Volume Title: Production of Industrial Materials in World Wars I and II

Volume Author/Editor: Geoffrey H. Moore

Volume Publisher: NBER

Volume ISBN: 0-87014-333-6

Volume URL: http://www.nber.org/books/moor44-1

Publication Date: March 1944

Chapter Title: Industrial Materials Output and Total Industrial Production in Peace and War

Chapter Author: Geoffrey H. Moore

Chapter URL: http://www.nber.org/chapters/c9456

Chapter pages in book: (p. 31 - 52)

1) Eleven industries have either already reached a definite peak in production (judging from the duration, size, and continuity of the subsequent decline), or show a marked decline in the rate of increase in output (suggesting that the indicated high point may be the actual peak, or at least is not far below it).

(a) In nine of these industries a definite peak in employment has been reached: lumber, leather, paper and pulp, metal mining, cement, tobacco, textiles, ferrous metals, and bituminous coal.

(b) In two there is no definite peak or retardation in employment: malt liquors and flour.

2) Three industries show no definite peak or retardation in production.

(a) In two of these a definite peak in employment has been reached: petroleum and meat packing.

(b) In one there is no definite peak or retardation in employment: nonferrous metals.

Despite some rather glaring differences in the behavior of the production and employment series, due partly to our failure to seasonally adjust the employment series, partly to lack of comparability in coverage, and partly to longer hours of work, the relation between employment and production in these basic industries seems clear. In all except three of the 14 industries (malt liquors, flour, and nonferrous metals) employment has declined considerably from the levels reached in 1941 or 1942. Unless these declines are checked, a substantial rise in the total production of industrial materials seems very unlikely and a moderate decline not at all unlikely. The latter outcome would not be without precedent; our index declined 4% from 1917 to 1918.

IV Industrial Materials Output and Total Industrial Production in Peace and War

In Section I we made certain tests of the validity of our industrial materials production index, but deferred consideration of the relation between the output of industrial materials and total industrial production. Obviously there would be little point in the foregoing analysis if *no* relation were to be expected. However, total industrial production depends not only on the output of materials but also on the rate at which they are consumed and on the amount of labor and other factors of production applied to them. In this section we attempt to

show how our index compares, in theory, with an 'ideal' index of industrial production; and how it compares, in practice, with other indexes that in certain respects approximate the ideal.

An index of industrial production should presumably include all the products of the mining, manufacturing, and construction industries. It could be drawn up on either of two plans: (1) by obtaining a weighted aggregate of series representing the output of finished goods and changes in stocks of unfinished goods, the weights being chosen to exclude the part of the value of a good that is produced outside 'industry', or (2) by aggregating the output of both finished and unfinished goods, the weights being chosen to exclude not only the part of the value of finished or unfinished goods that is produced outside 'industry', but also the part of the value of finished goods that is represented by unfinished goods.

Our index of industrial materials production does not meet any of these specifications exactly. It includes most of the principal products of the mining industry (though metals are represented as ingots rather than as ore) and most of the other principal materials used in the manufacturing and construction industries. But it includes few finished products of manufacturing industries and no products of the construction industry. It is hard to say precisely what fraction of total industrial production is included in our index in the base years 1914 and 1939; a fairly conservative estimate would put it at about one-fourth. The omission of the more highly fabricated products means that our index will understate the rise in total output if there has been a relative increase in the physical quantity of highly fabricated goods. Furthermore, our index is constant in composition, and as pointed out in Section I, the omission of new products probably imparts a downward bias.

So far as method of construction is concerned, our index is something of a hybrid. Since it includes the output of both finished and unfinished goods it resembles an index constructed according to the second plan mentioned above. But the method used to avoid duplication resembles that of the first, since we usually omitted data on output at earlier stages of production when we had data for a later stage. This enabled us to use value weights for all commodities except those of agricultural or foreign origin, for which it is necessary to use value added weights to limit the coverage to domestic industrial production. (For a fuller description and analysis of the coverage and weighting of our index see Appendix A.)

In order to appraise the rather disturbing deficiencies of our own index we supplement it by two others that resemble it in coverage (the pre-1940 Federal Reserve Board index and the current Federal Reserve Board index excluding manhours series), and compare these three indexes with three that have a coverage considerably closer to that of the 'ideal': an index combining Fabricant's manufacturing and Barger's mining indexes; the current Federal Reserve Board index of industrial production; and an index of gross commodity product based on Kuznets' estimates in 1929 prices (Table 9 and Chart 7).

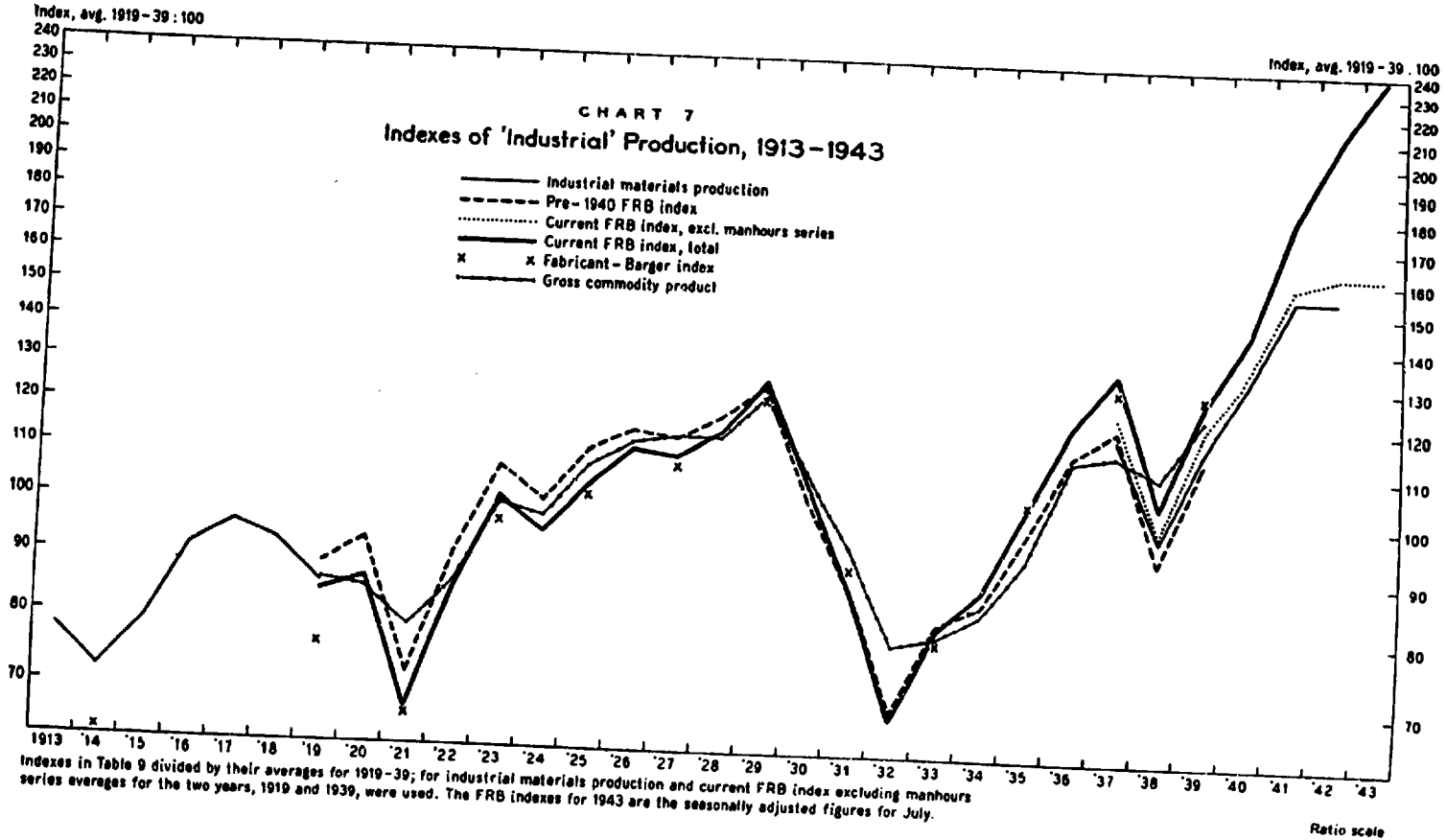
TABLE 9

Indexes of 'Industrial' Production, 1913–1943

	INDUSTRIAL MATERIALS PRODUCTION INDEX (1)	PRE-1940 FRB INDEX (2)	CURRENT FRB INDEX Excl. Manhours Series (3)	CURRENT FRB INDEX Total (4)	FABRICANT-BARGER INDEX (5)	GROSS COMMODITY PRODUCT (6)
			(*1939:100*)			
1913	68				50	
1914	63					
1915	69					
1916	80					
1917	84					
1918	81					
1919	75	79	68	67	60	71
1920		83		69		70
1921		64		54	53	65
1922		81		68		71
1923		96		81	77	83
1924		90		76		81
1925		99		83	81	89
1926		103		89		93
1927		101		88	86	94
1928		106		92		94
1929		113		102	98	102
1930		91		84		88
1931		77		69	71	77
1932	58	61	55	54		64
1933		72		64	62	65
1934		75		69		68
1935		86		81	81	76
1936		100		95		92
1937	103	105	102	105	101	93
1938	84	82	82	82		89
1939	100	100	100	100	100	100
1940	115		112	114		
1941	135		133	144		
1942	135		136	168		
1943[a]			136	190		

[a] Figures are for July 1943, adjusted for seasonal variation.

SOURCES:
1) For list of series included and their weights see Appendix Tables 1, 2, 3, and 5.



Indexes in Table 9 divided by their averages for 1919–39; for industrial materials production and current FRB index excluding manhours series averages for the two years, 1919 and 1939, were used. The FRB indexes for 1943 are the seasonally adjusted figures for July.

Since Fabricant's index is based on the Census of Manufactures, it covers only census years, which unfortunately just bridge the interval in which the first war was fought and end at the beginning of the second. Quantity data for a large and changing list of manufactured commodities, both finished and unfinished, are combined into industry indexes by means of value (price) weights; the industry indexes are then weighted according to value added by manufacture. Barger's index also is based on a large and changing list of commodities (minerals), both finished and unfinished, and weighted by values. Hence the combined index of mining and manufacturing conforms to the second of the two methods of construction indicated above. But it is not so comprehensive as our 'ideal' index would be, since the products of the construction industry are not included.

The current Federal Reserve Board index, though it also purports to cover mining and manufacturing output, is based on fewer commodity series. On the other hand, it is broader in coverage than our index: in addition to series representing the production or consumption of basic industrial materials, a number of important series that represent the output of finished products are included. Most of the latter are estimated by adjusting manhours of employment for changes in output per manhour, at some cost in statistical reliability, as we shall see. For purposes of analysis we eliminated the 'manhours series' from the total: the index in column 3 is similar in composition not only to our index of industrial materials production but also to the Federal

(*sources for Table 9, concl.*)

The index for 1913-19 is the one computed with 1914 weights, converted from a 1914 base by multiplying by the index for 1914 (63.4) computed on a 1939 base with 1939 weights.

2) Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin*, Aug. 1940, p. 807. Converted from 1923-25 base by dividing by the 1939 index, 105.

3) See Table 1, note 6.

4) Board of Governors of the Federal Reserve System, *op. cit.*, Sept. 1943, p. 879. Converted from 1935-39 base by dividing by the 1939 index, 108.

5) Weighted average of an index of manufacturing output (Solomon Fabricant, *The Output of Manufacturing Industries, 1899-1937*, National Bureau of Economic Research, 1940, p. 602) and an index of mining output (Harold Barger and Sam H. Schurr, *The Mining Industries, 1889–1939: A Study of Output, Employment and Productivity*, National Bureau of Economic Research, 1944). In combining the two indexes (by a modification of the Edgeworth formula) we used 1909 and 1919 weights (value added by manufacturing, value of products of mining) for the 1914 and 1919 indexes, 1919 and 1929 weights for the 1919-29 indexes, and 1929 and 1937 weights for the 1929-39 indexes, chaining the resulting indexes at 1919 and 1929.

6) Unpublished estimates by Simon Kuznets, similar to those in his *Commodity Flow and Capital Formation*, Volume One (National Bureau of Economic Research, 1938), p. 480, line VII. Dollar estimates in 1929 prices were converted to an index by dividing by the 1939 value, $68,975 million.

Reserve index as it was before its revision in 1940.[24] Since the Federal Reserve indexes include both finished and unfinished goods they are constructed according to the second method indicated above: value weights are used for mineral products, value added for manufactured products.

The index of gross commodity product is more comprehensive than either the Fabricant-Barger or the current Federal Reserve index, and is constructed according to the first plan. Since it purports to cover the output of all finished commodities (including producer durable goods and new construction) and additions to stocks of unfinished goods, all valued at current prices (cost to user) but deflated by price indexes, it is more comprehensive than an industrial production index really should be. It includes not only unmanufactured agricultural products (finished perishable commodities such as fresh fruits and vegetables, finished durable commodities such as capital livestock, and changes in stocks of unfinished commodities such as wheat) but also the part of the value of finished manufactured products that is contributed by agriculture. Apparently the agricultural component, which is hard to eliminate from the estimates, is neither large enough nor variable enough to affect our analysis greatly. The advantage of industrial comprehensiveness is offset, unfortunately, by a lack of precision, occasioned on the one hand by the limited amount of evidence available for estimating total value of output (particularly in intercensal years) and on the other by the limited scope of the price indexes used to deflate these values.

We have then three indexes that approximate our ideal more or less closely but differ considerably among themselves in composition and method of construction (the Fabricant-Barger index, the current FRB total index, and gross commodity product), and three indexes rather alike in composition and construction but much less comprehensive (our index, the pre-1940 FRB index, and the current FRB index excluding the manhours series). What conclusions do the comparisons suggest? Since most of the possible comparisons relate to peacetime, let us examine first the results for 1919-39.

All the indexes are highly consistent as to direction of change (Table 10). In nine of the ten census year comparisons all the in-

[24] According to Appendix Table 5 the proportion of total weight received by series of similar content used in all three indexes is 82% in the pre-1940 FRB index (1923-25 weights), 76% in the current FRB index excluding manhours series (1935-39 weights), and 79% in our industrial materials production index (1939 weights).

TABLE 10

Indexes of 'Industrial' Production, Percentage Changes, 1913–1943

	INDUSTRIAL MATERIALS PRODUCTION INDEX (1)	PRE-1940 FRB INDEX (2)	CURRENT FRB INDEX Excl. Manhours Series (3)	CURRENT FRB INDEX Total (4)	FABRICANT-BARGER INDEX (5)	GROSS COMMODITY PRODUCT (6)
			PERCENTAGE CHANGES FROM PRECEDING CENSUS YEAR			
1914–19	+19				+20	
1919–21		—19		—19	—12	—8
1921–23		+50		+50	+45	+28
1923–25		+3		+2	+5	+7
1925–27		+2		+6	+6	+6
1927–29		+12		+16	+14	+9
1929–31		—32		—32	—28	—25
1931–33		—6		—7	—13	—16
1933–35		+19		+27	+31	+17
1935–37		+22		+30	+25	+22
1937–39	—3	—5	—2	—5	—1	+8
			PERCENTAGE CHANGES FROM PRECEDING YEAR			
1913–14	—7					
1914–15	+10					
1915–16	+16					
1916–17	+5					
1917–18	—4					
1918–19	—7					
1919–20		+5		+3		—1
1920–21		—23		—22		—7
1921–22		+27		+26		+9
1922–23		+19		+19		+17
1923–24		—6		—6		—2
1924–25		+10		+9		+10
1925–26		+4		+7		+4
1926–27		—2		—1		+1
1927–28		+5		+5		0
1928–29		+7		+11		+9
1929–30		—19		—18		—14
1930–31		—15		—18		—12
1931–32		—21		—22		—17
1932–33		+18		+19		+2
1933–34		+4		+8		+5
1934–35		+15		+17		+12
1935–36		+16		+17		+21
1936–37		+5		+11		+1
1937–38	—18	—22	—20	—22		—4
1938–39	+19	+22	+22	+22		+12
1939–40	+15		+12	+14		
1940–41	+17		+19	+26		
1941–42	0		+2	+17		
1942–43[a]			0	+13		

Computed from indexes in Table 9.

[a] Indexes for 1943 are for July, adjusted for seasonal variation.

dexes move consistently; the exception occurs in 1937-39, when gross product rises while all the other indexes decline. In the 20 year-to-year comparisons the current and the pre-1940 Federal Reserve Board in-

dexes are perfectly consistent in direction of movement,[25] and between these two indexes and gross commodity product there are only three disagreements: 1919-20, 1926-27, and 1927-28.[26] We may conclude, then, that in peacetime an industrial materials production index is likely to give an accurate indication of the year to year direction of movement of total industrial production.

The percentage changes during short periods in peacetime tend to be smaller in gross commodity product than in the other indexes (Table 11). The index that most closely resembles our industrial

TABLE 11

Indexes of 'Industrial' Production, Measures Relating to Percentage Changes, 1919–1939

	AVERAGE ABSOLUTE PERCENTAGE CHANGE	
	From Preceding Census Year	From Preceding Year
Gross commodity product	14.6	8.0
Pre-1940 FRB index	17.0 (12.6)	13.2 (11.9)
Fabricant-Barger index	18.2	.....
Current FRB index	19.4 (15.6)	14.2 (13.3)

	AVERAGE ABSOLUTE DIFFERENCE BETWEEN PERCENTAGE CHANGES		RANK CORRELATION COEFFICIENT BETWEEN PERCENTAGE CHANGES	
	From Preceding Census Year	From Preceding Year	From Preceding Census Year	From Preceding Year
Pre-1940 FRB index & current FRB index	(3.2)	(1.8)	(+.98)	(+.98)
Pre-1940 FRB index & Fabricant-Barger index	5.0	....	+.98	....
Pre-1940 FRB index & gross commodity product	7.6	6.2	+.95	+.86

Computed from entries in Table 10, except that in computing the rank correlation coefficient tied values were eliminated, so far as possible, by computing the percentage changes to more decimal places. Parenthetic entries are for 1923-39 (cf. note 25).

[25] The 1940 revision of the Federal Reserve index did not cover 1919-22; the new index was spliced on to the old in 1923. Except for a difference in level, then, the current and the pre-1940 indexes are identical from 1919 to 1923, and their percentage changes in this period differ only because of rounding.

[26] If the index of gross commodity product were computed to one decimal place it would decline from 1927 to 1928 rather than remain constant. We are inclined to doubt its reliability in regard to direction of change in all three periods. General business activity certainly maintained a higher average level in 1920 than in 1919 and in 1928 than in 1927, and probably in 1926 than in 1927. A rough estimate of the agricultural component indicates that it does not affect the direction of change in gross commodity product in these years. However, since the percentage changes of all the indexes are relatively small in these years, the discrepancies are not large.

materials production index (the pre-1940 Federal Reserve index) occupies an intermediate position in this respect, but the differences between it and the Fabricant-Barger or the current Federal Reserve Board index are not large. The smaller percentage changes in gross commodity product are perhaps accounted for by its broader scope, but they may be due also to the method of construction.

To measure roughly the closeness of the relation between the index that is based largely on materials production and the more comprehensive indexes we subtract the percentage changes in the former from those in each of the latter and average without regard to sign. The results indicate that the pre-1940 FRB index is more closely related to the current FRB index than to the Fabricant-Barger index, and more closely related to the latter than to gross commodity product. These averages represent, in effect, the average error one would make in assuming that the percentage changes in industrial materials production are identical with those in 'total' industrial production. The assumption, of course, is not necessarily appropriate; that is, a better estimate of the change in the total might be obtained on the basis of a different assumption concerning the relationship. In estimating changes in gross product, for example, it would clearly be better to assume that the change would be in the same direction but *smaller* than in industrial materials production. In 13 of the 20 year-to-year comparisons the movements in gross product are in the same direction but smaller than in the pre-1940 FRB index; in four they are in the same direction but larger; in three they are in the opposite direction. There is also a tendency for a given rise in the pre-1940 FRB index to be matched by a somewhat greater rise in the Fabricant-Barger and the current FRB index, and for a given decline to be matched by a somewhat smaller decline. This occurs in eight of ten Census year comparisons with the Fabricant-Barger index, and in ten of the 16 year-to-year comparisons (1923-39) with the current FRB index. Hence, although the assumption of identical changes in industrial materials and 'total' production in this period is a fair first approximation, it can certainly be improved.

The limitations of the average absolute difference between percentage changes as a measure of relationship prompt us to supplement it with another measure that is unaffected by these limitations, the rank correlation coefficient. According to it, the pre-1940 Federal Reserve index is as closely related to the Fabricant-Barger as to the current Federal Reserve index, and more closely related to them than

to gross commodity product. But the differences among the coefficients are not large—all the coefficients are high.

The comparisons we can make for the war years are more limited in scope, and as far as they go, decidedly different in result, at least for the second war. For the first war we can make only a comparison between pre- and postwar levels: between 1914 and 1919 our materials production index rose 19%, the Fabricant-Barger mining and manufacturing index 20%. Despite the longer interval and the extraordinary upheaval it encompassed, the difference between these percentage changes is smaller than any of the differences between the biennial percentage changes from 1919 to 1939 in the pre-1940 Federal Reserve index and the Fabricant-Barger index.

Of our 'total' indexes the current Federal Reserve index alone extends beyond 1939.[27] From 1939 to 1940 it rises at about the same rate as the materials indexes (our index and the FRB index excluding manhours series). But from 1940 to 1941 and from 1941 to 1942 it rises much more rapidly than the materials indexes. The differences (7 and 9% in 1940-41, 15 and 17% in 1941-42) are larger than any of those between the peacetime year to year changes in the current and the pre-1940 Reserve Board indexes (the largest of which is 6%, in 1936-37). By 1942 the current Federal Reserve index reaches a level 68% above 1939, while the indexes based on materials production rise only about half as much, 35 and 36%. According to the monthly figures in Table 12 and Chart 8 the difference became marked about the middle of 1941. Since then the Reserve Board index excluding manhours series has neither risen nor declined appreciably, while the total index has continued to advance rapidly.

Statistically, this striking difference, which is equivalent in 1942 to one-third of the total product of industry in 1939, is due to differ-

[27] Current estimates of gross national product in 1939 prices are made by the Department of Commerce, yielding the following indexes, 1939-43: 100, 109, 126, 150, 179. (We estimated 1943 by adding to the seasonally adjusted annual rate for the second quarter one-half of the difference between that and the corresponding figure for the first quarter.) This total includes both commodities and services; with the breakdown provided, it is not possible to eliminate government expenditures for services, but if consumer outlay for services is eliminated, the index for 1939-43 becomes: 100, 110, 132, 161, 199.

The more rapid increases after 1940 as compared with our index of materials production are in decided contrast to the peacetime relationship. But there is serious doubt that the Department's estimates for the war years are conceptually comparable with those for peacetime, and that the Department's deflation procedure is adequate. As these questions are treated in *Occasional Paper 17:* National Product, War and Prewar, by Simon Kuznets, we do not discuss them here.

TABLE 12

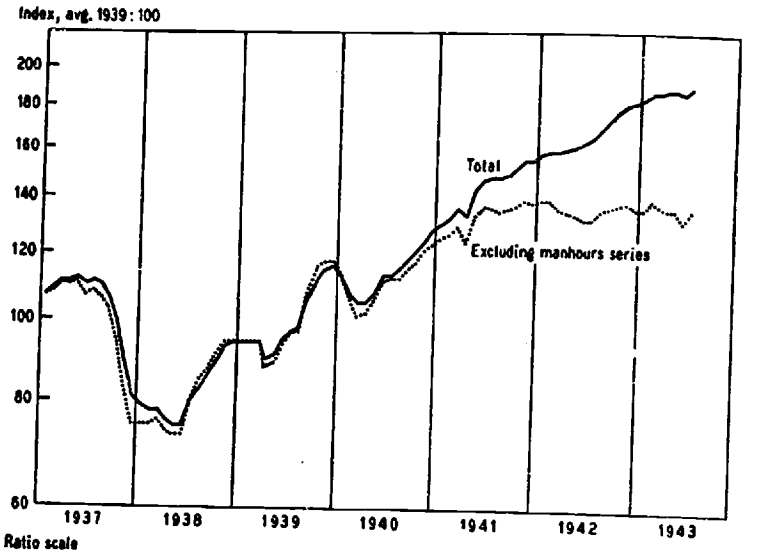
Federal Reserve Board Industrial Production Index, Adjusted for Seasonal Variation, Including and Excluding Manhours Series, 1937–1943

	1937		1938		1939		1940		1941		1942		1943	
	Total	Excl. Manhours Series	Total	Excl. Manhours Series	Total	Excl. Manhours Series	Total	Excl. Manhours Series	Total	Excl. Manhours Series	Total	Excl. Manhours Series	Total	Excl. Manhours Series
							(*Average 1939:100*)							
Jan.	107	107	79	75	94	94	113	113	130	125	158	139	184	136
Feb.	109	108	78	75	94	94	107	106	132	126	159	139	187	139
Mar.	111	111	78	76	94	94	105	101	136	129	159	136	187	137
Apr.	111	110	76	74	90	88	105	102	133	124	160	135	188	136
May	112	111	75	73	91	89	108	106	143	133	161	134	188	136
June	110	107	75	73	95	94	113	111	147	136	163	132	187	132
July	111	108	80	80	97	97	113	112	148	136	165	132	190	136
Aug.	110	106	83	85	98	97	115	112	148	135	169	135		
Sept.	106	103	86	87	106	107	118	115	149	136	173	136		
Oct.	99	94	89	91	112	115	121	117	152	137	177	137		
Nov.	89	83	93	94	115	117	124	121	155	139	181	138		
Dec.	81	75	94	94	116	117	128	123	155	138	182	136		
Avg.	105	102	82	82	100	100	114	112	144	133	168	136		

For source and method of computation see Table 1, note 6. Annual averages are computed directly from the averages on the original base.

CHART 8

Federal Reserve Board Industrial Production Indexes, Adjusted for Seasonal Variation, 1937–1943



ences in the composition of the indexes. In Table 13 the subgroup indexes that are roughly comparable in coverage are indicated. The differences in the weighting and in the behavior of the comparable subindexes are not inconsiderable. But it is as true of the components of the Federal Reserve Board index as it is of the components of our index that the percentage rises from 1941 to 1942 were *typically* small, and that retardation was *general*. The difference between the two indexes is due chiefly to two Federal Reserve Board series, machinery and transportation equipment, which contribute 18 of the 24 points (percentage of 1939) by which the Federal Reserve Board index rose from 1941 to 1942.

Now the output of the machinery and transportation equipment industries is extremely difficult to measure because (1) in any given year they produce a tremendous variety of goods, and (2) the goods produced in different years are not the same, especially in such years as 1941 and 1942, when many firms converted from peacetime to wartime production—automobile factories started producing tanks, machine guns, and so on. Consequently, not only is it difficult to get an adequate sample of physical production series representing the output of these industries, but even if it were possible to get the series it

TABLE 13

Component Indexes of Our Industrial Materials Production Index and of the Federal Reserve Index of Industrial Production, 1939–1942

GROUPS OF SIMILAR COVERAGE[1]	OUR INDEXES			FRB INDEXES			RISE OR FALL, 1941–42		POINTS CONTRIBUTED TO CHANGE IN TOTAL INDEX, 1941–42		ACCELERATION (+) OR RETARDATION (−), 1940–41–42[7]	
	1940	*1941*	*1942*	*1940*	*1941*	*1942*	Our Indexes	FRB Indexes	Our Indexes	FRB Indexes	Our Indexes	FRB Indexes
					(*1939:100*)							
Ferrous metals	127	157	163	130	164	176	6	12	1.0	1.4	—24	—22
Nonferrous metals	122	153	174	117	146	144	21	—2	1.3	—0.1	—10	—31
Fuels (unmfd.)	109	116	122	109	116	119	6	3	1.7	0.4	—1	—4
Other minerals[2]	108	132	145	106	133	132	13	—1	0.6	0.0	—11	—28
Textiles	109	144	146	102	135	139	2	4	0.3	0.5	—33	—29
Leather	93	121	128	91	117	121	7	4	0.0	0.1	—21	—22
Mfd. foods[3]	106	114	121	108	116	122	7	6	0.7	0.2	—1	—2
Alcoholic beverages	100	113	120	103	119	121	7	2	0.3	0.1	—6	—14
Tobacco	104	114	124	103	113	124	10	11	0.4	0.1	0	+1
Lumber	116	134	127	108	122	119	—7	—3	—0.4	0.0	—25	—17
Paper & pulp	123	136	136	108	125	122	0	—3	0.0	—0.1	—13	—20
Miscellaneous[4]	155	193	76	109	a	a	—117	a	—5.8	a	—155	a
OTHER GROUPS												
Transp. equipment				141	227	405		178		10.0		+92
Machinery				131	204	283		79		8.1		+6
Chemicals				110	134	166		32		2.0		+8
Mfd. Foods[5]				105	119	136		17		1.4		+3
Furniture				109	136	132		—4		0.0		—31
Shoes				95	117	113		—4		0.0		—26
Petroleum & coal products (mfd.)				105	116	111		—5		—0.2		—16
Printing & publishing[6]				105	117	108		—9		—0.6		—21
Government arsenals & quartermaster depots				a	a	a		a		a		a
Total index	115	135	135	114	144	168	0	24	0	24	—20	—6

would be hard to combine them, since so many would end in 1941 or 1942, and so many others would begin then.

The Federal Reserve indexes of production of machinery and transportation equipment are constructed by multiplying manhours of employment in these industries by indexes of output per manhour. But the difficulties in constructing a production index inevitably attach also to the construction of a productivity index. For the latter we need data on the output of particular products per manhour. Not only would the possible number of such series be great, but the series themselves would be discontinuous. Many, representing peacetime products, would end in 1941 or 1942; and as many others, representing wartime products, would begin then. How can such data be combined into a continuous index?

The Federal Reserve Board's solution is to construct, by more or less indirect means, annual or biennial indexes of production for these industries (or to use such indexes constructed by others),[28] divide

[28] For example, a biennial index of machinery production (1923-37) was constructed by 'deflating' an index of value added in the machinery industry, the deflator being the ratio of total value added in the iron and steel, nonferrous metals, and transportation equipment industries to Fabricant's production index for these industries. (Fabricant has not computed an index for machinery: "In the first place, few of the machinery industries are covered by adequate quantity data on output; and in the second place, the available statistics are ambiguous because the products are not divided into homogeneous subclasses."—*Ibid.*, p. 287.)

(*Notes to Table 13*)

For a list of series included in our indexes and their weights see Appendix Tables 1, 2, 3, and 5. The Federal Reserve indexes were computed by us from data published by the Board of Governors of the Federal Reserve System in *New Federal Reserve Index of Industrial Production* (1942); 'Revised Seasonally Adjusted Indexes of Industrial Production,' mimeo. release, Feb. 10, 1943; and *Federal Reserve Bulletin*, monthly issues through Sept. 1943.

[1] So far as possible the groups are similar in *conceptual* coverage, i.e., the coverage assumed in the weighting system. For example, our index of ferrous metals, based on steel ingot production, was considered comparable with a Federal Reserve index that includes iron ore, pig iron, and steel ingots, since this coverage is implicit in the weight we assign to steel ingots. The composition of the various groups may be determined from Appendix Table 5 and the footnotes below.

[2] Except petroleum and coal products (manufactured).

[3] Includes all food series in our index, and all food series except 'other manufactured foods' in the Federal Reserve index.

[4] Our index includes cotton linters, linseed oil, turpentine, ethyl alcohol, and rubber; Federal Reserve index includes industrial alcohol (since Jan. 1942), and rubber products.

[5] Includes 'other manufactured foods'.

[6] Includes newsprint consumption and printing paper production.

[7] Change in index from 1941 to 1942 minus the change from 1940 to 1941.

[a] Not available for publication.

these indexes by manhours of employment in the corresponding years, draw a smooth free-hand line through the resulting annual or biennial productivity estimates, and read off monthly productivity estimates from the free-hand line. After 1939 the construction of the basic production indexes was complicated by the absence of a Census of Manufactures and by the change in the character of output. The Board attempts to use all the production data it can obtain, but for converted industries it is difficult to see how such data can be used. In any event, all the productivity estimates made by the Board followed straight lines sloping gently upward through 1941 and 1942, and for machinery, at least, the slope of the line was determined by the trend in preceding years.

This general procedure for estimating production was used not only for transportation equipment (six component series being estimated separately: aircraft, automobile bodies, parts and assembly, railroad cars, locomotives, shipbuilding in private yards, and shipbuilding in government yards) and machinery, but also for chemicals, government arsenals and quartermaster depots, 'other' manufactured foods, and furniture. The entire group of 'manhours series' received 32% of the total weight in the index in the base period 1935-39; by 1942 this figure had increased to 45%, because of the more rapid rise in this group than in the other series; and by July 1943 it had reached 51%.

Probably most of the industries now producing finished war goods, such as aircraft, ships, tanks, and ordnance, are included in the manhours series. And of course the output of war goods expanded tremendously between 1940 and 1942. The War Production Board's monthly index of munitions output, starting from a level of 23 in July 1940 (November 1941:100), reaches 64 in July 1941, indicating an advance of approximately 180% from 1940 to 1941. From 1941 to 1942 it rose even more rapidly, the 1942 average being 320, or 351% above the 1941 average of 71. However, the output of many of the goods produced in the 'manhours industries' in peacetime, such as automobiles, railroad cars, washing machines, and refrigerators, has been curtailed, at least since 1941. Furthermore, this process of conversion has also taken place in some important industries not covered directly by the Federal Reserve index, notably fabricated metal products and construction (the Federal Reserve index, it will be recalled, purports to measure only mining and manufacturing production, not

construction).[29] Not all the manhours series, of course, represent 'converted' industries; but it is the series that do represent converted industries that account for most of the difference between the Federal Reserve index and our index. The question is how the wartime output of these industries compares, in physical magnitude, with their peacetime output, and whether, by the use of series on manhours of employment adjusted by gradually rising indexes of output per manhour, the Reserve Board has really measured the change.

It seems that all we can say with certainty concerning total industrial production between 1940 and 1942 is that the increase in input of labor, measured in manhours, greatly exceeded the increase in input of materials (Table 14). Manhours of wage earner employment in manufacturing increased 9% from 1939 to 1940, 30% from 1940 to 1941, and 22% from 1941 to 1942. If manhours of employment in mining were included, the percentage increases after 1940 would be somewhat less, since total employment in mining increased 8% from 1939 to 1940 but only 1% from 1940 to 1941, and declined 1% from 1941 to 1942. If manhours in construction work were also included, the percentage increase from 1939 to 1940 might be reduced slightly, that from 1940 to 1941 augmented, and that from 1941 to 1942 reduced, since the percentage changes in construction employment in these years are 6, 31 and −5, respectively. Hence total manhours of wage earner employment in manufacturing, mining, and construction

[29] The degree of conversion between 1939 and April 1943 in 35 metal fabricating industries is indicated in an article by Richard H. Lewis, 'Conversion of Metal Working Industries to War Production, 1939-43', *Monthly Labor Review*, Dec. 1943. Conversion is defined as the "shift of a plant from one industrial classification to another, as the result of a change in its major product". The extent of conversion in a given industry is measured by the percentage of total employees in the industry in April 1943 who were employed in plants which, on the basis of current output, would be classified in a different industry. These percentages range from 7.1 for the radio and phonograph industry to 100.0 for the washing machine industry. Twenty industries were more than 50% converted. Of the 2,950,100 employees in all 35 industries in April 1943, 57.6% were employed in converted plants. The employment in plants that continued to produce their major peacetime product declined 22% between June 1940 and April 1943, while the total employment in all plants increased 85%.

The latter figures enable us to illustrate the effect on production indexes of different assumptions (or judgments) concerning the productivity of labor in converted industries. Let us suppose that there was an increase of 20% in output per employee in plants producing the same product in April 1943 as in June 1940 (a somewhat greater increase than in weekly hours per employee). Further, let us suppose that in April 1943 the output per employee in converted plants is (a) four-fifths of, (b) equal to, or (c) five-fourths of the output per employee in unconverted plants. Ample 'justification' probably could be found for each of these assumptions or for others outside this range. But by assumption (a) we would find that total output in the metal fabricating industries had increased 96% from June 1940 to April 1943, by assumption (b) that it had increased 122%, and by assumption (c) that it had increased 154%.

TABLE 14

Industrial Production and Employment, 1939–1943

	PRODUCTION			EMPLOYMENT				
				WAGE EARNERS IN MANUFACTURING			TOTAL EMPLOYMENT			
	INDUSTRIAL MATERIALS PRODUCTION INDEX (1939:100) (1)	FRB INDUSTRIAL PRODUCTION INDEX (1935–39:100) Excl. Manhours Series (2)	FRB INDUSTRIAL PRODUCTION INDEX (1935–39:100) Total (3)	Number (thous.) (4)	Hours per Week (5)	Total Manhours per Week (mill.) (6)	Mfg. (7)	Mining (thousands) (8)	Construction (9)	Mfg., Mining, Construction (10)
1939	100	109	108	8,192	37.7	308.8	10,078	845	1,421	12,344
1940	115	122	123	8,811	38.1	335.7	10,780	916	1,507	13,203
1941	135	145	156	10,825	40.6	439.5	12,816	928	1,976	15,720
1942	135	148	181	12,479	42.9	535.3	14,563	921	1,885	17,369
1943[a]		148	205	13,895	45.2	628.1	16,127	833	1,050	18,010
					(1939:100)					
1939	100	100	100	100	100	100	100	100	100	100
1940	115	112	114	108	101	109	107	108	106	107
1941	135	133	144	132	108	142	127	110	139	127
1942	135	136	168	152	114	173	145	109	133	141
1943[a]		136	190	170	120	203	160	99	74	146

[a] Figures are for July 1943, adjusted for seasonal variation.

SOURCES:

1) For list of series included and their weights see Appendix Tables 1, 2, 3, and 5.

2, 3) See Table 1, note 6.

4) 1939–41: 'Wage Earners and Weekly Wages,' B.L.S. mimeo. release, Feb. 1943; 1942 and July 1943: B.L.S. 'Employment and Payrolls,' monthly through Sept. 1943. July 1943 was adjusted by the Federal Reserve seasonal index for factory employment.

5) 1939–41: 'Hours and Earnings in Manufacturing,' B.L.S. mimeo. release LS43–4394; 1942 and July 1943: B.L.S., 'Hours and Earnings,' monthly through Sept. 1943. July 1943 was adjusted by a seasonal index computed by us.

6) Product of columns 4 and 5.

7, 8, 9) 1939–41: *Federal Reserve Bulletin*, Nov. 1942, p. 1156; 1942 and July 1943: *ibid.*, monthly through Sept. 1943.

10) Sum of columns 7, 8, and 9.

probably advanced about 8% from 1939 to 1940, 30% from 1940 to 1941, and 16-18% from 1941 to 1942, or approximately 65% from 1939 to 1942.[29a] These increases contrast sharply with those registered by our index of industrial materials production and the Federal Reserve index excluding manhours series: 15 and 12%, respectively, from 1939 to 1940, 17 and 19% from 1940 to 1941, 0 and 2% from 1941 to 1942, or 35 and 36% from 1939 to 1942. Although these indexes do not strictly relate to, and may understate the increase in the consumption of materials (owing to limitations of coverage and, possibly, consumption of stocks) it does not seem likely that consumption of materials increased nearly so rapidly, after 1940, as manhours of employment. The total Federal Reserve index, on the other hand, rose almost as rapidly, after 1940, as total manhours.

In peacetime, when it is possible to make industrial classifications that remain relatively homogeneous, at least for short intervals, one can determine with some confidence the relative merits of two possible interpretations of a more rapid increase in labor than in materials input: (1) that a greater proportion of labor relative to materials is required to produce given products (implying a decline in output per unit of labor), and (2) that the composition of output has shifted in the direction of products that ordinarily require more labor relative to materials.[30] But in the transition from peace to war it is impossible to make such homogeneous classifications for much of finished goods output. The automobile industry is no longer the auto-

[29a] Since the above statements were written the Bureau of Labor Statistics has released preliminary estimates of manhours of wage earner employment in these industries ('Manhours in Agriculture, Mining, Manufacturing, and Construction, 1939-1943', Jan. 1944). The percentage changes in the annual averages of the monthly figures are:

	1939-40	*1940-41*	*1941-42*	*1939-42*
Mining	+13	+12	+ 8	+36
Manufacturing	+ 9	+32	+24	+78
Construction	+19	+49	− 1	+75
Total	+11	+33	+20	+75

[30] Actually, this situation does not seem to have arisen in 1919-39. The average year to year percentage change in an index of manhours of wage earner employment in manufacturing (Solomon Fabricant, *Employment in Manufacturing, 1899-1939*, National Bureau of Economic Research, 1942, p. 331) is 12.0; the corresponding figure for the pre-1940 Federal Reserve index is 13.2. The year to year directions of movement of the two indexes are the same except in two instances: 1919-20, when the production index rises 5% while the manhours index declines 2%, and 1927-28, when the production index rises 5% while the manhours index declines 1%. The average difference between the year to year percentage changes in the two indexes is 3.8%, and in only two instances (1933-34 and 1936-37) does the manhours index rise more rapidly than the index based on materials production.

mobile industry when, instead of producing automobiles, it produces munitions. Hence in such a transition period, if the proportion of labor to materials increases, one would have great difficulty in choosing between explanations (1) and (2) or assessing their relative importance.

Under these circumstances it seems best to abandon any attempt to measure total industrial production, for the fact of conversion lends an element of arbitrariness, unreality, and uncertainty to any index that purports to measure the total. There is arbitrariness in the choice of weight factors used to combine discontinuous series; there is unreality in the idea of comparing aggregates that, to a large extent, consist of commodities not common to both peace and war periods; there is uncertainty because widely different results can be obtained by different methods of selecting (a) the weight factors mentioned above, and (b) the series that are to be included. We do not believe these difficulties attach, to nearly the same extent, to an index of industrial materials production. This does not mean that such an index measures total output; but it does measure a part that it is feasible to measure, a part that is of interest *per se*, and a part that does influence the aggregate amount of commodities produced in both peacetime and wartime.[81] While no precise rule can be formulated to determine when it is and when it is not feasible to construct a production index, it is our opinion that there is an insufficient statistical basis for an index of total output in World War I, and that in World War II, while the statistical data are more comprehensive, the conceptual difficulty is much greater because conversion has been more extensive. Whether or not it is possible to arrive at an informed judgment concerning the changes in degree of fabrication of materials and in productivity of labor in the two war periods, we think there is little advantage and some real danger in incorporating these impressions in an index. At least the basis for them and the margin of error should be clearly stated.

These conclusions are forced upon us by the transformation in the

[81] In this connection one must be careful not to misinterpret the rather close relation between materials and total production in peacetime. The implications of this relation are (a) that in peacetime similar results (the degree of similarity is indicated) can be obtained with a wide variety of indexes, and (b) that in peacetime a materials index, such as ours, does not give markedly distorted results. It follows that the wartime difference between our index and the current FRB index is not only unprecedented in terms of peacetime experience, but also is not to be explained by any idiosyncrasy of our index that appears in peacetime. It does not follow that a materials index, or any other index, will properly measure total output in wartime.

character of industrial production between 1941 and 1942. Two further implications may be considered. By the summer or autumn of 1942 most of the conversion of industry from peace to war output had apparently been accomplished.[32] Granting that total output in 1942 is incommensurable with total output in 1941 or prior years, what of total output since? While industry is on a war basis, an index that comprehends at least the greater part of industrial production is theoretically conceivable, though the question whether data adequate to compute it are available is worth serious consideration. On the other hand, once the war is ended, there will presumably be another and opposite transformation in the character of output, during which it will again be difficult to measure changes in the total. However, so far as the goods produced in that future peacetime economy resemble those of pre-war days (and some say the resemblance will be slight!), it will be possible to compute indexes of 'total' output that span the war, such as those Fabricant computed for 1914 and 1919.

We contemplate, then, two indexes of total industrial production: a *wartime* index that begins when conversion of industry to war production has been substantially completed and ends when reconversion begins to be important, and a *peacetime* index that omits the period covered by the wartime index and also the accompanying periods of conversion and reconversion. As to the probable behavior of these indexes we can offer only some highly tentative observations. The divergence between the Federal Reserve index excluding man-hours series and the total Federal Reserve index continues after the middle of 1942. Which, if either, corresponds to our hypothetical index of wartime industrial production? The validity of the increases registered by the manhours series after mid-1942 is still open to question, since considerable uncertainty attaches to the productivity indexes. Some rise, in any event, in the manhours series as a whole is indicated by the fact that war output continued to expand, though not so rapidly as before (the WPB munitions index rose 75% from July 1942 to July 1943, as compared with 430% from July 1941 to July 1942). Another vexing question concerning the manhours series after mid-1942 is their weights. So far as their increases up to that time are arbitrary or meaningless, so also are their weights as of that date. It is reasonable to suppose, however, that a revision of the weights

[32] Cf. Division of Information, War Production Board, 'War Production in 1942', pp. 12-3.

would not greatly affect the relations between the manhours and other series in the index, and that their combination would register an increase after the middle of 1942. If some index of construction activity were included, the increase would certainly be reduced (cf. Table 14). Hence the rise in this hypothetical index of industrial production after the summer of 1942 might be smaller or larger than the actual increase registered by the Federal Reserve index (15% from July 1942 to July 1943), but it would probably exceed the negligible change recorded by the index excluding the manhours series. The rise would probably not continue beyond 1943, for the Federal Reserve index is showing signs of nearing a peak.[88]

As for a comparison that spans the war, it seems that unless there is a revolutionary change in the composition of peacetime output, involving a greater proportion of goods requiring much labor relative to materials, our hypothetical peacetime index of industrial production should correspond rather closely to an index based on materials output. Such a revolution may well be in process; but if not, the implication is that after the war the Federal Reserve index will resume its prewar position relative to materials output, and that total manhours of industrial employment will do likewise. Such a realignment might come about through a decline in the Federal Reserve index and in total manhours, or by a rise in the output of industrial

[88] The recently revised Federal Reserve index (cf. note 4) exhibits this tendency less clearly. The new index rises more rapidly than the old, especially after 1941, and while a leveling off after February 1943 is perceptible in the old index it is scarcely visible in the new.

New Federal Reserve Index

	1939	*1940*	*1941*	*1942*	*July 1943 (seas. adj.)*
1935-39:100	109	125	162	199	239
1939:100	100	115	149	183	219

These alterations were brought about largely by the revision of the old manhours series and the addition of several new ones (in June 1943 series of this type received 58% of the weight in the new index, 50% in the old). The addition of 18.4 points (1935-39:100) to the 1942 average of the new as compared with the old index is accounted for as follows:

1) Revision of old manhours series: 15.0 points
2) Addition of new manhours series: 1.8 points
3) Revision of other series: 1.6 points

As in the old index, many of the manhours series are based on annual (sometimes quarterly) production indexes; that is, in many cases the monthly figures on manhours are used merely to interpolate (or extrapolate) production data. Apparently the use of actual physical production data for this purpose was considerably extended and the reliability of the productivity estimates thereby enhanced. Our comments on the measurement of the output of converted industries and the effect of these measurements on the total index apply, however, to both the new and the old version.

materials, or by other compensating changes. While it would be interesting to speculate on the likelihood of the various possibilities, it cannot be done in this paper.[84]

[84] It is dangerous in this connection to point to our experience after World War I, if for no other reason than that, since there are no comprehensive data on manhours during the first war, we do not know whether such data would indicate a 'gap' similar to that which has now developed between manhours and materials output. We do know, however, that: (1) the rises between 1914 and 1919 in our materials production index and in the more comprehensive Fabricant-Barger index of mining and manufacturing are nearly identical (19 and 20%, respectively); (2) the rise between 1914 and 1919 in Fabricant's index of manhours of wage earner employment in manufacturing is almost the same (21%; cf. Solomon Fabricant, *ibid.*, p. 331); and (3) our index of materials output declined 6% from 1918 to 1919.