. In meat packing there was a net decline in h/p during every one of the four expansions and a net rise during all of the four contractions. But elsewhere there are exceptions. H/p falls in some expansions but rises in others and it rises in some contractions but falls in others.

For such an industry, we need a scale in which to weigh the conflicting factors; we use what we call an index of conformity. A fall in h/p during an expansion, or a rise during a contraction, suggests that h/p is inversely related to production; conversely, a rise during an expansion, or a fall during a contraction, implies a positive relation. We count the number of phases that suggest a positive relation, deduct the number that suggest an inverse relation, divide by the total number of phases, and express the quotient as a percentage. If h/p always rose and fell with production, the conformity index would be +100. If it always moved inversely to production, the score would be —100. If it never changed, or if it changed positively in half the observations and inversely in the other half, the score would be zero. Scores of exactly zero are impossible with an odd number of observations unless one of them indicates no change. Scores near zero could easily be reversed by more observations and in any case suggest little consistency. We shall arbitrarily assume that indexes numerically equal to or less than 25 indicate negligible conformity, whatever their sign may be.

Of the eleven industries for which there are adequate monthly data, ten have indexes between —26 and —100 (Table 3). Since technological advance frequently causes annual data to indicate declines in h/p even in contractions, such figures are likely to suggest inverse conformity in expansions, positive conformity in contractions, and therefore little conformity of either kind on the whole. If even annual data suggest inverse conformity over entire cycles, it is fairly certain that the inverse relation is real. Considering both annual and monthly figures, we have data for eight or more phases in each of twenty-three industries, in addition to the eleven already discussed. For each of these we have computed a conformity score, based on the direction of change as indicated by monthly data, if any, and by annual data in other phases. We now find thirteen additional industries with scores between —26 and —100; together with the ten previously found, there are twenty-three in all.

In addition to the twenty-three industries in Table 3 that we have classified as inversely conforming, eight have inverse but very low conformity scores, while three have positive but very low scores. In all these cases we rely heavily or entirely on annual figures. It is possible that monthly figures would raise some of the low inverse ratios.

Among the industries for which we have data covering eight or more phases, none has a positive index higher than 25, and only fertilizer has a rating even that high.

TABLE 3

Indexes, for Individual Industries, of Inverse or Positive Relation Between Hours or Cost per Unit of Product and Production

	Hours per Unit	Cost per Unit
Based entirely on monthly data		
Bituminous	−9	9
Meat	−100	−50
Cotton	−64	−45
Wool	−67	−67
Hosiery	−33	−33
Paper	−75	−62
Tires and tubes	−75	50
Shoes	−38	−54
Cement	−50	−25
Steel	−80	−40
Railroads	−64	−86
Based on annual, or annual and monthly, data		
Iron ore	−100	[a]
Copper ore	−75	[a]
Anthracite	9	[a]
Ice cream	−33	−64
Canning and preserving	−29	−20
Grain products	−7	−20
Cane sugar	−44	−11
Confectionery	11	−11
Cigars	−8	[a]
Chewing and smoking tobacco, snuff	−20	25
Silk	−56	−33
Lumber	−33	−13
Furniture and fixtures	−23	38
Paints and varnishes	−45	−9
Fertilizer	25	[a]
Petroleum refining	−25	−25
Beehive coke	−75	[a]
By-product coke	−71	[a]
Glass	−11	−11
Clay products	−41	−6
Nonferrous smelting and refining	−78	[a]
Agricultural implements	−23	−50
Motor vehicles	−33	−78

NOTE: Hours and cost for production workers only. Cost does not include social security, pensions, etc.

[a] Not enough data.

Inverse Changes Often Fairly Large

Although we have found quite a number of industries in which hours per unit are inversely related to volume, we have not yet considered whether the fluctuations in h/p are trivial or of some consequence. We have done this for each industry with a negative figure numerically exceeding -25 in the first column of Table 3, i.e., for each industry with a fairly strong tendency toward inverse conformity as indicated by direction of change. There would, of course, be no point in asking how big the inverse changes are in an industry in which they are not usually inverse.

For each expansion of output in a well-conforming industry, we calculated the ratio of production at the initial trough to that at the terminal peak, and of h/p at the trough in production to h/p at the peak. In expansions it might seem more natural to calculate the ratio of peak to trough, since the peak occurs later than the trough; but such a calculation would give awkwardly large ratios for production in industries with violent fluctuations, such as iron ore and coke. It would also make difficult a comparison of changes in expansion with those in contraction, a comparison that will prove instructive. In contractions of output we compare production and h/p at the terminal trough with production and h/p at the initial peak. Here we do measure levels at the terminal date in terms of those at the initial date. Where we have monthly data we base our percentages on the three-month averages for peak and trough periods in production. Otherwise we use annual data for peak and trough years in production.

We have classified the many resulting observations according to the size of the change in production, adding together observations at different times or in different industries as long as they show the same range of fluctuation in output. The calculations are summarized in Table 4. The first line of the table, for example, shows that we have twenty-four expansions in which the rise in output was rather small. Production at the trough was equal to 90 per cent or more of the production achieved at the peak. In these expansions the ratio of h/p at the trough ranged from 93.9 to 116.3. The lowest ratio pertains to the expansion in the pulp and paper industry from July 1942 to July 1943. In this expansion, contrary to the more common experience, h/p increased, from 93.9 per cent of its final level to 100 per cent. The highest ratio refers to the expansion in beehive coke production from 1919 to 1920. H/p fell from 116.3 per cent of its eventual terminal level to 100 per cent.

The median trough-to-peak ratio for h/p—that is, the average of the twelfth and thirteenth when all twenty-four observations are arranged in the order of size—is 104.2. In other words, the median change in h/p follows the expected pattern: h/p declined as production rose. The median change

TABLE 4

Percentage Ratio of Hours per Unit (h/p) at Trough to Peak of Expansions and Contractions in Production

Ratio of Production at Trough to Peak	Expansions of Production					Contractions of Production				
	Number of Expansions	Ratio of h/p at Trough to h/p at Peak			Corresponding Production Ratio	Number of Contractions	Ratio of h/p at Trough to h/p at Peak			Corresponding Production Ratio
		Lowest	Highest	Median			Lowest	Highest	Median	
90.0 to 99.9	24	93.9	116.3	104.2	95.7	42	86.9	109.8	98.2	96.9
80.0 to 89.9	37	93.3	134.7	107.4	87.1	55	81.6	121.6	100.9	85.2
70.0 to 79.9	32	84.6	130.6	111.7	73.9	24	78.1	126.2	102.6	74.8
60.0 to 69.9	24	100.6	155.0	119.4	67.6	16	64.8	129.8	106.2	63.8
50.0 to 59.9	10	110.9	170.9	130.4	51.6	10	89.2	121.5	102.2	54.6
40.0 to 49.9	17	96.1	212.2	122.5	49.4	8	89.8	147.4	111.6	47.6
30.0 to 39.9	7	103.6	163.5	124.4	32.2	7	80.3	150.5	121.4	30.0
20.0 to 29.9	5	113.2	175.4	144.3	28.9	5	103.6	119.4	104.1	27.0
10.0 to 19.9	3	120.6	236.5	149.2	18.3	2	159.0	184.5	171.8	11.9

NOTES: "Corresponding" production ratio is ratio of production at trough to production at peak for the two dates and the industry to which the median h/p ratio applies. Where median is average for two phases, two corresponding production ratios have been averaged.

Derived from work tables for individual industries showing h/p at peaks and troughs in production.

Hours of production workers only.

in h/p for every other group likewise followed the expected rule: h/p at the initial trough in production was always more than 100 per cent of h/p at the terminal peak. With one exception, the same rule held in contractions of output; in every size of contraction, the median ratio of h/p at terminal trough to h/p at initial peak was greater than 100. The exception is the median for the smallest contractions, those in which production at trough was at least 90 per cent of production at peak.

There was, however, a meaningful difference between expansions and contractions. During an expansion of production, technological progress tends to reduce h/p, i.e, to make it high at the initial trough relatively to the peak. In contractions, on the other hand, technological progress tends to make h/p low at the terminal trough relatively to the peak. One would expect a greater inverse fluctuation in h/p during expansions than during contractions of similar size, and such a difference appears in the medians for every size range but one. In expansions in which production at the trough ranged from 60.0 to 69.9 per cent of peak, for example, the median ratio of h/p at trough to h/p at peak was 119.4, while in contractions in which production at the trough had a similar ratio to production at peak, the median ratio for h/p is only 106.2. The exception occurs on the bottom line of Table 4, where the medians are derived from three or two observations only.

The observations that we group on any line of the table have only one thing inevitably in common: a specified range of fluctuation in production. The operating setup in different industries may be such that equal percentage cuts in output have more serious effects on h/p in one than in another. The observations of h/p in and underlying the table are blunted in varying degrees by partial or complete reliance on annual data. In Chart 2, we attempt to avoid these difficulties by confining ourselves to changes based on three-month averages, shown individually for each industry with a long monthly record as well as a strong direction-of-change conformity. Obviously, much irregularity remains—in no case do the dots fall neatly on a line, either straight or curved.

For any one dot on the chart, we can judge how severely the change in production appears to affect h/p by drawing a diagonal from the dot to the intersection of the horizontal and vertical 100 per cent lines. If the line has a steep tilt, the change in h/p is large relative to that in production; if it has a gradual slope, the relative change is small. To measure the slope we subtract 100 from the ratio of h/p at trough to h/p at peak; we likewise subtract 100 from the ratio of production at peak to production at trough, and divide the first remainder by the second. In the expansion of meat production from November 1932 to June 1933, for example, the three-month average of h/p at the trough is 112.1 per cent of the average at the peak. The corresponding ratio for production itself is 76.3. This means that h/p was 12.1 per cent higher at the trough and production was 23.7 per cent lower: $12.1 \div (-23.7) = -.511$, the negative sign indicating an inverse relation. In this particular expansion, h/p declined by about one-half of 1 per cent of its ultimate level for each 1 per cent of rise in meat production toward *its* ultimate 100 per cent.

In any one industry different expansions or contractions give different measures of slope. Where a dot lies below the horizontal 100 per cent line on the chart, the slope will actually be positive. We can, however, array the slopes for the industry, and pick out or compute the median. The median slope ratios vary a good deal from industry to industry, and those for expansions differ quite a bit from those for contractions (Table 5). But

TABLE 5

Median Ratio of Percentage Change in Hours per Unit to Percentage Change in Production, Ten Industries

	Expansion	Contractions
Meat	−.542	−.944
Cotton	−.295	−.272
Wool	−.337	−.114
Hosiery	−.172	−.194
Paper	−.452	−.381
Tires and tubes	−.326	−.212
Shoes	−.545	+.038
Cement	−.630	−.616
Steel	−.598	−.337
Railroads	−.809	−.164

NOTE: The percentage changes in production underlying these ratios vary widely.

even the medians indicate respectably large changes in h/p relative to production. For meat, the percentage fall in h/p was 54 per cent of the percentage rise in production; for pulp and paper, the percentage rise in h/p was 38 per cent of the percentage fall in production.

The monthly BLS figures pertain to "wage earners" in the earliest years, and to "production and related workers" thereafter. In addition, manufacturing enterprises employ numerous salaried workers or workers who, whether they receive wages or salaries, are engaged in activities such as administration, accounting, purchasing, and selling that are not regarded as production. The BLS reports their number, but not their hours or compensation. It was not possible, therefore, to include their work in computing

CHART 2

Man-Hours per Unit of Product and the Level of Production

(Horizontal scale: Percentage ratio of production at its trough to production at its peak. Vertical scale: Percentage ratio of hours per unit at production trough to hours per unit at production peak. Each dot represents one expansion or contraction in production.)

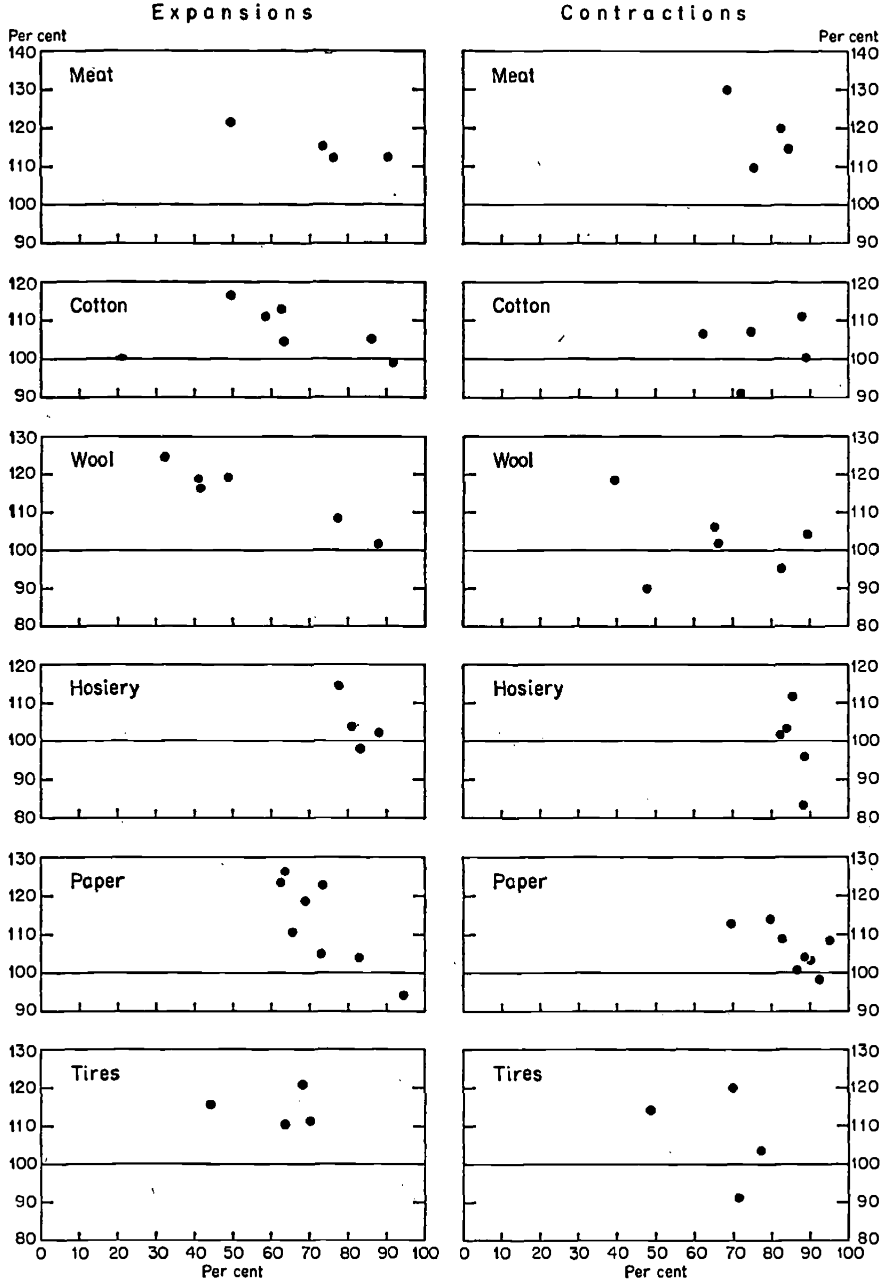
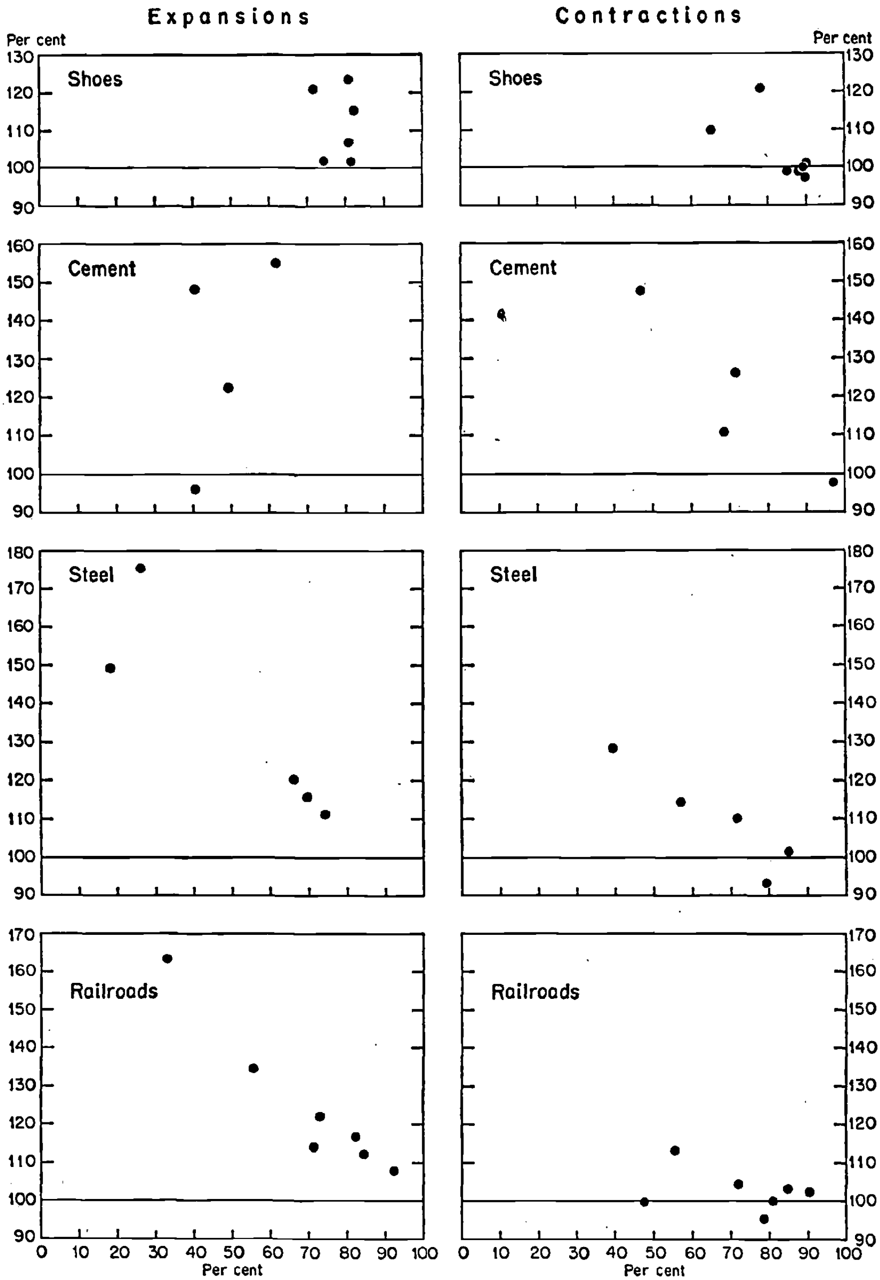


CHART 2, concluded



hours per unit; but if it were, it would probably be found that the inverse changes in h/p are even greater, percentagewise, than those the available data indicate, for the other workers tend to have more stable jobs. From 1929 to 1946, the ratio of the total number of employees in all manufacturing to the number of production employees declined in every expansion of manufacturing output, rose in every contraction (Table 6). After 1946, to be sure, the ratio rose in expansions and contractions alike, but less

TABLE 6

Ratio of All Employees in Manufacturing to Wage Earners, or to Production Workers, at Peaks and Troughs in Manufacturing Production

Date of Peak or Trough	Level of Production [a]	Months from Preceding Date	Ratio (Three-Month Average)	Change in Ratio: Total	Change in Ratio: Per Month: To peak from trough	Change in Ratio: Per Month: To trough from peak
Ratio to wage earners						
July 1929	Peak	...	1.217	...	...	...
July 1932	Trough	36	1.264	.047	...	.00131
May 1937	Peak	58	1.191	−.073	−.00126	...
June 1938	Trough	13	1.236	.045	...	.00346
Ratio to production workers						
June 1938	Trough	...	1.261 [b]	...	...	...
Nov. 1943	Peak	65	1.160	−.101	−.00155	...
Feb. 1946	Trough	27	1.205	.045	...	.00167
Oct. 1948	Peak	32	1.208	.003	.00009	...
Nov. 1949	Trough	13	1.225	.017	...	.00131
July 1953	Peak	44	1.244	.019	.00043	...
July 1954	Trough	12	1.272	.028	...	.00233
Aug. 1957	Peak	37	1.302	.030	.00081	...
Apr. 1958	Trough	8	1.329	.027	...	.00338

[a] Based on Federal Reserve index of manufacturing production.

[b] Both ratios are available for 1940. In that year the monthly average ratio to production workers exceeds the monthly average ratio to wage earners by .025. We have raised the June 1938 ratio to wage earners by this amount.

rapidly in the former than in the latter. The fluctuations in production after 1946 were mild in comparison with those in the earlier period. In any future expansions of greater amplitude it is likely that the ratio will again fall.

It seems likely, furthermore, that non-production workers do not work overtime when production is heavy, and are not put on part time when it is light, to the same extent as production workers. Such at least is the case in the iron and steel industry, where figures for all workers as well as production workers are available. The ratio of hours per week for all employees to hours per week for production employees was higher at troughs than at peaks (Table 7). Such figures mean that hours worked by the

TABLE 7

Hours per Week: Production Workers and All Employees, Iron and Steel Industry, at Peaks and Troughs in Production, 1934-58

Date of Peak or Trough	Level of Production	Hours per Week		Ratio of All to Production	Change in Ratio	
		Production Workers [a]	All Employees		To Peak from Trough	To Trough from Peak
1934	[b]	29.5	30.5	1.034	...	...
1937	Peak	36.8	37.3	1.014	−.020 [b]	...
1938	Trough	27.6	29.1	1.054		.040
1943	Peak	43.0	42.8	0.995	−.059	
1946	Trough	35.1	36.1	1.028		.033
1948	Peak	39.1	39.4	1.008	−.020	
1949	Trough	34.5	35.4	1.026		.018
1951	Peak	40.2	40.4	1.005	−.021	
1952	Trough	35.8	36.6	1.022		.017
1953	Peak	39.4	39.6	1.005	−.017	
1954	Trough	36.1	36.8	1.019		.014
1955	Peak	39.2	39.5	1.008	−.011	
1958	Trough	35.2	36.0	1.023	...	.015

[a] Employees receiving hourly, piecework, or tonnage rates; generally comparable with BLS production and related workers.

[b] We here treat 1934, the earliest full year for which the figures are available, as a trough. The production index for 1934 is only 50 per cent of the index for 1937.

average non-production employee did not increase in proportion to hours worked by the average production worker during expansions of output, and did not fall as much in contractions. Considering the stability both of the number of other than production workers and of hours per man (if the steel industry is representative), we may conclude that the aggregate hours of such work per unit of product fall with rising output and rise with falling output by even greater percentages than aggregate hours of production workers per unit of product, at least when the fluctuations in output are severe.

Inverse Changes More Frequent at Beginning of Swings in Production

So far we have confined our attention to the net change in hours per unit between the beginning and end of an upswing or downswing in production. But their direction of change is often not continuous during the course of such an upswing or downswing. Chart 3, again for the mill-shapes industry, illustrates how the course may alter. On this chart the asterisks indicate peaks and troughs, and mark off cycles, in man-hours per unit (h/p). Obviously the direction of change in h/p is not always consistent throughout a phase of production. During the 1950-51 contraction in production, hours per unit at first rose, then later fell. (As before, we ignore minor fluctuations and take note only of the longer movements marked by the asterisks.) The decline continued all through the following expansion. On the other hand, both the beginning and the end of the last complete upswing in h/p coincide neatly with the beginning and the end of the last complete downswing in output.

Graphs like Chart 3 have been drawn for all our industries. They enable us to classify every production phase according to the sequence of change in man-hours per unit. In the present instance we classify the 1950-51 contraction in output as a case of rise, fall; the 1951-52 expansion as a case of continuous fall; and the 1952-53 contraction as one of continuous rise. We have classified all our production phases in this manner (Table 8).

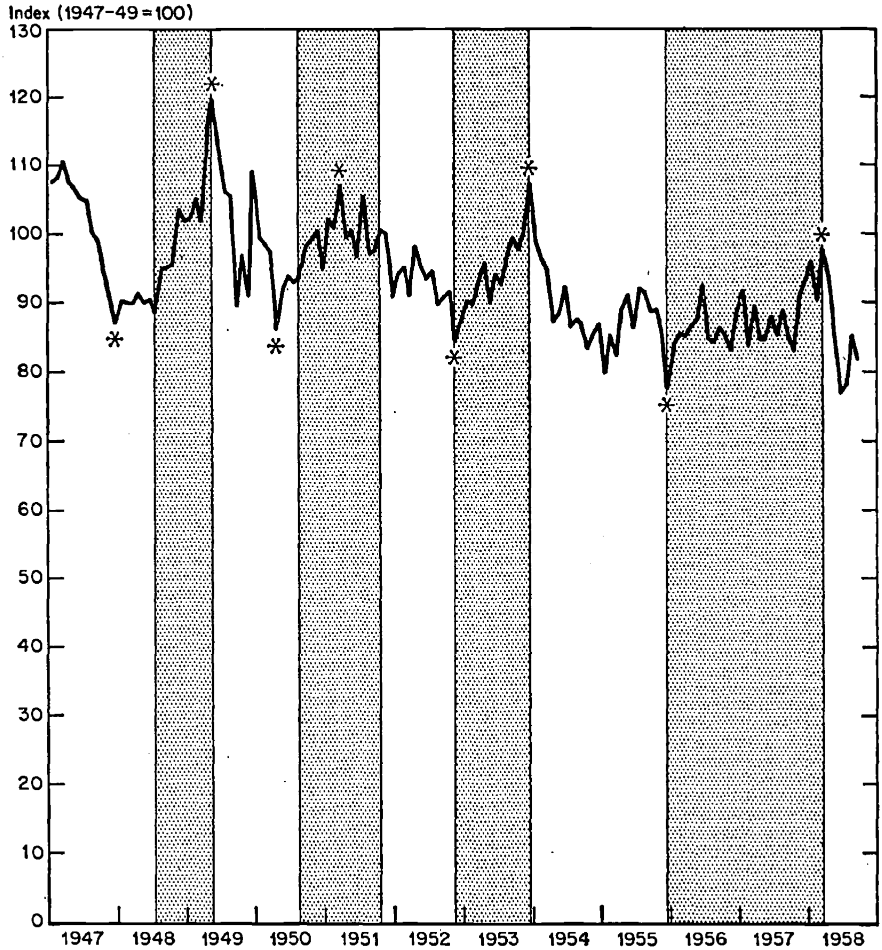
Man-hours per unit declined during the earliest months in a large majority of the output expansions, 78 of 90. In 27 of the 78 instances, however, the initial fall turned into a rise that persisted to the end of the expansion. Still other sequences occurred, but just before the end, declines were less common than at the beginning. Even so they outnumbered rises, by 52 to 38.

Most contractions, 54 of 99, began with hours per unit rising. Of the rises, 27 were consistently maintained and 25 turned into falls that persisted. Continuous declines also were fairly common. Whatever the sequence, hours per unit were falling at the end in a majority of instances, somewhat larger than the majority of rises in the beginning.

The contrary movement of production, on the one hand, and hours per unit, on the other, was therefore much more conspicuous at the beginning than at the end of upswings or downswings in production.

CHART 3

Aluminum and Copper Mill Shapes, Index of Man-Hours Paid for per Unit of Output, January 1947–September 1958



Shaded areas are contractions in production of aluminum and copper shapes.

Changes in hours per unit, hourly earnings, or cost per unit can be studied in a more systematic and progressive manner by dividing each upswing or downswing of production into a standard number of stages regardless of its length. Let us call the initial, three-month trough period of an expansion Stage I, the next peak period Stage V, and the terminal trough period of a contraction Stage IX. We divide the months between the actual trough month and the next peak and likewise those between each peak and

TABLE 8

Man-Hours and Labor Cost per Unit of Product, Sequences of Change During Expansions and Contractions of Production, Twenty-three Industries

	Number of Expansions or Contractions with Indicated Sequence			
	In Hours per Unit		In Labor Cost	
	Expansions	Contractions	Expansions	Contractions
Rise	9	27	22	52
Rise, fall	3	25	3	33
Rise, fall, rise	...	1	4	1
Rise, fall, rise, fall	...	1	...	1
Fall	43	32	15	8
Fall, rise	27	9	42	4
Fall, rise, fall	5	4	1	...
Fall, rise, fall, rise	2	...	3	...
Fall, rise, fall, rise, fall	1	...	...	...
All sequences	90	99	90	99
Rising at beginning	12	54	29	87
Falling at beginning	78	45	61	12
Rising at end	38	37	71	57
Falling at end	52	62	19	42

NOTE: Hours and cost for production workers only. Cost does not include social security, pensions, etc.

the next trough into three periods, equally long if possible; if necessary we make the middle stage a month longer or shorter than the others.

This procedure gives us Stages II, III, and IV of an expansion or VI, VII, and VIII of a contraction. We strike an average of, say, man-hours per unit for all the months included in a stage. In effect, we break each expansion into four successive segments, the first running from I to II, the second from II to III, and so forth; and we likewise break each contraction into four segments. The method is illustrated for one cycle of cement production in Table 9. The figures for man-hours per barrel on each line of the last column is an average for the months indicated on the same line in preceding

TABLE 9

Division of 1938-44 Cycle in Production of Cement into Stages
(Initial trough in production, February 1938; peak, April 1942; terminal trough, May 1944)

	Months Included		Number of Months	Man-Hours per Barrel
	First	Last		
I	Jan. 1938	Mar. 1938	3	0.447
II	Mar. 1938	June 1939	16	0.396
III	July 1939	Nov. 1940	17	0.375
IV	Dec. 1940	Mar. 1942	16	0.363
V	Mar. 1942	May 1942	3	0.365
VI	May 1942	Dec. 1942	8	0.370
VII	Jan. 1943	Aug. 1943	8	0.427
VIII	Sept. 1943	Apr. 1944	8	0.526
IX	Apr. 1944	June 1944	3	0.538

columns. (This is one of the industries in which we use ordinary physical units rather than index numbers.)

Sometimes an expansion is too short for this procedure; the first and last stages would include almost all the months. In such cases, we restrict stages I and V or V and IX to a single month, the actual peak or trough month. In one of the 90 expansions, the data for single months are not reliable. In two of our 99 contractions, the trough occurred in the third month after the peak. These three phases cannot be divided into five stages.

In the remaining 89 expansions and 97 contractions, we can now find the frequency of rises and falls in hours per unit in the various segments. In Table 9, for example, man-hours per barrel were 0.447 in Stage I but only 0.396 in II; we therefore count the 1938-42 expansion in cement as one of the expansions in which hours per unit fell from I to II. All in all, this happened in 80 of our 89 expansions, or 90 per cent. Similar percentages for all pairs of stages appear in Table 10.

Declines in hours per unit became less and less frequent in expansions. The percentages fell from 90 per cent in the first segment to 85 in the second, 71 in the third, and 71 in the fourth. In contractions, the character-

TABLE 10

Man-Hours per Unit of Product, Number of Changes from Stage to Stage of Production Cycles, Classified by Direction, Twenty-three Industries

From Stage	To Stage	Rises	Zero Changes	Falls	Observations	Per Cent		
						Rising	Unchanged	Falling
I	II	7	2	80	89	8	2	90
II	III	12	1	76	89	13	1	85
III	IV	24	2	63	89	27	2	71
IV	V	26	0	63	89	29	0	71
V	VI	72	0	25	97	74	0	26
VI	VII	58	0	39	97	60	0	40
VII	VIII	55	2	40	97	57	2	41
VIII	IX	54	3	40	97	56	3	41
I [a]	V [a]	7	0	83	90	8	0	92
V [a]	IX [a]	70	1	28	99	71	1	28

NOTE: Derived from worksheets showing man-hours per unit or index thereof for each stage of each production cycle in each industry. Man-hours of production workers only.
[a] Based on three-month averages in all instances.

istic initial rises likewise became less frequent; the successive percentages are 74, 60, 57, 56.

But Inverse Relation Dominant in All Segments of Production Cycles

Although rises in hours per unit became more and more frequent as expansions proceeded, the tendency did not become predominant, as Table 10 demonstrates. Even in the fourth segments, declines outnumbered rises; and, as we noted before, h/p was usually lower at the end than at the beginning. Although declines became more and more frequent in contractions, rises continued to outnumber them. Even in the fourth segments of contractions, the percentage of rises exceeds 50, and h/p was higher at the end than at the beginning of most contractions.

Possible Reasons for the Cyclical Variation

The foregoing sections indicate that the relation between hours per unit and cyclical fluctuations in production has two outstanding characteristics. In many industries, hours per unit are inversely related to output, but the relation is more and more frequently replaced by a direct one as expansion or contraction proceeds.

A detailed exploration of the physical and technical setup in the various industries would be needed for an understanding of the reasons for the inverse relation. One can see, however, that the aggregate hours worked by some kinds of employees counted as "production and related workers," e.g., watchmen, are not likely to increase or decrease as fast as production. One can surmise, too, that the output of some processes can be varied by changing the speed of the machinery, or of the blast through the furnaces, without a corresponding change in the size of the working group. Some kinds of machinery have to be adjusted for each order because of varying specifications. When orders are small, as they are likely to be in times of low production, the percentage of time spent in making the adjustment must be larger. Railroads cannot vary the number of trains they run, or the number of train crews, in proportion to the traffic unless they are willing to impair the convenience of their service.

The increasing frequency of rises in hours per unit as expansion proceeds, and falls as contraction proceeds, may be explicable in terms of workers' efficiency and psychology. Wesley C. Mitchell, who investigated the point many years ago, concluded that the new men who are taken on as expansion proceeds are on the average less experienced than the men already at work. Man-hours are absorbed in training, and it takes the new workers time to attain peak efficiency. They are more likely to be too old or too young, or to have bad working habits. Increasing overtime results in fatigue and spoiled work. Contraction reverses these influences.[1] The *Wall Street Journal* collected similar opinions from many business executives, union officials, and workers in two recent recessions.[2] It must be noted, however, that not all of the people interviewed testified to the same effect. Dissenters reported that the fear of unemployment makes some workers so nervous that their performance becomes poorer; some try to stretch the work out in the hope that it will last longer; men with high seniority do not worry very much about losing work; "bumping" in the exercise of seniority rights puts many workers in jobs with which they are not familiar.

Nevertheless our findings may reflect a conflict between the influence of

[1] Wesley C. Mitchell, *Business Cycles and their Causes*, Berkeley, Calif., 1941 (a republication of Part III of the author's *Business Cycles*, Berkeley, Calif., 1913), pp. 9-10, 31-33, 139. Mitchell based his conclusions largely on the testimony of employers and workers assembled in the report by the federal Commissioner of Labor, *Regulation and Restriction of Output*, Washington, 1904. He had to comb this voluminous document carefully, since the inquiry was directed primarily at other questions. For specific citations of the testimony, see the references on p. 198 of the 1941 reissue, note 6.

[2] Articles on "Worker Perk-Up," February 16, 1954, and "Worried Workers," January 22, 1958.

spreading overhead and that of changes in morale and efficiency. The amount of labor required to perform a particular task may increase, but the number of such tasks to be performed per unit of final product may decline. If the efficiency of railway track gangs were to decline, for example, the number of man-hours required to maintain a mile of track might rise by 10 per cent, say, but the traffic over that mile might simultaneously increase 20 per cent, and in that case the number of man-hours required per unit of transportation service would decline. Or the amount of labor required to keep a factory warm and clean might increase by 10 per cent, while the output of the factory increased 20 per cent.

The effect of spreading overhead on hours per unit should become smaller and smaller as production expands. To take the extreme case, suppose that the aggregate man-hours of a particular kind of labor, if there were no changes in morale or personal efficiency, would be a constant, k, regardless of output, p. Then, for this kind of labor, hours per unit of production would be k/p. This ratio decreases as p increases, but the decrease per additional unit of product becomes smaller and smaller. On the other hand, if, as many observers believe, growing employment tends to be accompanied by declining morale and efficiency, the influence of the latter on hours per unit presumably becomes stronger and stronger, except perhaps in an expansion of production that is out of phase with the movement of business at large.

Statistical Aggregates Conceal Typical Experience

Economic questions are sometimes discussed in terms of aggregate figures for broad areas of the national economy—all manufacturing, all trade, all private industry, and so on. Our data largely preclude us from entering into this kind of discussion, even with respect to manufacturing, since we have no production figures, except those based on assumptions about productivity, for much of this broad field. Beginning in 1947, however, we have data for fifteen industries that account for roughly one-fourth of factory activity.

Change in hours per unit in the fifteen combined can be measured in at least two ways. One method adds man-hours worked in all fifteen in each month, and divides the total by aggregate man-hours in an average month of 1947-49. This index of man-hours is divided by an index of production in the fifteen industries combined to yield a composite index of hours per unit.[3] The result is influenced by changes in the industrial

[3] Where our measures of hours per unit and production for individual industries are initially expressed in natural units, e.g., man-hours per pair of shoes and pairs produced, we of course have to convert these into indexes on the 1947-49 base before proceeding toward composite measures.

The composite index of production that we use is a miniature Federal Reserve composition of man-hours and production. One industry may at all times have lower hours per unit of production—as production is measured in the Reserve index—than others. If production increases faster in that industry than in the others, composite hours per unit can fall even if no single industry experiences any change in that respect. The second way to make a composite index of hours per unit avoids this difficulty. The index of hours per unit in each industry is multiplied by a constant weight in every month to give the composite.[4]

The outcome of these calculations is instructive in a very special sense. In one or another of the fifteen industries, there were 47 contractions of production that began and ended within the 1947-58 period. In 34 of these, there was a net rise in hours per unit from the peak to the trough, a net fall in only 13. The experience of this period, in other words, was similar to that revealed by our whole body of data. When the data for the fifteen industries are combined, the composite measure of production has peaks and troughs as individual industries do; in fact it has four contractions during the period. The composite index of hours per unit declines, however, not only in the expansions, but in the contractions too, except for the second variant in one contraction (Table 11).

What has happened to the cyclical rise in contractions? How did it vanish? In the first place, the production cycles in the various industries do not coincide with each other. At times, some are expanding their production while others are contracting theirs. In so far as rising production tends to reduce hours per unit, this tendency is minimized by the combination of divergent production movements. In the second place, one of the fifteen industries, cigars, had no contraction of production in this period. In the third, industries managed to avoid rising hours per unit, as we have seen, in thirteen instances.

In a more subtle sense, however, the influence of output can still be traced in the composite index of hours per unit. The decline in the latter during each contraction of output is less rapid than during the preceding or following expansion (Table 11). Consolidating the figures for the fifteen industries turns the preponderance of rises in hours per unit that we observe when we regard the industries individually into a mere retarded fall when we regard them collectively.

index. The Federal Reserve assigns a weight of .0017 to cigars, for example; .0469 to textiles, etc.; and .2170 to the fifteen industries. We multiply the production index for cigars in any month by .0017 ÷ .2170, or .0078; the production index for textiles by .0469 ÷ .2170, or .2161; and so on, and sum the products for the fifteen industries to get the composite.

[4] We use the Federal Reserve production weights. In terms of the examples in the preceding footnotes, we multiply the index of hours per unit for cigars by .0078, the index of output per unit for textiles by .2161, etc., and sum the products.

TABLE 11

Composite Indexes of Hours per Unit at Turning Points in Composite Production, Fifteen Manufacturing Industries, 1948-58

Date of Peak or Trough	Level of Production	Months from Preceding Date	Index I of Hours per Unit	Change in Index I			Index II of Hours per Unit	Change in Index II		
				Total	Per Month			Total	Per Month	
					To Peak from Trough	To Trough from Peak			To Peak from Trough	To Trough from Peak
July 1948	Peak	...	99.5	...	...	...	99.7	...	...	...
Oct. 1949	Trough	15	95.2	−4.3	...	−0.29	98.2	−1.5	...	−0.10
Sept. 1950	Peak	11	88.4	−6.8	−0.62	...	88.9	−9.3	−0.85	...
July 1952	Trough	22	88.1	−0.3	...	−0.01	90.1	1.2	...	0.05
July 1953	Peak	12	82.4	−5.7	−0.48	...	83.8	−6.3	−0.52	...
July 1954	Trough	12	81.0	−1.4	...	−0.12	82.7	−1.1	...	−0.09
Nov. 1955	Peak	16	74.0	−7.0	−0.44	...	75.4	−7.3	−0.46	...
Apr. 1958	Trough	29	72.2	−1.8	...	−0.06	75.3	−0.1	...	−0.00

NOTE: Index I: Index of aggregate hours in fifteen industries divided by aggregate production. Affected by changes in relative importance of various industries. Index II: Indexes of hours per unit in each industry, weighted by same weight for each industry in every month.

Reliable Measures for All Manufacturing Not Feasible

Statisticians have endeavored to compute an index of "productivity" for all manufacturing by dividing an index of all production-worker man-hours, based on BLS data, into the Federal Reserve index of total manufacturing production. Such a productivity measure, however, is not likely to indicate correctly the change in output per man-hour from month to month, nor is its reciprocal apt to indicate correctly the changes in production-worker man-hours per unit.

The purported index of productivity is, in effect, a weighted average of two implicit component indexes, with roughly equal weights. One component pertains to industries in which production itself is estimated from man-hours by adjusting the latter for changes in productivity. Annual indexes of output per man-hour are taken as points of departure for monthly interpolations, and the designers of the production index state that the change from month to month is assumed to occur smoothly. A chart of the implicit monthly index for this group of industries would look like a chart of an annual index. But we have seen that an annual index of hours per unit tends to obscure any cyclical fluctuation that may be present, and to show a continuous decline. Its reciprocal, an annual index of output per hour, tends to show a continuous rise. An index made by smooth monthly interpolation between annual data must have a similar appearance.

Yet it may well be that, if we had independent monthly information on production in these industries, product per man-hour would be found to rise and fall with production. Or, on the other hand, these industries may differ radically from those we have studied in this paper; higher production may be obtainable in the short run only by a disproportionate expenditure of man-hours; productivity may vary inversely with production. In either case, a true index might show a cyclical variation that is largely assumed away by the monthly interpolation. The first component of the purported index must have a large degree of built-in cyclical neutrality.

The second component pertains to those industries whose production is measured independently of man-hours. When the neutral first component and the second are averaged, any cyclical fluctuation in the second will appear in the composite with diminished amplitude. If the real situation in the first group of industries is that productivity rises and falls with production, a true composite index would show more cyclical variation than the purported one. If the real situation is that productivity varies inversely with production, a true composite index might show no cyclical variation, or even an inverse cyclical relation. Conceivably both indexes might show a continuous rise over long periods, but the comparative rates of rise in two successive segments of a composite production cycle (or business cycle) might well be different in the two indexes. Since an index of hours per unit is the reciprocal of a "productivity" index, all the foregoing criticisms apply to any index of hours per unit in all manufacturing that can be constructed from the available data.

They also apply to any index of production labor cost per unit in all manufacturing computed by dividing the Federal Reserve production index into an index of BLS payrolls. Such a purported index of labor cost is, in effect, the product of a purported index of hours per unit and an index of hourly earnings. When "productivity" rises faster than the assumed smooth rate, the purported index of labor cost rises too much or falls too little. When productivity does not rise as fast as the assumed smooth rate, the purported index of labor cost rises too little or falls too much.

On the basis of what happens to cost in the industries we have studied, we may be willing to risk an inference as to what happens in most other industries. But that inference can receive no support and no refutation from the over-all measures we have just considered.

The Federal Reserve authorities have recently published a revised version of their production index. The treatment of the first group of industries, as described above, has been modified. Interpolations and extrapolations of productivity, now made by a mechanical process, are still the initial step. A composite index of productivity for the first group is then constructed and compared with a similar composite index for the second. At certain periods, when the two composites diverge considerably, the initial component indexes for the first group are altered in such a way as to bring the composite for that group closer to the composite for the second. This method has not been applied to the index for periods before 1947, and it assumes that the month-to-month fluctuation in productivity is similar, although not identical, in the two groups.