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Employment and Output in the Natural Resource Industries, 1870–1955

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RESOURCES FOR THE FUTURE, INC.

INPUT and output in the resource industries are of interest from several points of view. Malthusians with an analytical turn of mind might look for falling productivity in this area of the economy as a measure of overpopulation and a forecast of calamity. Much popular opinion attaches this kind of significance to resources problems. Economists regard the resource area as one of inelastic demands or necessities. They note that it is subject to violent fluctuations as a result of business cycles, and there is a view that these industries are basic. Legislators look at resources as a measure of the nation's self-sufficiency, power, and prosperity. It is partly for this reason that these industries furnish a springboard for numerous subsidy schemes.

This paper does not address these policy problems. It represents, rather, part of an attempt to measure trends in labor input and output in the extractive sector of the economy, over the eighty-five year period from 1870 to 1955. Thus it ranges from the days of free land and virtually untapped minerals to the present era. It is part of a larger study[1] in which the authors have gathered data providing economic measures of the extractive sector of the economy: its prices, outputs, imports and exports, domestic consumption and employment.

In this enterprise we have of course been dependent on a multiplicity of sources. Very few studies or sources of data cover so long a time span. This has forced us to splice series which are frequently independent and unconnected. We have checked for consistency of movements in the different series, where overlap presented this possibility. We have found a gratifying number of cases of apparent consistency, nearly as many as in the supposedly continuous series.

Output

Tables 1 and 2 show our estimates of output in the extractive sector of the economy and its principal subsectors, with indexes of manufacturing output and GNP as scales for comparison.

[1] *U.S. Natural Resource Statistics, 1870–1955: Measures of Price, Output, Foreign Trade, Consumption, Employment, and Productivity*, a forthcoming study to be published by Resources for the Future, Inc. We wish to acknowledge many helpful suggestions and criticisms from our colleagues, particularly Harold J. Barnett, who has given general supervision to the study during its two and a half years of preparation.

TABLE 1

Output of Resource Industries (billions of dollars, in 1954 prices)

	Agriculture	Timber	Mining	Fish, Fuel-wood, and Waterpower	All Extractive	GNP
1869		.84				
1870	5.8		.33		7.6	19
1871	5.9		.41		7.8	19
1872	6.2		.46		8.1	24
1873	6.2		.52		8.3	24
1874	6.2		.49		8.3	24
1875	6.8		.48		8.8	24
1876	7.1		.51		9.3	26
1877	8.0		.59		10.2	28
1878	8.3		.58		10.6	29
1879	8.6	1.19	.68		11.0	32
1880	9.1		.71	.60	11.6	36
1881	8.1		.81	.58	10.8	37
1882	9.4		.95	.58	12.4	39
1883	9.2		1.01	.57	12.2	39
1884	9.9		1.04	.56	13.0	41
1885	9.8		1.01	.56	12.8	41
1886	9.8		1.08	.54	13.0	44
1887	9.6		1.21	.53	13.1	45
1888	10.3		1.36	.54	13.9	44
1889	10.8	1.78	1.35	.55	14.5	46
1890	10.3		1.49	.55	14.1	50
1891	11.5		1.59	.54	15.5	52
1892	10.1		1.67	.54	14.2	57
1893	10.2		1.64	.52	14.4	54
1894	10.5		1.57	.51	14.7	53
1895	11.4		1.77	.51	15.8	53
1896	12.2		1.80	.50	16.7	59
1897	13.1		1.86	.49	17.6	63
1898	13.8		1.99	.49	18.6	65
1899	13.7	2.32	2.25	.48	18.8	71
1900	13.8	2.78	2.40	.48	19.5	72
1901	13.4	2.84	2.58	.48	19.3	81
1902	14.0	2.86	2.64	.49	20.0	82
1903	13.9	2.86	3.10	.48	20.3	86
1904	14.6	2.86	3.11	.47	21.0	85
1905	14.6	2.87	3.54	.46	21.5	91
1906	15.5	3.02	3.65	.47	22.6	101
1907	14.4	3.06	4.18	.47	22.1	103
1908	15.0	2.80	3.78	.47	22.0	95
1909	14.8	2.98	4.20	.48	22.5	104
1910	15.5	2.98	4.54	.48	23.5	107
1911	15.0	2.84	4.49	.48	22.8	110
1912	16.8	2.97	4.78	.49	25.0	116

(TABLE 1 concluded)

Output of Resource Industries (billions of dollars, in 1954 prices)

	Agriculture	Timber	Mining	Fish, Fuel-wood, and Waterpower	All Extractive	GNP
1913	15.2	2.94	5.11	.49	23.7	117
1914	16.8	2.73	4.74	.50	24.8	112
1915	17.3	2.57	5.0	.51	25.4	111
1916	15.7	2.72	5.7	.51	24.6	120
1917	16.5	2.51	6.1	.52	25.6	120
1918	16.8	2.30	6.2	.52	25.8	133
1919	16.8	2.43	5.3	.52	25.1	133
1920	17.8	2.46	6.1	.52	26.9	126
1921	15.7	2.09	4.9	.51	23.2	115
1922	17.3	2.38	5.2	.50	25.4	133
1923	17.5	2.65	7.1	.51	27.8	149
1924	17.3	2.56	6.6	.52	27.0	149
1925	17.8	2.61	6.9	.54	27.8	162
1926	18.5	2.53	7.4	.55	29.0	171
1927	18.3	2.44	7.5	.58	28.8	170
1928	19.0	2.42	7.4	.61	29.4	172
1929	18.8	2.56	8.1	.65	30.1	182
1930	18.3	1.95	7.1	.62	28.0	165
1931	20.1	1.45	5.9	.56	28.0	153
1932	19.3	1.07	4.8	.55	25.7	130
1933	17.8	1.24	5.3	.59	24.9	127
1934	15.2	1.35	5.7	.67	22.9	138
1935	18.3	1.61	6.1	.72	26.7	153
1936	16.5	1.87	7.2	.73	26.3	173
1937	20.8	1.95	8.0	.72	31.5	183
1938	20.1	1.72	6.8	.72	29.3	175
1939	20.3	1.94	7.6	.74	30.6	189
1940	21.1	2.06	8.4	.74	32.3	206
1941	21.8	2.32	9.2	.79	34.1	238
1942	24.4	2.34	9.8	.79	37.3	267
1943	23.9	2.22	10.0	.86	37.0	297
1944	24.6	2.17	10.5	.89	38.2	318
1945	24.4	1.91	10.2	.91	37.4	314
1946	24.9	2.22	10.0	.88	38.0	282
1947	24.1	2.32	11.2	.88	38.5	282
1948	26.4	2.40	11.7	.92	41.4	293
1949	25.7	2.12	10.2	.97	39.0	293
1950	25.4	2.46	11.3	1.01	40.2	318
1951	26.2	2.51	12.5	.99	42.2	342
1952	27.2	2.51	12.3	1.00	43.0	353
1953	27.4	2.51	12.5	1.01	43.4	369
1954	27.4	2.50	12.1	.99	43.0	363
1955	28.4	2.72	13·1	1·06	45·2	393

Source: See Table 2.

TABLE 2
Output Indexes, 1947–49 = 100

	Agriculture	Timber	Mining	All Extractive	Manufac-turing	GNP in 1954 prices
1870	23	(37)	3.0	19	3.8	6.6
1871	23		3.7	20	4.1	6.6
1872	24		4.1	21	5.0	8.3
1873	25		4.7	21	4.9	8.3
1874	24		4.5	21	4.8	8.3
1875	27		4.4	22	4.6	8.3
1876	28		4.6	24	4.6	9.0
1877	32		5.4	26	5.2	9.7
1878	32		5.3	27	5.5	10.0
1879	34	52	6.2	28	5.9	11.1
1880	36		6.5	29	7.4	12.4
1881	32		7.4	27	7.5	12.8
1882	37		8.6	31	8.5	13.5
1883	36		9.2	31	8.4	13.5
1884	39		9.4	33	8.4	14.2
1885	38		9.1	32	8.1	14.2
1886	39		9.8	33	9.7	15.2
1887	38		11.0	33	10.0	15.6
1888	40		12.3	35	10.2	15.2
1889	42	78	12.3	37	11.4	15.9
1890	41		13.5	36	12.1	17.3
1891	45		14.4	39	13.3	18.0
1892	40		15.1	36	13.3	19.7
1893	40		14.8	36	11.8	18.7
1894	41		14.2	37	11.6	18.3
1895	45		16.1	40	14.1	18.3
1896	48		16.4	42	12.9	20.4
1897	52		16.9	44	14.5	21.8
1898	54		18.0	47	15.7	22.5
1899	54	102	20.4	48	16.0	24.5
1900	54	122	21.7	49	16.3	25
1901	53	125	23.4	49	18.4	28
1902	55	125	23.9	51	20.6	28
1903	55	126	28.1	51	21.1	30
1904	58	125	28.2	53	19.8	29
1905	58	126	32.1	54	23.7	31
1906	61	132	33.1	57	25.4	35
1907	57	134	37.9	56	25.7	36
1908	59	123	34.2	56	21.3	33
1909	58	131	38.1	57	25.2	36
1910	61	130	41.1	59	26.8	37
1911	59	125	40.7	58	25.7	38
1912	66	130	43.3	63	29.6	40
1913	60	129	46.3	60	31.6	40
1914	66	120	42.9	63	29.7	39

(TABLE 2 concluded)
Output Indexes, 1947–49 = 100

	Agriculture	Timber	Mining	All Extractive	Manufac-turing	GNP in 1954 prices
1915	68	113	46	64	35	38
1916	62	119	52	62	41	41
1917	65	110	55	65	41	42
1918	66	101	56	65	41	46
1919	66	106	48	63	38	46
1920	70	108	55	68	39	44
1921	62	92	44	59	30	40
1922	68	104	47	64	39	46
1923	69	116	65	70	45	52
1924	68	112	60	68	43	51
1925	70	114	62	70	48	56
1926	73	111	67	73	50	59
1927	72	107	68	73	50	59
1928	75	106	67	74	52	59
1929	74	112	73	76	58	63
1930	72	86	64	71	48	57
1931	79	64	54	71	39	53
1932	76	47	44	65	30	45
1933	70	55	48	63	36	44
1934	60	59	51	58	39	48
1935	72	71	55	67	46	53
1936	65	82	65	66	55	60
1937	82	86	73	80	60	63
1938	79	76	62	74	46	60
1939	80	85	69	77	57	65
1940	83	90	76	82	66	71
1941	86	102	83	86	88	82
1942	96	103	89	94	110	92
1943	94	98	91	93	133	103
1944	97	95	95	97	130	110
1945	96	84	92	94	110	109
1946	98	97	90	96	90	98
1947	95	102	102	97	100	98
1948	104	105	106	105	103	101
1949	101	93	92	99	97	101
1950	100	108	103	102	113	110
1951	103	110	113	107	121	118
1952	107	110	111	109	125	122
1953	108	110	114	110	136	128
1954	108	110	109	109	127	125
1955	112	119	119	114	140	136

Sources: The general nature of our sources for the extractive output data are given in the text. For detailed sources, see the authors' forthcoming study, *U.S. Natural Resource Statistics, 1870–1955.*

The manufacturing output index was prepared by linking Warren Person's index *Forecasting Business Cycles* to Solomon Fabricant's index *Output of Manufacturing Industries, 1899–1937*, and this to the Federal Reserve Board Index. Overlap periods were, of course, compared. The dates of linkage chosen were 1899–1909 and 1919–29.

The Gross National Product estimates are those of the Department of Commerce for 1909–55. To this were linked tentative estimates prepared by the authors, with the aid of preliminary estimates made available by Simon Kuznets and John W. Kendrick, to whom we make grateful acknowledgement. They should not be charged with any errors which appear, however, as we have made a number of changes.

Most noteworthy is the relative decline in the extractive industries (except for mining) since the 1870's. While real GNP expanded nearly sixteen times from 1870 to 1955, the extractive industries expanded five and a half times. In terms of output in 1954 prices, this means that the extractive industries dropped from producing about one-third of GNP to only 12 per cent. As can be seen from Chart 1 and the indexes in Table 2, the greatest decline is in forestry, with fishing, etc., next in order of decline (though the data here are quite thin), and agriculture a strong third. Output in mining, on the other hand, rose as a percentage of GNP.

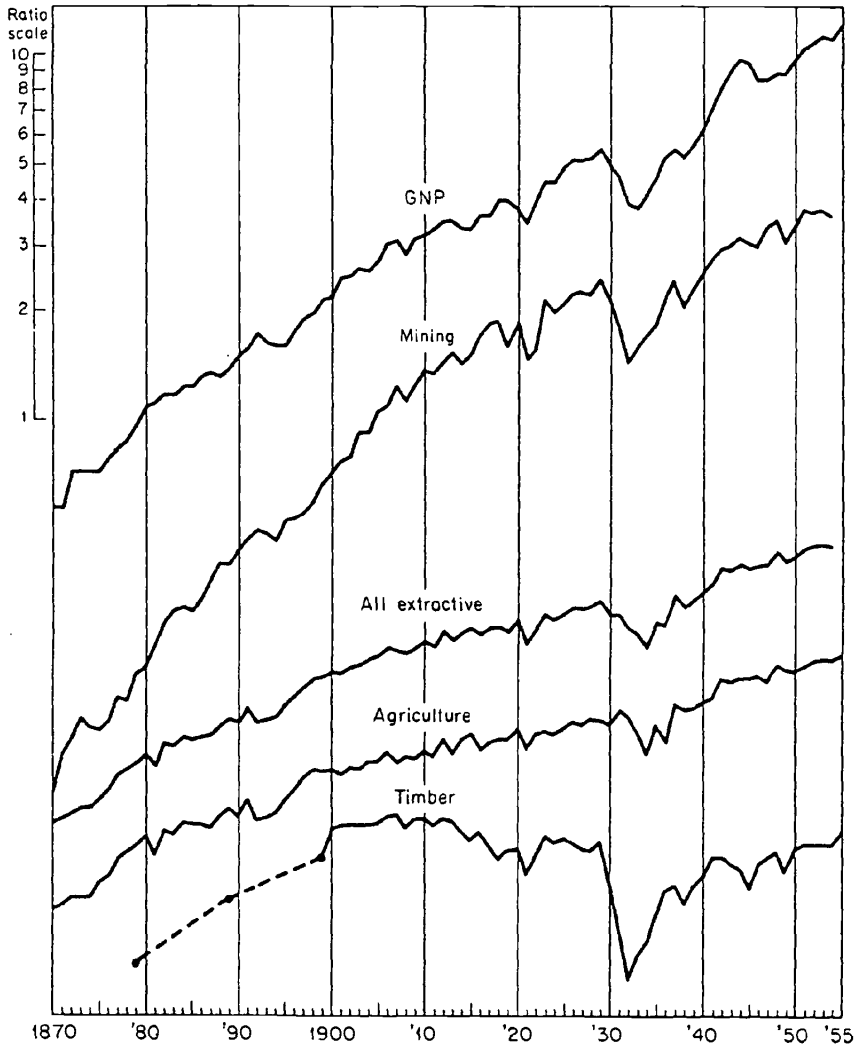
These data reflect the familiar fact that manufacturing, trade, and service activities have increased more than real GNP, while consumer nondurable goods have increased less. Food and fiber output have risen approximately in proportion to population, and these cover the bulk of farming and fishing. Farm output has risen to four and a half times its level of the early 1870's, while population has risen to four times its level in that period. Timber output appears to have risen to only about three times its 1870 level.

Additional insight may be gained by observing the timing of the movements (see Chart 1). Agricultural output has risen very nearly in step with population all the way. Timber output, however, rose a good deal more rapidly than population until 1900, apparently as fast as GNP. Since 1900 there have been no important short-term increases in timber output, while there have been some important declines; there may be a down trend. The decline of timber relative to real GNP and the other extractive industries has thus been severe, from 4 per cent of the GNP down to less than 1 per cent (in 1954 prices).

The growth of mining output up to 1900 was even more rapid than output of timber, manufacturing, or real GNP. In 1954 prices, mining output was only 1.5 per cent of GNP in 1870, but it had grown to 3.5 per cent by 1900. Mining continued to grow more rapidly than GNP until World War I. It held its peak in the 1920's, and has since shown a moderate decline relative to GNP. The present mining/real GNP relationship is the same as in 1900.

The all-extractive output index is constructed by combining the

CHART 1
Output: Extractive Industries and GNP



indexes of output in the separate sectors, with weights proportioned to values of output in 1954. How suitable for the economic concept of extraction are these weights? Is agriculture overweighted because the commodities it produces are more nearly finished than iron ore or crude oil? Or is agriculture underweighted because we have used value of output rather than employment as our weighting factor? Are sawlogs or finished lumber more comparable to threshed wheat and shipped milk? Does monopolistic pricing in one field overweigh that field relative to the others?

These philosophical questions probably have no answer, but the following table shows that the value weights we have chosen give about three times as great a relative weight to minerals and timber as would employment weights. As a result, the index shows a greater rise for all-extractive output than would an employment-weighted index.

	Percentage of Total Weight in 1954	
	By Value	*By Employment*
Agriculture	64	86
Timber	6	2
Minerals	28	10
Other	2	2
All Extractive	100	100

The combined index of output of all resources follows very closely that of Spencer and Wardwell[2] for the overlap period, 1900–52, with the exception of 1934, where they seem to have made less allowance for a drop in agricultural output than any of our sources show.

In agriculture the index was constructed by splicing the Strauss and Bean index of farm production[3] for 1870–1909 to that of the Department of Agriculture's Agricultural Research Service for 1910–55. This means that the weighting system is a combination of current year and 1910–13 prices for the period 1870–1909; 1935–39 prices for the period 1910–39; and 1947–49 prices for 1940–55. The 1910–37 period of overlap between the Strauss and Bean and the ARS indexes shows very close correspondence between the two, with no discernible difference in trend. The series of Barger and Landsberg,[4] however, computed as a linked series with the use of the Edgeworth formula (weighted by the average of base-year and given-year prices) shows a trend that declines slightly relative to our spliced Strauss and Bean-ARS series.

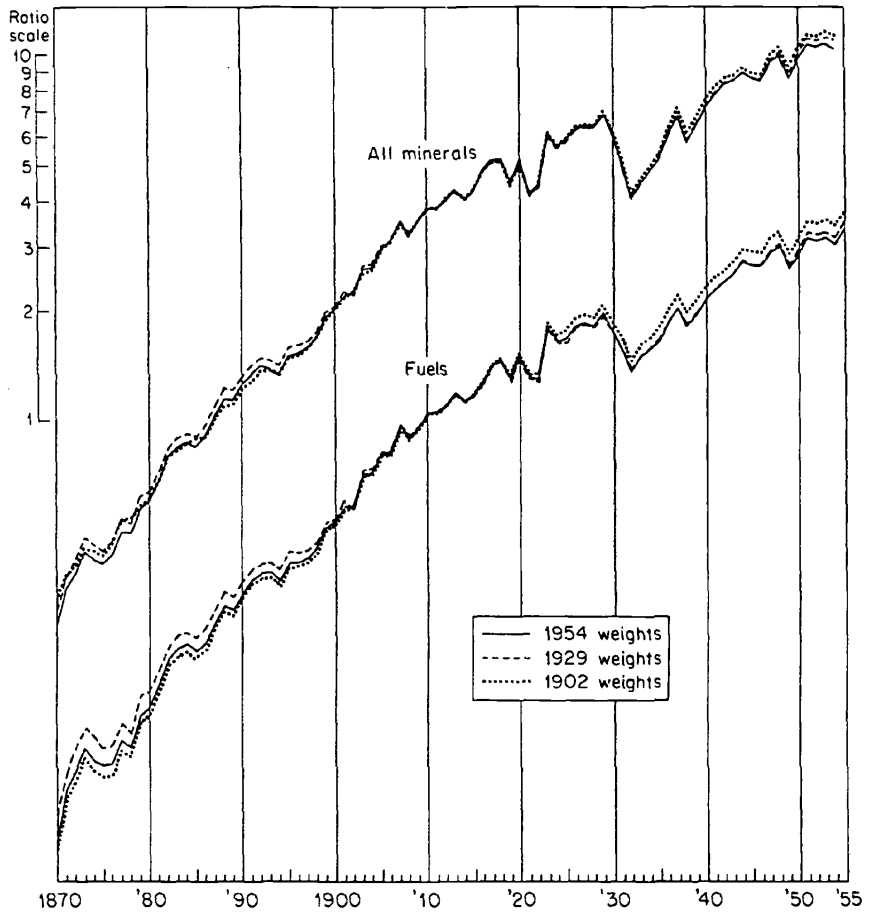
The timber series is our own sum of the estimated output of lumber, pulpwood, veneer logs, and other wood products (except fuel wood), each multiplied by an approximate average 1954 price for logs of each category. Extrapolation by the lumber series was necessary

[2] Vivian Eberle Spencer and Charles A. R. Wardwell, *Raw Materials in the United States Economy, 1900–1952* (Bureau of the Census, 1954: processed), p. 72.

[3] Frederick Strauss and Louis H. Bean, *Gross Farm Income and Indices of Farm Production and Prices in the United States, 1869–1937*, Table 60. We have used the index computed according to Irving Fisher's "ideal" index, which is the index favored by the authors; it uses a geometric mean of indexes computed with base period weights and with current year weights—that is, it is a geometric mean of a Laspeyres Index and a Paasche Index.

[4] Harold Barger and Hans H. Landsberg, *American Agriculture, 1899–1939: A Study of Output, Employment, and Productivity*, National Bureau of Economic Research, 1942, Table 5.

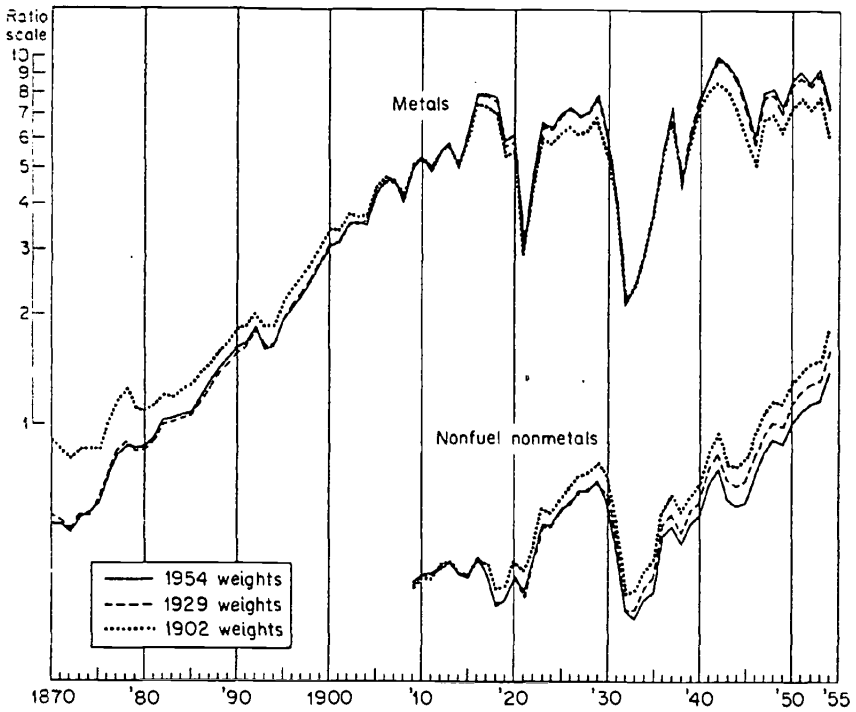
CHART 2
Output Indexes with Alternative Weights: All Minerals and Fuels



to extend the Forest Service series for miscellaneous wood products to years before 1899. This is a considerable deficiency, as these products are estimated at about 25 per cent of all timber output in 1899, and may have varied considerably relative to lumber over the thirty-year period. Pulpwood and veneer logs must also be handled by extrapolation before 1899. This appears to be a minor matter, as large uses of pulp and plywood did not appear until later.

The minerals index is a weighted sum of the physical output of all the significant minerals produced, accounting for about 97 per cent of all employment in mining as given in the 1954 Census of Mineral Industries. (The principal omissions are the uranium group, unimportant before World War II, and some minor nonmetals.) The weights are as near as we could come to the 1954 value of each

CHART 3
Output Indexes with Alternative Weights: Metals and Nonfuel Nonmetals



mineral at the mine or concentrator (or well, pit, etc.), according to the Census concepts.

How reliable is this minerals index? Is the single set of 1954 price weights, applied to the entire period 1870–1955, adequate to picture the movements of real output? The answer to this index-number problem depends on our objectives. Do we want to know what the rate of growth was in terms of present-day values, or in terms of the values of some "normal" period like 1926, 1935–39, or 1947–49?

The problem may be a minor one relative to our general conclusions, mainly because there is so much similarity of growth in output among the minerals. We have computed indexes for all minerals and the major sectors with 1902, 1929, and 1954 price-weights;[5] the results are shown in Charts 2 and 3.

The all-minerals indexes nearly coincide over the whole eighty-five-year period. The maximum difference is between the 1902-weighted

[5] These years were chosen because there is a Mineral Census for each of them. In fuels, the data were taken from the Minerals Yearbook, as Census did not cover oil and gas in 1929; the differences were very small in years where both Bureaus had coverage. For natural gas in 1902, an estimate of value at wells had to be made, as *Mineral Resources* gave only value at point of consumption.

index and the 1954-weighted index; the difference (see Chart 2) is that of a 4.3 per cent (with 1902 weights) and a 4.4 per cent annual increase. The fuels indexes are separated slightly more, with a maximum difference of 4.8 per cent annual growth (1902 weights) *versus* 4.5 per cent. For metals, the 1929-weighted index is almost identical in movement to that with 1954 weights (Chart 3); with 1902 weights, however, the index rises less rapidly. [6]

In the nonmetals, data are too skimpy prior to 1902 to warrant comparisons of this sort. For the 1902–54 period, however, we note (Chart 3) that the 1929- and 1954-weighted indexes are closely parallel. The 1902-weighted index rises faster, with a 4.6 per cent annual rate of growth for the fifty-two-year period, as against 3.6 per cent per year for the 1954-weighted index.

When we compare the present minerals index (with 1954 weights) with indexes computed by others (Y. S. Leong, Bureau of Mines, Barger and Schurr, Federal Reserve Board, Paley Commission), we find differences which are generally small (less than 5 per cent) over the whole span of years in which the indexes overlap. There is, however, a tendency for our series to run higher than the others for the period 1899–1921. Individual pairs of years may show differences considerably larger than 5 per cent.

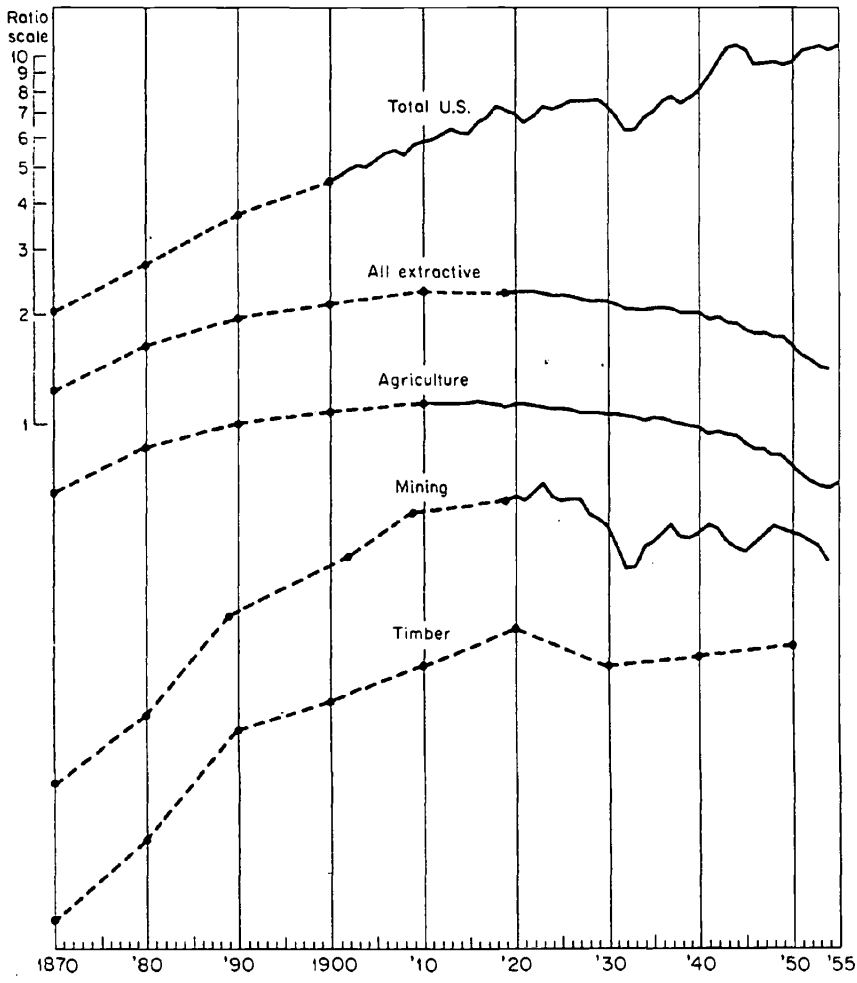
Employment

Indexes of labor input or employment are presented in Tables 3 and 4 and in Chart 4. It is apparent that the extractive industries have declined as employers relative to the national total. In the early 1870's they used about 55 per cent of all labor; in the early 1950's they used only about 15 per cent. The greatest relative decline was in agriculture, which also was and is the largest sector of the extractive industries. The absolute increase in agricultural employment over the eighty-five years was less than 10 per cent, while the national total of employment rose over 300 per cent, mining employment about 500 per cent, and timber perhaps 400 per cent.

Agriculture has declined relative to the national total almost continuously since 1870. An absolute decline in agricultural employment started after World War I and has continued practically without interruption, accelerating after 1945. Mining increased its share of

[6] This is chiefly because gold (whose output actually *decreased* over the period) is assigned a relatively heavier weight by 1902 prices, while iron and copper (the large growing items) are assigned relatively lighter weights. It will be noted from Chart 3, however, that a large part of the difference is in the period 1870–90. If we start with 1890, we find only a moderate divergence: with 1902 weights, the rise is 1.9 per cent per year; with 1954 weights, it is 2.4 per cent per year.

CHART 4
Employment: Extractive Industries and Total U.S.



the national total of employment from 1870 to 1920, then started an absolute as well as relative decline which almost parallels that of agriculture. Logging employment rose relative to the national total until 1920 and has declined a little absolutely (and a great deal relatively) since that time. The result of these changes is that agricultural employment declined from 95 per cent of the extractive total to eighty-five per cent, while mining rose from less than 3 per cent to over 10 per cent.

In preparing these indexes, we sought measures of employment which would properly represent the trends of real labor inputs required to produce the output of each industry. This ideal is, of

TABLE 3

Employment in Resource Industries (millions)

	Agriculture	Timber	Mining	Fishing	All Extractive	Manufac-turing	Total U.S.
1869						2.1	
1870	6.3	.03	.19	.04	6.6		12.6
1879						2.9	
1880	8.4	.05	.30	.05	8.8		17.0
1889			.56			4.0	
1890	9.8	.10		.08	10.5		23.1
1900	10.5	.12		.09	11.5	5.4	28.4
1901						5.7	29.7
1902			.81			6.2	30.9
1903						6.4	31.6
1904						6.1	31.5
1905						6.6	32.8
1906						7.1	34.2
1907						7.2	34.8
1908						6.5	33.9
1909			1.07			7.5	35.9
1910	11.1	.15		.09	12.4	7.7	36.5
1911	11.1					7.7	37.0
1912	11.1					8.2	38.2
1913	11.1					8.6	39.4
1914	11.1					8.1	38.7
1915	11.1					8.1	38.6
1916	11.2					9.5	41.2
1917	11.1					9.7	42.3
1918	11.0					10.0	45.5
1919	10.8		1.15		12.3	10.5	44.4
1920	11.0	.19	1.18	.07	12.4	10.5	43.6
1921	11.0		1.15		12.4	8.1	41.2
1922	10.9		1.21	.07	12.4	9.0	42.9
1923	10.8		1.28	.07	12.3	10.2	45.4
1924	10.7		1.18	.08	12.1	9.5	44.8
1925	10.7		1.15	.08	12.1	9.8	45.7
1926	10.6		1.16	.09	12.0	10.0	47.0
1927	10.4		1.16	.10	11.8	9.8	47.0
1928	10.4		1.06	.10	11.7	9.8	47.3
1929	10.4		1.03	.10	11.7	10.5	47.7
1930	10.3	.15	.98	.10	11.6	9.4	45.7
1931	10.3		.87	.10	11.4	8.0	42.6
1932	10.2		.75	.09	11.1	6.8	39.1

(TABLE 3 concluded)

Employment in Resource Industries (millions)

	Agriculture	Timber	Mining	Fishing	All Extractive	Manufac-turing	Total U.S.
1933	10.1		.76	.10	11.1	7.3	39.4
1934	9.9		.86	.10	11.0	8.3	42.5
1935	10.1		.89	.10	11.2	8.9	44.1
1936	10.0		.94	.10	11.2	9.7	47.1
1937	9.8		.99	.10	11.1	10.6	48.4
1938	9.7		.92	.10	10.8	9.3	46.7
1939	9.6		.91	.10	10.8	10.1	48.2
1940	9.5	.16	.95	.10	10.8	10.8	50.2
1941	9.1		.99	.09	10.3	13.0	54.2
1942	9.2		.97	.09	10.5	15.1	59.7
1943	9.1		.89	.09	10.2	17.4	65.4
1944	9.0		.86	.10	10.1	17.1	66.6
1945	8.6		.84	.12	9.7	15.3	64.7
1946	8.3		.89	.14	9.5	14.5	58.9
1947	8.3		.94	.14	9.5	15.3	59.1
1948	8.0		.98	.14	9.3	15.3	59.8
1949	8.0		.96	.14	9.3	14.2	58.7
1950	7.5	.17	.94	.13	8.8	15.0	60.0
1951	7.1		.93	.12	8.3	16.1	64.0
1952	6.8		.90	.12	8.0	16.3	65.2
1953	6.6		.87	.12	7.7	17.2	66.0
1954	6.5		.79	.12	7.6	16.0	64.3
1955	6.7		.80	.12	7.8	16.6	66.1

Source: See Table 4.

TABLE 4

Indexes of Employment in Resource Industries

(1947–49 = 100)

	Agriculture	Timber	Mining	Fishing	All Extractive	Manufac-turing	Total U.S.
1870	78	18	20	29	70	15[a]	21
1879						19	
1880	104	29	31	36	94		29
1889			58			27	
1890	121	59		58	112	28	39
1900	129	71		66	123	36	48
1901						38	50
1902			84			42	52
1903						43	53
1904						42	53

(TABLE 4 continued)

Indexes of Employment in Resource Industries

(1947–49 = 100)

	Agriculture	Timber	Mining	Fishing	All Extractive	Manufac-turing	Total U.S.
1905						45	55
1906						48	58
1907						48	59
1908						44	57
1909			111			50	61
1910	137	88		66	132	52	62
1911	137					52	63
1912	137					55	65
1913	137					58	67
1914	137					54	65
1915	138					54	65
1916	138					64	70
1917	137					65	71
1918	136					67	77
1919	134		120		131	71	75
1920	136	112	123	51	132	71	74
1921	136		120		132	54	70
1922	135		126	49	132	60	72
1923	133		133	52	131	68	77
1924	132		123	56	129	64	76
1925	132		120	61	129	66	77
1926	131		121	68	128	67	79
1927	128		121	75	126	66	79
1928	128		110	72	125	66	80
1929	129		107	73	125	71	81
1930	128	88	102	71	124	63	77
1931	127		91	71	122	54	72
1932	126		78	67	118	46	66
1933	125		79	69	118	49	67
1934	122		90	72	117	56	72
1935	125		93	74	120	60	74
1936	124		98	74	120	65	80
1937	121		103	74	118	71	82
1938	120		96	75	115	62	79
1939	119		95	76	115	68	81
1940	118	94	99	72	115	72	85
1941	112		103	68	110	87	92
1942	114		101	63	112	101	101
1943	112		93	68	109	116	110
1944	111		90	71	108	115	113
1945	106		88	86	103	102	109
1946	103		93	103	101	97	99

(TABLE 4 concluded)

Indexes of Employment in Resource Industries
(1947–49 = 100)

	Agriculture	Timber	Mining	Fishing	All Extractive	Manufacturing	Total U.S.
1947	102		98	101	101	102	100
1948	98		102	101	99	103	101
1949	99		100	98	99	95	99
1950	93	100	98	95	94	100	101
1951	87		97	91	89	108	108
1952	84		94	87	85	109	110
1953	81		91	89	82	116	111
1954	80		82	88	81	108	109
1955	83		83	88	83	111	112

[a] Calculated by interpolation.

Sources, Tables 3 and 4:

Agriculture: 1929–55, *Economic Report of the President, 1957*, p. 140 (sources, Department of Labor and Census' *Monthly Report on the Labor Force*); 1910–28, U.S. Department of Agriculture, Agricultural Marketing Service, *Farm Labor* bulletin, January 10, 1956, p. 9, linked to above series; 1870–1900, Daniel Carson, "Industrial Composition of Manpower," in *Studies in Income and Wealth*, Vol. XI, p. 47, based on Census of Population (Occupations), linked to above series.

Timber: The data cover logging only, as sawmills are engaged in manufacturing. Figures based on Census (Occupations).

Mining: These data are a summation of series we have gathered and spliced from a number of sources, principally Bureau of Mines, the *Census of Mineral Industries*, Bureau of Labor Statistics, Barger and Schurr's *The Mining Industries*, Department of Commerce National Income Division, and the WPA National Research Project. The concepts used are not always consistent with each other (see text). We have sought to get consistent indicators of the movement (rather than the level) of labor input required to produce fuels or ores ready for use or refining. We have tried to avoid inclusion of manufacturing operations but attempted to include all operations required to extract and prepare a commodity of uniform quality—metal ores ready for smelting, coal separated from slate, etc.

Fishing: Data from U.S. Fish and Wildlife Service, *Fishery Statistics of the U.S.*, linked to Census Occupation data for years prior to the 1920's. Since the ratio between the Census data and the Fish and Wildlife data is not very stable in the period of overlap (1930, 1940, 1950), the resulting series is only a rough approximation.

Manufacturing: A series prepared for us by Stanley Lebergott. He used Bureau of Labor Statistics *Employment and Payrolls* reports, extrapolated with adjusted Census of Population (Occupations) figures, and interpolated by unpublished estimates of Edwin Frickey.

Total U.S. Employment: 1929-55, Department of Commerce *National Income* figures, adjusted to use our figures on farm employment, since Commerce omits family labor; 1900–28, Sum of our agricultural employment, plus a series on nonfarm employees prepared for us by Stanley Lebergott, plus a series on nonfarm proprietors prepared by Alba Edwards for the 1940 *Census of Population*, plus a series on government prepared by John W. Kendrick, linked to above series; 1870–90, Daniel Carson's "Manpower" series, prepared from Census of Population (Occupations) data (in *Studies in Income and Wealth*, Vol. XI), linked to above series.

course, nowhere attainable over the whole eighty-five-year period, and we have used a variety of substitutes. In choosing substitutes, we put long-term consistency for each series above consistency of concept as between series (e.g., between agriculture and mining, or among mining industries).

WEIGHTING

The employment data are not "weighted," as we have followed the usual practice of simply adding all persons engaged in each industry. However, perhaps employment data should be weighted, as there are certainly qualitative differences among workers, between different classes of workers, and between industries. Much farm labor, for instance, is unskilled, casual, and juvenile, while mining and timber use large proportions of skilled adult males. If allowances for quality were made, the decline in extractive employment might be less than is shown in our figures, for farming would have a smaller relative weight, and its quality may be increasing relatively as well as absolutely.

CONSISTENCY

In data over a long period and as between industries, consistency is, of course, not attainable in any complete sense, as we have been forced to utilize different sources for different industries and different time-periods. Different agencies collect data by different questions and methods, and classify them differently. In mining, for example, the Bureau of Mines has collected data on workers subject to accident hazards, without regard to their wage or salary status, type of work, etc. The Census has collected data on "production and development workers" (called "wage earners" in earlier years), plus "other employees" and "proprietors." Since about 1913 the Bureau of Mines has separated men working in mills, smelters, and concentrators from those mining ores. Census makes this separation only for man-hours and only for 1939 and 1954. The Bureau of Mines averages employment for active periods, i.e., when the mine was open and operating. Census gets average employment over an entire twelve months, including periods of zero employment. Mines frequently includes Alaska, Hawaii, Puerto Rico, Canal Zone, etc., under "United States"; Census does not. The Department of Agriculture defines farm employment as working one hour or more per week on a farm. The Census Monthly Report on the Labor Force counts only those working a majority of their time on a farm.

Wherever we have been forced to use apparently inconsistent data in this way, we have attempted to appraise the different series and the

reasons for divergencies. We have also checked as long an overlap period as possible and made the link on an average basis, or at the point where there was nil or trivial difference.

DEFICIENCIES OF DATA

In agriculture and timber there are acute data problems which we would like to mention. Farmers are poor record-keepers, in any case. The problems of keeping adequate and meaningful records of labor input on the farm are enormous even when serious attention is given to them. Much of the labor is seasonal, migratory, or has irregular hours. Most important, a large portion is family labor, and it is often difficult to tell when people are merely living on a farm and when they are working on it. The efficiency of the labor varies over a very wide range, due to variations in skill, strength, energy, and intelligence. The problem is so serious that the Department of Commerce National Income Division excludes any allowance for family labor in its "persons engaged" figures.[7]

This problem, together with the insuperable problem of allocating labor input among the various crops and livestock products, leads the Department of Agriculture to discard its employment data when it comes to estimating productivity on the farm. The Agricultural Research Service estimates output-per-man-hour-equivalent ratios, which means they estimate the standard adult male labor it would have taken to produce the year's output, rather than the actual hours it did take.

Finally, farming presents the problem of the labor devoted to supplying services, food, etc., to the household, rather than to the market. This is still an important problem in the measurement of labor input required for agricultural output. In 1870 it was a much larger problem, for most farm households then supplied not only much of their food but also their own fuel and frequently housing, clothing, and refrigeration as well. We do not have data on the amount of labor that went into supporting these services, but we can be sure that the effect of our being unable to exclude it introduces a bias into our employment series. This overstates the decline in labor input to produce farm products and consequently the decline in labor cost per unit of such output.[8]

The timber employment data are perhaps even more subject to

[7] *National Income*, 1954 edition, Table 28, footnote 1.

[8] It is true that the farm output series include some products consumed on the farm as well as those sold; but numerous minor products and all services are excluded, and the excluded outputs must surely have declined, causing the above-mentioned bias.

error than those for agriculture. The difficulties are great; the labor used to "extract" the resource—that is, labor used to fell trees, and to bring logs and pulpwood to the mill—is customarily associated closely with manufacturing operations, principally sawmills. The sawmills generally use considerably more labor than is employed in logging operations, so that a small error in segregating workers hired by sawmill companies might produce an error of as much as 100 per cent in the estimates of logging labor. Moreover, lumber mills themselves have been handled in several ways in the different censuses. The basic sawing of the logs is closely associated with operations of trimming, planing, and further manufacture, and different questionnaires and classifications seem to have produced erratic results, as indicated for example by Fabricant's employment-to-output ratios in *Employment in Manufacturing* (p. 311). Thus there is no line of demarcation which is altogether satisfactory.

In the case of pulpwood, we have a material coming largely from unorganized small operators and farmers, so data on the cost of gathering this type of timber is rare or nonexistent.

EMPLOYMENT VS. MAN-HOURS

A note should be given on our reasons for presenting employment data but not man-hour data, commonly used as a measure of labor input. Estimates of man-hours usually require not only estimates of employment but also a series of hard-to-get estimates of hours per week or per year for each type of labor. Much of this data is of too low a degree of accuracy to provide any improvement in the measure of trend in labor input over that provided by our employment series.

In agriculture, in particular, there are extant the most widely divergent views or estimates of the average length of the workweek. The Twentieth Century Fund has estimated that the farm workweek rises as we go backward in time to something like sixty hours in 1910, while the Agricultural Research Service gives figures in connection with its productivity estimates which imply that the week on the farm has remained constant at a little under forty hours on the average. There is also considerable doubt whether man-hours on the whole are a better measure of labor input than is employment. There has been very great progress in the past eighty-five years in reducing the amount of idleness in a day's work and in increasing the time lost in commuting. Reductions in weekly hours have often been accompanied by a tightening-up of working procedures so as to get as much output from an eight-hour day as from a ten-hour day. (See Denison's paper in this conference.)

Labor Cost

In Table 5 and in Charts 5–12, we present the input-output or unit labor cost data. It is apparent that employment per unit of output (hereafter "labor cost" for short) in resource industries has fallen about as rapidly as in manufacturing and slightly more rapidly than in production of GNP. In view of the difficulties with the data, one should hesitate to say there has been a discernibly greater rate of increase in productivity in the resource industries than in the rest of the economy over the eighty-five-year period. It can certainly be said there has been no important lag.

We now look at the trends of labor cost in the subsectors and individual commodities of the resource industries.

TABLE 5

Indexes of Employment per Unit of Output

(1947–49 = 100)

	Agriculture	Timber	Mining	All Extractive	Manufacturing	GNP
1870	341	48	598	370	384	320
1879					329	
1880	291	58	446	320		230
1889			435		236	
1890	298	85		310	233	226
1900	238	63		250	222	192
1902			326		202	184
1909			271		200	169
1910	225	73		220	193	167
1911	232				202	164
1912	207				185	161
1913	228				183	165
1914	207				182	169
1915	203				155	170
1916	222				153	168
1917	211				158	172
1918	205				165	167
1919	203		233		186	163
1920	194	112	210	194	181	169
1921	219		257	225	182	175
1922	199		255	206	154	158
1923	193		197	186	151	149
1924	194		195	189	148	147

(TABLE 5 concluded)

Indexes of Employment per Unit of Output
(1947–49 = 100)

	Agriculture	Timber	Mining	All Extractive	Manufac-turing	GNP
1925	188		183	184	134	138
1926	180		172	175	134	134
1927	178		171	173	132	135
1928	172		158	168	126	134
1929	174		142	164	122	128
1930	178	111	155	175	131	135
1931	161		164	172	138	136
1932	165		175	182	152	147
1933	178		164	188	135	151
1934	204		173	203	143	150
1935	173		166	177	130	141
1936	190		148	180	118	133
1937	148		140	149	118	129
1938	152		153	152	135	130
1939	148		135	149	118	125
1940	142	114	127	141	109	119
1941	131		122	127	99	112
1942	119		111	119	92	109
1943	120		100	116	88	107
1944	114		93	111	88	102
1945	110		94	109	93	101
1946	105		101	105	108	102
1947	107		96	104	102	103
1948	95		96	95	100	100
1949	98		107	100	98	98
1950	93	100	95	92	89	92
1951	84		85	83	89	91
1952	79		84	78	88	90
1953	75		80	75	85	87
1954	74		75	75	84	86
1955	74		70	73	80	82

CHART 5. Employment per Unit of Output: GNP and Major Extractive Sectors (labor cost)

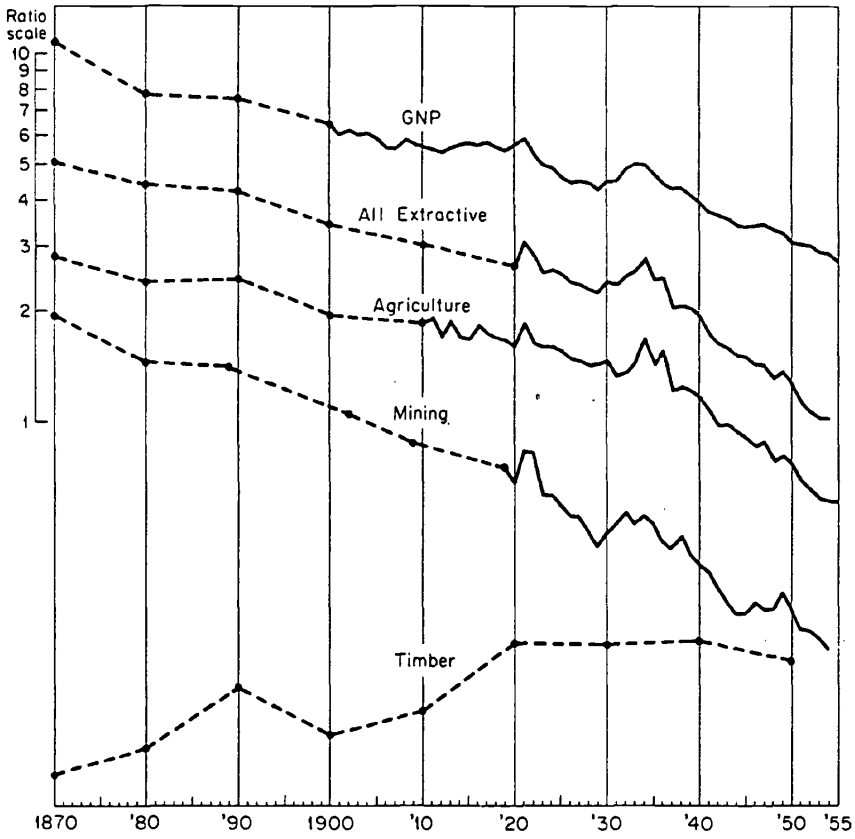


CHART 6. Agriculture and Sectors: Labor Cost

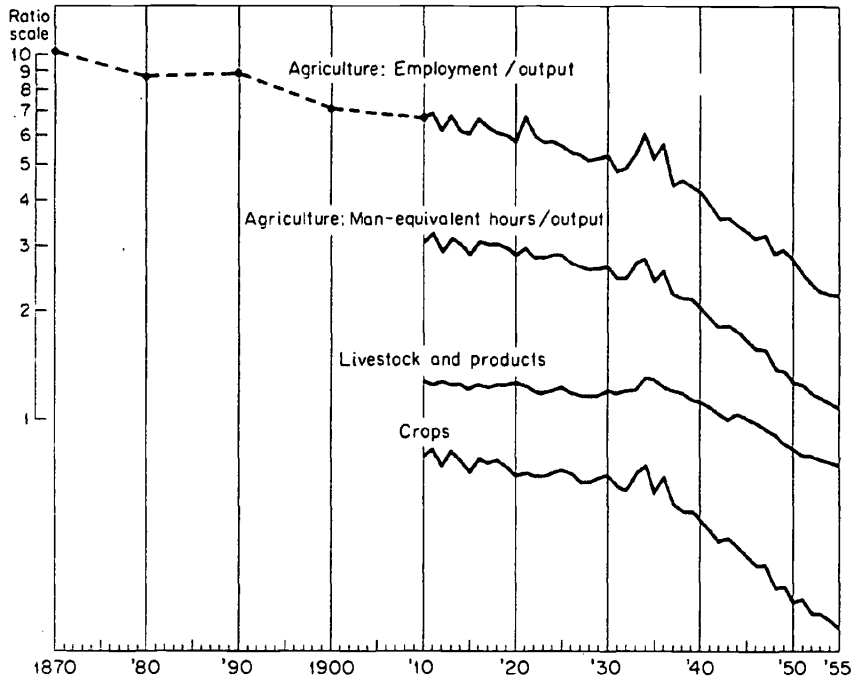


CHART 7. Crops: Labor Cost

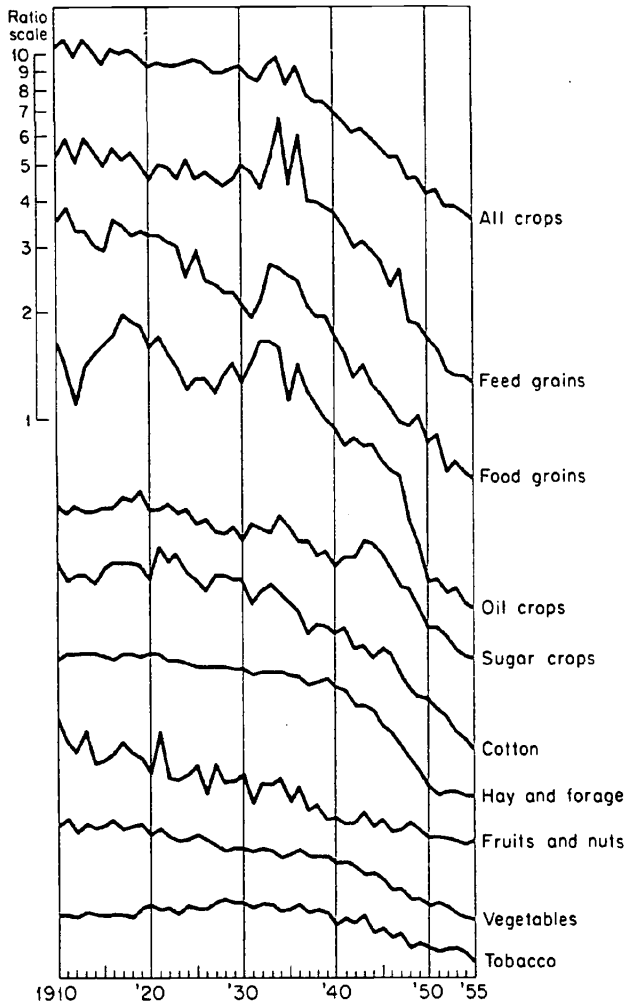


CHART 8. Livestock and Products: Labor Cost (1947–49 = 100)

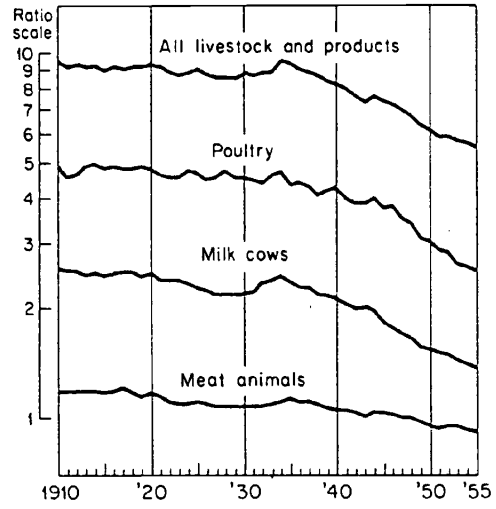


CHART 9
Employment per Unit of Output: Mineral Sectors

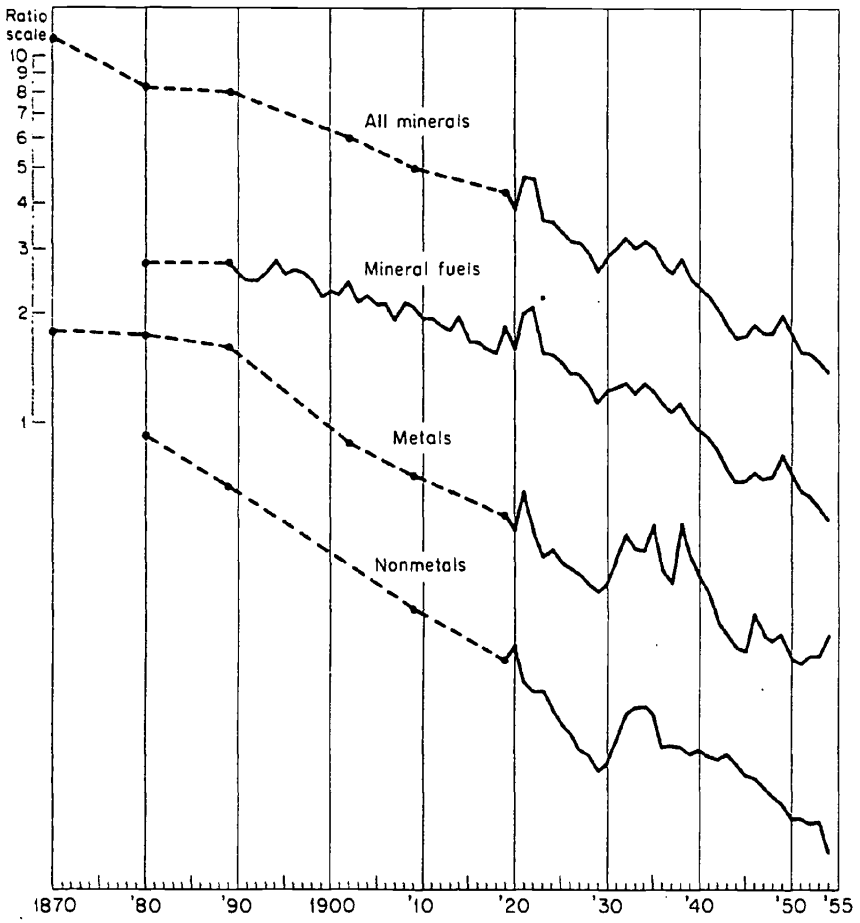


CHART 10
Mineral Fuels and Components: Labor Cost (1947–49 = 100)

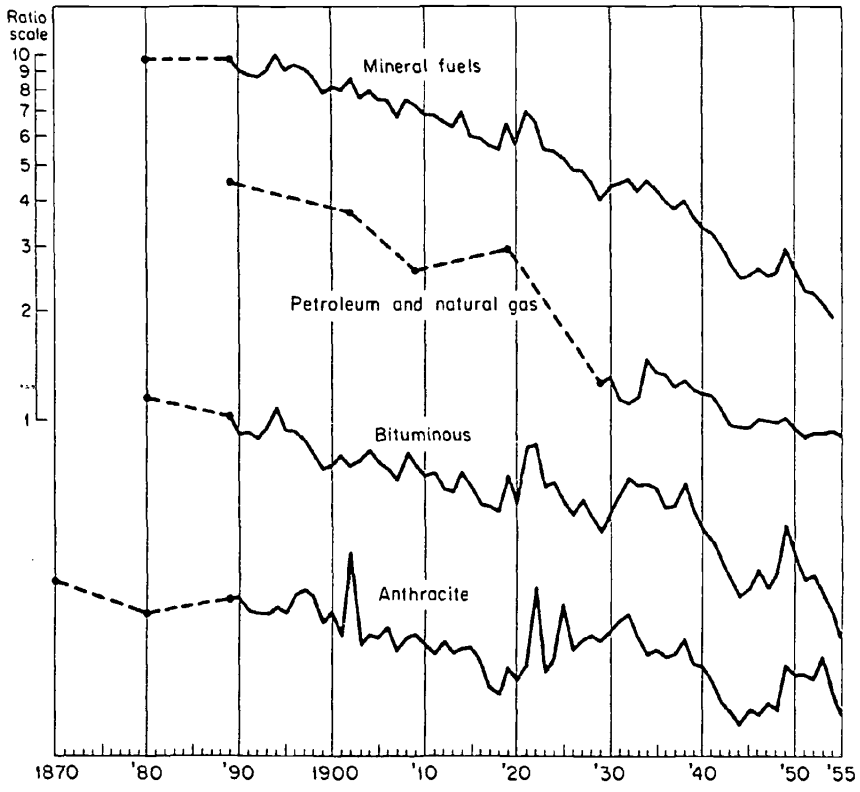


CHART 11
Metals and Major Components: Labor Cost

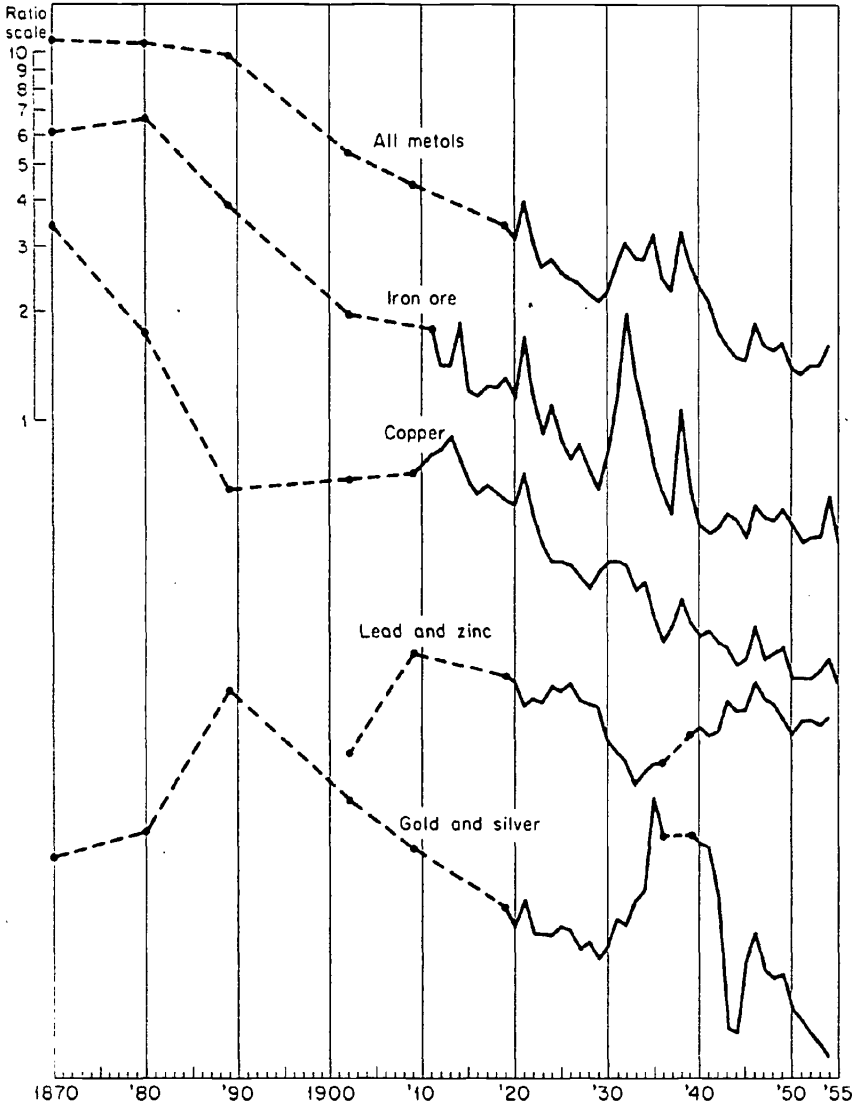
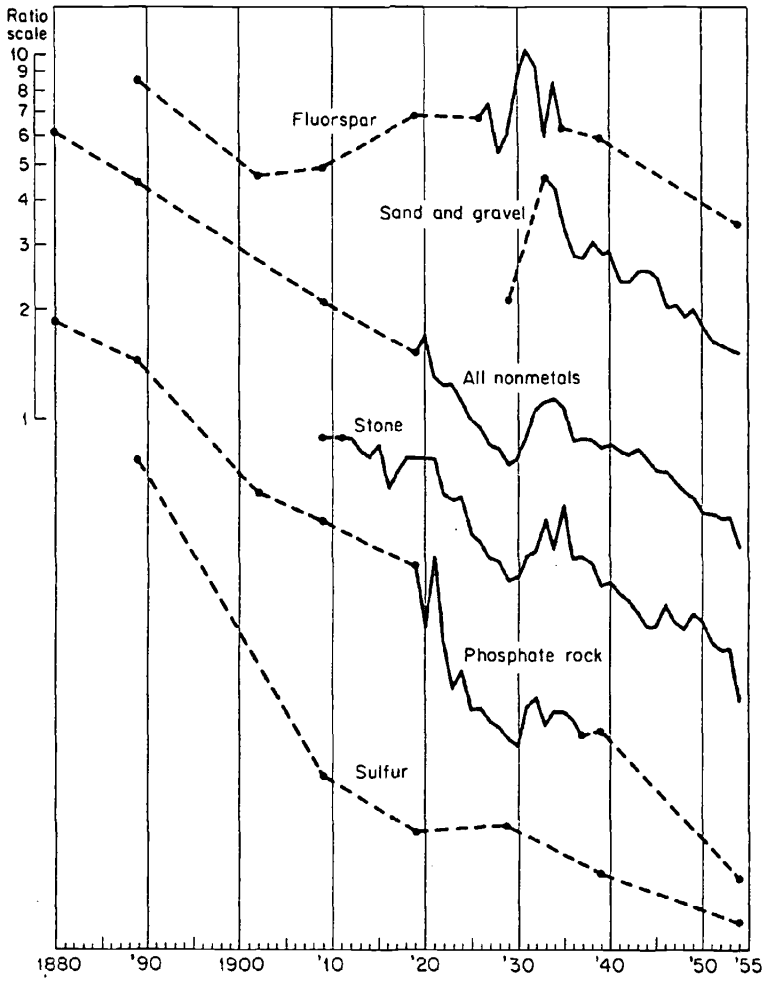


CHART 12
Nonmetals: Labor Cost



AGRICULTURE

There are no data on productivity or labor costs for any subdivisions of agriculture, except the constructs begun by WPA's National Research Project and continued by the Department of Agriculture's Agricultural Research Service.[9] These are estimates of the time it would require an average adult male to produce the various crop and livestock products, with allowances for the techniques, equipment, weather, geographical distribution of plantings, etc., observed by the Department of Agriculture's reporters. While this method raises some doubts in our minds, there is reassurance in the fact that for the period 1910–55 this method yields approximately the same percentage change in over-all labor costs as does our method of dividing our employment data by the index of farm output (see Chart 6). The fall in labor cost for the "man-equivalent hours" technique is 65 per cent, while our decline in employment per unit of output is 67 per cent for 1910–55.

According to these data (Chart 6), the decline in the labor cost index for crops is almost identical with the decline in the total farm labor cost index: 66 per cent decline for crops, 65 per cent for the allfarm index (1910–55). The livestock-and-products labor cost index, on the other hand, falls only 41 per cent in this period. There was during the period a relative shift of labor from crops to livestock, and a relative increase in the output of livestock products. One might deduce that this must have been a shift to products of higher value per man-hour, but the complexity of the computation makes it impossible without further study to know the reason for the apparent inconsistency between the allfarm index and its components.

As indicated in Chart 7, the greatest rates in decline in labor cost among crops have been in food grains (principally wheat) with oil crops (soybeans, peanuts, flaxseed) a close second. The slowest gain has been made in tobacco, perhaps because so much careful cultivation, picking, and curing must be done by hand. Vegetable crops, fruits, and hay also have shown slow productivity gains only a little faster than tobacco's.

Among livestock and products (Chart 8), meat animals have been the slowest to gain (only 21 per cent decrease in labor cost since 1910), while dairies show a 46 per cent decline in labor cost.

MINING

Here we can give a more complete analysis, as we have not

[9] U.S. Work Projects Administration, *Changing Technology and Employment in Agriculture*, published by the Bureau of Agricultural Economics, 1941; USDA, Agricultural Research Service, *Changes in Farm Production and Efficiency*, published annually in June.

depended upon unknown methods and unpublished worksheets of others. Our indexes are simple quotients of employment and output, weighted by average unit values in the case of the group indexes for output, as noted above.

Since about 1902, the unit labor cost of fuels has declined at the same rate as all minerals (Chart 9). This reflects in part the close parallels among the three mineral sectors, and the fact that fuels constituted about two-thirds of the total value of output in 1870 and about three-quarters in 1954. However, the principal constituent was anthracite in the earlier period and is now petroleum, whose value is as great as that of all other minerals put together. As can be seen in Chart 10, the fuels whose employment/output ratios have fallen fastest have been oil and gas (employment for these two fuels cannot be separated). Yet the decline of the all-fuels index is as great as that for oil and gas, because of the considerable shift of the distribution of employment from the coals to oil and gas, where output per man has generally been about three times that in coal (valued in 1954, 1929, or 1902 prices). In recent years this effect has been somewhat augmented by the shift from anthracite to bituminous coal. In the earlier years, however, this movement had an adverse effect on the all-fuels productivity index, as output per man in anthracite was then generally higher than in bituminous coal (both valued in constant 1954, 1929, or 1902 prices).

The unit labor cost of metals declines at the same rate as that of all minerals since 1902, but more rapidly than the other minerals from 1870 to 1902, when output expanded most rapidly. All the major metals—iron, copper, and gold and silver—show this same rate of decline in unit labor input, about 3 per cent per year (Chart 11). Gold and silver appear to have had a sharp increase in labor cost between 1870 and 1889, but thereafter they fall more or less in line with iron and copper. Of the minor metals, lead, zinc, and mercury show almost horizontal trends in labor cost, while bauxite (a very minor employer) shows an irregular and sharp decline, and manganese shows a moderate decline. (These last two are not charted.)

The nonfuel nonmetals labor cost index shows a downtrend similar to that of all minerals for the period since 1919, but a considerably less sharp dropoff in the earlier period. We offer this conclusion with some trepidation, however. The data are quite thin, and dependent on backward extrapolative estimates with respect to stone, which is a highly heterogeneous group of commodities, with a range of labor costs from about an eighth of a man-year to ten man-years per 1,000 tons (1954 Census data).

In phosphate rock, where the best data on employment and output

in the nonmetal field appears, we observe a fall in labor costs that is more rapid than that for the other nonmetals (Chart 12). Sulfur has shown a much more moderate decline in labor costs, after the big drop in costs that came with the introduction of the Frasch process in the first decade of the century. Fluorspar shows a slow rate of decline throughout the period.

Sand and gravel show a steep rate of decline since 1933, when regular statistics from the Bureau of Mines became available. The Census data (not shown here) indicate a significant rise in labor cost over the decade 1929–39. This is a surprising result, for which we have not yet found an explanation.[10]

Stone output dominated the nonmetals picture until the 1920's, so there is little difference between the trend in labor cost of stone and of all nonmetals until 1919. After that year, however, in the period in which we have better data, the labor cost of stone has declined more rapidly than that for all nonmetals.

In timber, the trends are the opposite of those in agriculture and mining. Labor cost increases absolutely, as well as quite steeply relative to the other sectors. It may be that falling quality and decreasing accessibility of timber has more than offset the advantages of the improved machinery for making roads, hauling, cutting, etc., but a review of the employment estimates indicates that these interesting results may be due to defects in our data.

It will be clear from the foregoing review of labor input and output data in the resources field that much remains to be desired, especially in the earlier period, when the Director of the 1870 Census (Francis Walker) commented:

> "... The Statistics of Mining and Fishing Industry in the United States, with the present modes of collection, are so distressingly inadequate to the known facts of the case, that their admission to The Tables of Manufacturing Industry amounts to a positive disparagement of the latter. The Statistics of Manufactures have their own faults, as is elsewhere frankly acknowledged, under the present census system of the United States; but they are incomparably more complete and accurate than any Statistics of Mining or Fishing Industry to be obtained by existing machinery."[11]

Yet the attempt to picture the development of the Nation from the period of primeval forests, unbroken sod, and unexplored mines to

[10] A correction for the number of man-shifts per year in 1929 and 1939 (worked out on a rough basis from a table in the 1929 Census, classifying plants by ranges of days open per year) gives a more moderate rise than the simple employment data.

[11] *Ninth Census of the U.S.*, Vol. 3, "Statistics of the Wealth and Industry," p. 383.

the present inevitably involves the use of such data, at least on the first attempt. We have tried to remove the errors and inconsistencies which were apparent in the summary data from various sources. Our next hope is that those with more detailed knowledge in the specialized fields can offer corrections which will enable us to make these indexes a more adequate representation of the "known facts of the case."

COMMENT

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The production series covering the years 1870 to 1955, presented by Potter and Christy, are closely related to the President's Materials Policy Commission Census series, which begin with 1900. Their paper throws light on the effect of changes in the weighting systems, adds figures for years before 1900, and provides some groupings of raw materials slightly different from those used in the PMPC-Census reports. New measures of employment for the raw materials industries are also presented for the period 1870 through 1954 and on an annual basis from 1919 through 1954. Productivity measures have been calculated by dividing the employment series by the production series. Since the implications of the types of trends shown are discussed in other papers, my remarks are confined primarily to the statistics as related to other available measures. However, in attempting to appraise the validity of these new measures, I have been somewhat hampered by lack of full detail on actual sources and methods used.[1]

Let us consider in order the three Potter-Christy measures: (1) the "output of resource industries" series as related to the PMPC-Census measures of raw materials production from 1900 to the present; (2) the employment measures as related to various concepts of employment; and (3) the productivity measures as derived from the employment and production series.

Production Series

The Potter-Christy production series, like those of the PMPC-Census, give raw materials figures in terms of constant dollar aggregates, separately for agriculture, mining, and two other groups of raw materials. The third Potter-Christy series is called timber and seems to differ in concept from the PMPC-Census series for forest products principally by the exclusion of fuel wood in the former. The fourth Potter-Christy series is called fish, fuel wood, and water

[1] These were available to me, in part only, from an unpublished manuscript.

power, and the fourth PMPC-Census series fishery and wildlife products.

A series for "hydro energy" for the period 1900–50 was presented in the PMPC report, but it was not included as a component of the all-raw materials aggregates because of some obvious questions of significance. For example, it would seem equally appropriate to include in the raw materials aggregates a measure for use of water for purposes other than energy, and such use is implicitly included in the GNP figures as a component of the statistics for services and governments. Wildlife production was not covered by Potter and Christy. Nevertheless, whatever the differences in these fringe series, both sources agree that they amount to only about 2 per cent of the all-raw materials or all-extractive totals.

Indexes of the Potter-Christy and original PMPC-Census series on a 1947–49 base follow each other, in general, very closely. This is particularly true of indexes of the minerals series, which differ in all years before 1953 by 3 points or less. Both series were based on 97 per cent or more coverage of mineral products, uranium ore being the principal commodity completely omitted in both. The Potter-Christy series also excludes stone and clay produced and used in the same establishment in manufacturing cement and structural clay products. Note that near identity of the indexes is achieved even though the Potter-Christy series uses 1954 weights, while the Census series used 1935–39 weights.

The agriculture series from the two sources, expressed as indexes, diverge only slightly more. Both consist primarily of Department of Agriculture aggregates, but different Agriculture Department series were selected for the later years. Potter and Christy used an agriculture production series developed especially for measuring productivity, whereas the PMPC-Census used the Bureau of Agricultural Economics series, "Production for Sale and for Farm Home Consumption."[2] In the early years the movement of the two indexes is very similar, since both were based on the Strauss and Bean index of farm production for 1909 and previous years.

An index of the Potter-Christy timber series agrees fairly closely with an index of the PMPC-Census series including fuel wood. But when fuel wood is removed from Census figures, it exceeds the latter index in the early period by 50 to 70 per cent. The significant difference between the trends shown by the two series of more comparable coverage seems to be due primarily to the relatively lower weight given by Potter and Christy to pulpwood and "minor products" as

[2] The new series for "Supply and Utilization of Farm Commodities" was not completed in time to be included in the 1900–52 Census report.

compared with the weight given to lumber. It is also influenced by their use of a somewhat different series for "minor products" and their apparent exclusion of figures for naval stores.

The fish, fuel wood, and water power series, expressed as an index, bears little comparability in the aggregate to related PMPC-Census series because of the different weights assigned to fuel wood. Potter-Christy measures fuel wood in terms of the value of coal which would be required to provide its heat equivalent.

Since indexes of the major series for minerals and agriculture agree closely, indexes of the Census "all-raw materials" series and the Potter-Christy "all-extractive" figures also agree closely. When expressed as indexes with 1947–49 as a base, they differ by 4 points or less in all but one year, by 3 points or less in all but three years, and by 2 points or less in all but eight years.

One of the interesting contributions made is the comparison of segments of the minerals index using different weight bases, presented in Charts 2 and 3. In view of the wide fluctuations over the years in some minerals prices, it is surprising not to find more significant differences when 1902, 1929, and 1954 prices are used as weights. The nearly identical indexes based on the Potter-Christy and PMPC-Census series provide another example of the small effect of changing weight base, since 1954 weights were used by Potter and Christy and 1935–39 weights by the Census.

Employment Measures

The paper lists fairly completely the major problems in developing employment figures for the raw materials area.[3] It is highly desirable to have a measure of labor input for the production of raw materials, including figures on an annual basis insofar as possible. My evaluation of the figures in the Potter-Christy report was hampered by lack of a uniform and clearly stated objective in developing the employment measures. Instead, the authors indicate that the employment series represent an attempt to reveal trends in real labor inputs, but that this ideal is nowhere attainable, and that a variety of substitutes were used. For example, after listing various possibilities, an objective for the employment measure for minerals is not set as either the Census concept of average number of employees during the entire year or as the Bureau of Mines concept of average number of employees on active days—two employment measures that may differ

[3] It was because of such problems that the Census report did not go further than reproduction of broad classifications for number of gainful workers in the raw materials area for the period 1820–1940, with roughly comparable OBE figures for persons engaged full-time for the years 1929, 1940, and 1950.

greatly. In the 1954 Census, when both figures were obtained for the coal industries, the average number of employees on active days exceeded the average for twelve months in the anthracite industry by about 29 per cent, and in the bituminous coal industry by 14 per cent.[4] Nor is it made clear by the authors whether the employment figures represent only production and related workers or include all other employees. No statement is made about the inclusion or exclusion of working proprietors. The figures given in the report for the mining series seem to agree fairly closely with those I obtain by use of the Census data for average number of employees for twelve months, including both production and related workers and all other employees, after these are adjusted for omission of certain industries or parts of industries in censuses before 1954, shown below in millions.

Year	*Potter-Christy Employment*	*Adjusted Census Employment*
1870	0.19	0.16
1880	0.30	0.31
1889	0.56	0.54
1909	1.07	1.04
1919	1.15	1.10
1939	0.91	0.86
1954	0.79	0.81

These figures differ at most by 5 per cent. The 1954 figure used by Potter and Christy agrees exactly with the total employment in the mineral industries as shown in Table 2 of the General Summary in the 1954 Census of Mineral Industries volumes. This figure does not include the approximately 20,000 employees engaged in mining operations at manufacturing establishments. Such mining employment is included in Table 1 of the 1954 Census General Summary referred to above which furnishes a basis for the adjusted Census employment shown. (This mining employment at manufacturing establishments is required to produce certain mineral products and the production of such products is included in the PMPC-Census production series.) However, the identity of the Potter-Christy employment for 1954 and the Census employment excluding mining at manufacturing operations is, in part, an accident, since the Potter-Christy figures represent the sum of employment from various sources rather than a series adjusted to the 1954 census. In fact, while it excludes employment at quarries operated in conjunction with cement plants it includes employment at quarries associated with

[4] These different definitions, of course, would affect the cyclical trend more than the long time trend, if the same definition is used consistently from year to year.

lime kilns. Again, it includes employment at quarries operated in conjunction with dimension stone dressing plants (which are classified in manufacturing) but excludes employment at the dressing plants.

The Potter-Christy discussion of the problems of measuring employment for the timber series clearly points up the difficulty of measuring logging employment without including employees at associated sawmills. The basic difficulty is the fact that, for a significant portion of this industry, the same employees work in logging and sawmill operations of individual establishments. While it might be more feasible to segregate man-hours for logging and sawmill activities, no adequate series of this type are currently available.

The difficulties in measuring agricultural employment are also well-stated, but again the paper does not make objectives entirely clear. The authors indicate carefully the problems of measuring production and employment and state that the exclusion of some of the production for farm home use introduces a downward bias in the labor cost per unit output series. The evidence presented, however, is not enough to indicate clearly the direction of bias in the over-all measure of agriculture productivity.

The importance of part-time work when using an employment measure rather than a man-hour one, which is emphasized in connection with the agriculture series, should not be disregarded in mining. For example, the 1939 Census of Mineral Industries, which obtained separate data for full-time and part-time workers in the crude petroleum and natural gas industries, showed 19 per cent of all such wage earners as part-time workers.

Productivity Measures

For the productivity measures, I will not discuss the relative significance of using a particular type of index number or of using price rather than employment weights. I would like to emphasize, however, the extreme importance of covering the same areas in a production and an employment series if they are to be used for measuring labor productivity. In the current paper I find too little emphasis on this point. It is hard to measure the bias introduced into these series by lack of availability of comparable output and employment measures for some of the areas covered.

Such comparability was attempted for minerals by excluding stone and clay used in cement and structural clay products plants. However, no adjustment was made to exclude value added by dimension stone dressing at plants operated in conjunction with quarries, even though employment at the dressing plants was excluded. We have been able to check fairly closely the indicated rate of decline in employment

per unit output by dividing the PMPC-Census production series (or, for years before 1900, the Potter-Christy output measure) by the adjusted Census employment shown above. On a 1954 index base the comparative figures are given below.

Year	*Potter-Christy Index*	*PMPC-Census Index*
1870	797	714
1880	595	650
1889	580	602
1909	361	413
1919	310	340
1939	180	178
1954	100	100

The Potter-Christy report includes some discussion of the advantages and disadvantages of using man-hours rather than employment in a productivity measure. For the minerals area, more reliable annual man-hour figures may be available for the last three or four decades than annual employment figures measured under the Census concept, because of the relatively high quality of the man-hour figures in the Bureau of Mines accident reports. In any case, the 1939 and 1954 minerals censuses provide a benchmark check on the effect of measuring labor cost in man-hours. The employment per unit output index given above as 178 for 1939 would have been changed to 153 if man-hours had been used, because of an increase in average hours worked per man-year, from 1,664 in 1939 to 1,933 in 1954.

This effect of changing hours per man-year appears to be the principal explanation of the behavior of the 1929 and 1939 Census sand and gravel figures referred to in the Potter-Christy paper. The Census figures actually show about the same ratio of wages and salaries to value of shipments for the sand and gravel industries for 1929 and 1939. However, the number of employees per unit output for 1939 is about 25 per cent higher than for 1929, and similar ratios occur for each of the major sand and gravel producing states. An analysis of the information in the 1929 Census report shows that over 92 per cent of all sand and gravel establishments were working six full days or more a week in 1929, and that about 36 per cent of them worked over 300 days. In 1939, however, a considerably less-full year appears to have been worked.

The Potter-Christy productivity measure for timber, which shows increasing employment per unit output, is not substantiated by related Census statistics. The authors include a discussion of the

weaknesses of the employment figures, based as they are on occupation statistics from the decennial censuses. A rough estimate of 1939 employment in logging operations on the basis of the 1939 Census of Manufactures gives a figure not far from the 0.16 million employees indicated by Potter and Christy. However, our rough computations of the changes in logging productivity indicated by 1919, 1929, 1939, and 1954 Censuses of Manufactures figures, show productivity increasing significantly rather than declining. The upward trend shown in the Potter-Christy labor cost per unit output series is probably the result of dividing employment by an index of production which is not sufficiently comparable to it in coverage. Moreover, the employment coverage may be significantly different from census to census. One may question, for example, whether labor used in the production of fuel wood is actually excluded from the Potter-Christy employment series to the same extent for all years. For recent years, persons devoting part time to the production of fuel wood may frequently be classified in agriculture by census takers; but for early census years, when much more fuel wood was used, a large number of persons cutting fuel wood for sale may have reported themselves as engaged in such an activity as wood chopper. On the other hand, by-product fuel wood employment would be included for all years, but in later years, such wood constitutes a larger proportion of all wood used for fuel.

In closing, it should be noted that the reliability of a productivity index computed as the quotient of two indexes of this type is, in general, less than that of the component indexes. For example, if the production and employment indexes are of equal reliability, the computed "labor cost" index will be roughly one-half as reliable as the component indexes.