Labor Savings in American Industry 1899-1939

SOLOMON FABRICANT

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Summary

PRACTICALLY EVERY INDUSTRY engaged in extraction, fabrication, power production, transportation, and communication—the production areas for which specific information is available—reduced its manhour requirements per unit of product during the four decades bounded by 1899 and 1939, and the great majority also cut number of workers employed per unit. Industries in which exhaustion of natural resources might be expected to play a significant role effected reductions in unit labor requirements hardly different from those in the fabricational industries and public utilities. The average reduction, 1899-1939, in workers per unit of product for all these industries combined is about 58 percent; when labor input is measured by manhours, about 65 percent. Both percentages probably understate the decline because they fail to take full account of the improved quality of product and ignore entirely greater economies in material and fuel consumption.

Important as are the industries for which we have detailed information, they do not constitute the whole of industry. As these selected industries contribute somewhat under one-half of the national product, we cannot assume that the increase in labor economy in them measures the increase for the productive system at large. Indeed, there are some grounds for believing that in the service industries increase in the productivity of labor has been relatively slow, if we ignore improvements in the quality of service. If so, the productivity of labor in all industries combined has risen less rapidly than in the selected industries. Estimates of national product and total employment confirm this expectation. The nation's total product seems to have approximately paralleled output in the selected industries; but total employment rose more rapidly than employment

in these industries. While conceptual and statistical difficulties obscure the results, and many important quality changes must of necessity be disregarded, it appears that for the economy as a whole the decline from 1899 to 1939 in persons employed, including the self-employed, per unit of product has been about 40 percent—less than in any major group of the industries for which we have specific information.

The corresponding increase in national product per worker, some 70 percent, does not reflect the total gains from enhanced productivity. Hours of labor per week also declined—up to a third in manufacturing and averaging perhaps a fifth for all industry combined. In terms of output per manhour, the increase in productivity has been about 100 percent.

A NATION'S ECONOMIC LEVEL depends, among other things, upon its real income and on how much work it has to do. The level tends to be high if many goods and services are acquired with a small expenditure of labor. The ratio of these two quantities is therefore an index of a basic condition of human existence. It measures either the economy with which a nation utilizes labor or the productivity of a nation's labor, depending on how it is computed; and changes in it indicate whether—in one important respect—a nation's economic lot is growing better or worse.

Analysis of the ratio of product to labor, or labor to product, contributes to understanding our economic development. Indeed, "the history of the productivity of our labor is the foundation of a scientific economic history, and the backbone of any and all history."[1] Yet we know little that is comprehensive and accurate about the changing relation between product and labor. Even for the United States, far better supplied than other countries with economic statistics, and even for the relatively recent period between the opening of the century and the outbreak of the war, the rather scanty and sometimes ambiguous information is difficult to arrange in an orderly and consistent fashion. But interest in the trend of labor productivity—for even one country and a relatively short period—is so deep that it is worth while to bring together what information there is.

The story of the changing economy of labor in the industrial system at large may be begun most conveniently with the changes in its individual sectors. First of all, therefore, in this Paper we review prewar trends in the relation between labor input and product turned out in individual American industries. We draw upon several National Bureau reports, published and

[1] V. G. Simkhovitch, 'Rome's Fall Reconsidered', *Political Science Quarterly*, June 1916, p. 243.

unpublished, dealing mainly with the first four decades of this century.[2]

I Economy of Labor in Selected Industries

We survey in detail the various industries for which adequate statistics have been compiled. These, which we shall call the 'selected industries', fall into two groups: (1) producers of commodities—agriculture, mining, manufacturing; and (2) public utilities—providers of transportation services, light, heat and power, and means of communication. With few important exceptions, all industries in these groups are covered. The major omission from the first group is construction, and from the second, intracity transportation. For both, what statistical data are available still require considerable study before they can be put to use.

It is tempting to call these extractive, fabricational, and utility industries 'basic' industries. But to do so would mean premature judgment concerning the function of other industries in the nation's economy.[3]

AGRICULTURE

If any industry were to be considered basic, it would apparently be farming. When the work required to raise a bushel of wheat, for example, approaches 50 hours of a man's labor, life may be sustained, but there is virtually no time left for any-

[2] These were prepared at the National Bureau with the aid of funds provided by the Maurice and Laura Falk Foundation. Volumes so far published include: *Output of Manufacturing Industries, 1899-1937*, by Solomon Fabricant, assisted by Julius Shiskin (1940), *Employment in Manufacturing, 1899-1939: An Analysis of its Relation to the Volume of Production*, by Solomon Fabricant (1942), *American Agriculture, 1899-1939: A Study of Output, Employment and Productivity*, by Harold Barger and H. H. Landsberg (1942), *The Mining Industries, 1899-1939: A Study of Output, Employment and Productivity*, by Harold Barger and S. H. Schurr (1944). Studies in preparation cover the gas and electric utilities, by J. M. Gould; transportation industries, by Harold Barger; and service industries, by George Stigler.

[3] In an economic system in which distinctions among industries are at all worth making, no industry or group of industries is basic in the sense that its scope and organization would or could continue unchanged if all other industries were to perish. Nor, as Professor Paul M. O'Leary points out, would it be sensible to say that fancy melon raising or gadget manufacture is more 'basic' than the wheat trade or the public health service.

thing else.[4] It is the margin between these 50 hours and today's actual labor requirement per bushel, about two-thirds of an hour,[5] that makes possible the production of the host of consumption goods other than the staff of life, and the leisure in which to enjoy them. Yet some substantial fraction of the hours saved must be reserved to pay for the contribution of manufacturing, trade, education, and other industries to agricultural production. Even agriculture, therefore, is but part of an interdependent system.

Farming is a way of life as well as a way of making a living. There is extensive use of family labor and, far more than in other industries, lack of clear-cut distinction between time devoted to the farm as a productive enterprise and time spent in other ways. The measure of total labor input in agriculture therefore lacks the precision reached for most other branches of the economy. On the production side, farming is characterized by a relatively high degree of mixed output and by variable ratios of direct to indirect production. For these reasons, as well as because of scanty data, a good index of unit labor requirements can be calculated only for total agriculture. However, a sense of what has occurred in different branches of farming can be obtained if we examine indexes of labor requirements per unit for the several major products for which they can be computed at least roughly, and for the several regions into which American farming is divided.

These indexes (Tables 1 and 2), available only for the period beginning with 1909, show declines in unit labor requirements, ranging from moderate to very substantial, for all individual products and practically all areas. For the Eastern cotton area alone is there a rise between 1909-13 and 1932-36; but when the period is extended to 1937-41 the slight rise becomes a decline.[6] The National Bureau's index for total agri-

[4] At that rate of labor input per unit, a man would have to spend almost all his time to provide a family of three with the calories necessary to sustain life at something approximating the present level of consumption. Of course, in such a situation there would be a shift toward higher-yielding products, such as potatoes.

[5] 'Labor Requirements for Crops and Livestock', by M. R. Cooper, *et al.*, Department of Agriculture, May 1943 (mimeographed), p. 17. The figure is for 1930-39 and covers wheat production in the entire United States.

[6] As may be seen from Appendix Table I, unit labor requirements dropped rather

TABLE 1

Agriculture: Changes in Employment per Unit of Product, by Region

REGION	TOTAL % CHANGE 1909-13 to 1932-36	TOTAL % CHANGE 1909-13 to 1937-41	AV. ANNUAL % CHANGE 1909-13 to 1932-36	AV. ANNUAL % CHANGE 1909-13 to 1937-41
Corn	—24	—38	—1.2	—1.7
Eastern dairy	—22	—25	—1.1	—1.0
Western dairy	—26	—41	—1.3	—1.9
Middle eastern	—12	—27	—0.6	—1.1
Eastern cotton	+1	—14	+0.0	—0.5
Delta cotton	—14	—33	—0.7	—1.4
Western cotton	—8	—19	—0.4	—0.8
Small grain	—12	—28	—0.6	—1.2
Range	—21	—37	—1.0	—1.6
Northwestern	—35	—39	—1.9	—1.8
California	—37	—45	—2.0	—2.1
Total U. S.				
Estimate A	—16	—30	—0.8	—1.3
Estimate B	—26	—43	—1.3	—2.0

SOURCE: Except for 'Estimate B' (for the total U. S.), the indexes are computed from data compiled by the Bureau of Agricultural Economics and National Research Project, and extended by the Bureau of Labor Statistics. For the 1909-13/1932-36 figures see J. A. Hopkins, Changing Technology and Employment in Agriculture (Bureau of Agricultural Economics and Works Projects Administration, National Research Project, May 1941), p. 182. These figures were extrapolated through 1937-41 by data published in N.R.P. Reports A-6 and A-8, and the *Monthly Labor Review*, March 1944.

'Estimate B' is from App. Table I.

Employment is measured by the total number gainfully occupied.

culture declined some 10 to 13 points more than did that of the National Research Project.[7] It is likely, therefore, that most (if not all) of the regional changes shown in Table 1 would be more sharply downward were labor-savings indexes of the type computed by the National Bureau used instead of those

abruptly during the last few years covered—to below the straightline trend that may be fitted to the data. For this reason, figures for both periods are presented in Table 1.

[7] The NRP indexes of output were based upon manhour instead of value weights. The latter are more appropriate for the purpose to which we are putting the indexes; for with their use the ratio we derive between labor and product will (as it should) reflect shifts in the relative importance of goods requiring more or less than the average amount of labor per unit of goods. As shown below, these shifts sometimes cause significant changes in the labor used by an industry or group of industries per unit of its product.

As important in accounting for the differences in Table 1 as the discrepancy between the output indexes is the difference between the NRP and NBER measures of employment. See Barger and Landsberg, pp. 239-44.

TABLE 2

Agriculture: Changes in Manhours of Direct and Total Labor Employed per Unit of Product, by Type of Product

PRODUCT	% CHANGE PER UNIT OF PRODUCT 1909-13 TO 1932-36	
	Manhours of direct labor	Manhours of total labor
Corn	—17	—40
Wheat	—54	—64
Oats	—36	—50
Cotton	—20	—18
Potatoes	—19	. .
Milk	—7	—33
Hogs	—6	. .
Weighted average 7 products	—17	. .
All agricultural products	—18	—(26 to 30)

SOURCE: The figures on direct labor per unit for individual products are from Hopkins, *op. cit.*, Ch. VIII. According to those computations, the direct labor used for the seven products constituted about two-thirds of all direct labor, and about two-fifths of all labor, expended on farms 1932-36. The weighted average for the seven products is the tentative result of computations by the National Research Project and is used with its permission. The period is approximate in some cases; for the exact period, see Hopkins, *op. cit.*

The indexes of total labor per unit are rough estimates based on Hopkins' figures adjusted by indexes of the ratio of direct to total manhours; for the latter, see Barger and Landsberg, *op. cit.*, p. 273.

The figures on total labor per unit for all agricultural products are from App. Table I, note a, adjusted as indicated above to obtain the figures for direct labor per unit.

of the National Research Project, and the one rise would be converted into a decline.

The seven products for which separate data are given in Table 2 account for a substantial proportion of total farm output. Something like two-fifths of agricultural labor went into their production. But despite their importance, the average of the indexes for these seven products (5 of which are crops) is not necessarily representative of the average for all farm products (including many important animal products not covered). There are, in fact, grounds for believing that economizing of labor in the production of farm products other than the seven listed in Table 2 proceeded at a somewhat slower pace than in the production of the seven. The gasoline tractor, one of the most effective means of cutting labor requirements in crop production, cannot be used to such good advantage in livestock farming, which is less well represented in Table 2. Yields in livestock production, such as milk per cow and eggs per hen,

have risen, and in crop production have barely changed (except during the 'thirties), it is true; but this difference has not been sufficient to offset the influence of mechanization on crop production.[8] At the same time, products yielding high value per labor hour increased in importance.[9] These opposing trends partly offset each other, causing the index for all products combined (last line of Table 2) to fall not much faster than the average for the seven products (next to the last line of Table 2).

What information there is concerning hours of labor on farms suggests that hours worked per year have changed but slightly. Some declines may have occurred in the hours put in by 'full-time' workers. On the other hand, persons working relatively few hours per year—children and casual laborers—became fewer in number.[10] The net result was only a slight reduction in hours, if hours changed at all. The indexes of man-hours per unit of product may therefore be considered substantially the same as those of number of gainfully occupied persons per unit.

For the period since the turn of the century, or earlier, adequate data are available for total agriculture alone (App. Table I). The percentages vary somewhat, depending upon the measure of labor input and the period covered. However, in view of the character of the data, small differences can be ignored and their conformity considered good. They indicate that, in relation to output, labor input definitely fell more than 1 percent per annum.

As we shall see, this rate compares favorably with corresponding declines in other, less ancient sectors of the economy. Technological progress in agriculture and supplying industries has led to improvement in methods and means of cultivation and harvesting, in seed, in animal breeding, in pest control, and in fertilizer. Returns per unit of labor expended increased rather than diminished.

[8] Barger and Landsberg, pp. 285-7. The evidence in Table 1 would seem to contradict this conclusion. However, the area designations are only roughly indicative of the kinds of product raised.

[9] This is suggested by comparison of the NBER and NRP indexes of output; see Barger and Landsberg, p. 249, and note 7 above.

[10] Barger and Landsberg, p. 269.

LABOR PER UNIT OF PRODUCT IN AGRICULTURE	TOTAL % CHANGE 1909-13 to 1932-36	1898-1902 to 1937-41	1869-71 to 1937-41	ANNUAL % CHANGE* 1909-13 to 1932-36	1898-1902 to 1937-41	1869-71 to 1937-41
Farmers and adult male laborers	—22	—42		—1.1	—1.4	
Gainfully occupied	—26	—48	—65	—1.3	—1.7	—1.5
Manhours (gainfully occupied)						
Estimate A	—30			—1.5		
Estimate B	—26			—1.3		

*The average annual percentage changes presented here and elsewhere in this Paper were computed from the total percentage changes by the compound-interest method.

MINING

In the case of American agriculture, it is safe to say, the threat of depletion through exhaustion of the soil has been lessened except in a few isolated areas. By scientific methods of cultivation, rotation of crops, use of fertilizer, irrigation, and enlightened forestation policies we are learning to hold our own, perhaps even to recover some lost ground. In mining, however, deterioration of known resources is inevitable in a sense not characteristic of farming or any other industry. Discoveries are being made continually, of course, and the opening up of new sources of mineral wealth may for a time keep the average 'quality' of resources from falling. But we know that the final result will be a reduction in the quality of mineral resources.

Technological advance, which plays a role in new discoveries, may help also to counteract the depletion of existing deposits. Improved milling methods make possible the utilization of lower grade ores, and improved cutting and conveying machines help meet the increased difficulty of extraction as seams get narrower or deeper.

The disease brings with it its own palliative. Both discoveries and technical advance in extraction are in important degree stimulated by the pressure of worsening reserves. But whether these factors offset or counteract depletion, and what the net effect is on labor requirements per unit of product cannot be excogitated. How the balance is turning can be learned only by examining the historical record.

Really adequate records of changes in unit labor requirements in individual mining industries begin with the Census of 1902. Only rough measures can be made on the basis of

earlier Censuses; the changes between 1880 and 1939 are less accurate than those between 1902 and 1939.

For every mineral product, labor per unit declined considerably; in some the reduction may fairly be termed enormous (Table 3). In terms of manhours, labor per unit fell more than three-quarters in 37 years in phosphate rock, oil and gas wells, and iron ore; even the smallest decline, in anthracite, was over 40 percent. Declines are less steep when labor input is measured by mandays or average number of men (i.e., manyears), since hours per day and per year had fallen rather considerably. But even in terms of men per unit, a measure that takes no account of the reduction in working hours per day and working days per year, the declines are substantial.

TABLE 3
Mining: Changes in Labor per Unit of Product

INDUSTRY	TOTAL % CHANGE PER UNIT OF PRODUCT				
	1880 to 1939			1902 to 1939	
	Mandays	Manhours	Men	Mandays	Manhours
Iron ore	—92		—72	—72	—78
Copper	—85		—63	—63	—67
Other metals			—41	—44	—52
Anthracite coal	—36		—21	—21	—42
Bituminous coal	—61		—38	—38	—51
Oil & gas wells		—84	—55	—67	—79
Phosphate rock	—94		—83	—83	—87
Gypsum			—68	—68	—75
Total, excl. oil & gas			—42	—44	—55
Total, incl. oil & gas		—83	—63	—64	—73

INDUSTRY	AV. ANNUAL % CHANGE PER UNIT OF PRODUCT				
	1880 to 1939			1902 to 1939	
	Mandays	Manhours	Men	Mandays	Manhours
Iron ore	—4.2		—3.4	—3.4	—4.0
Copper	—3.2		—2.6	—2.6	—3.0
Other metals			—1.4	—1.6	—2.0
Anthracite coal	—0.8		—0.6	—0.6	—1.5
Bituminous coal	—1.6		—1.3	—1.3	—1.9
Oil & gas wells		—3.1	—2.1	—3.0	—4.1
Phosphate rock	—4.7		—4.7	—4.7	—5.4
Gypsum			—3.0	—3.0	—3.7
Total, excl. oil & gas			—1.5	—1.6	—2.1
Total, incl. oil & gas		—3.0	—2.6	—2.7	—3.5

SOURCE: Barger and Schurr, *op. cit.*, pp. 69 and 77; V. E. Spencer, Production, Employment and Productivity in the Mineral Extractive Industries, 1880-1938 (National Research Project, *Report S-2*, June 1940), pp. 8-9, 153-55, 163; and Y. S. Leong *et. al.*, Technology, Employment, and Output per Man in Copper Mining (National Research Project, *Report E-12*, Feb. 1940), p. 214.

Extension of the indexes, to cover the longer period 1880-1939, increases the average annual rates of decline in mandays per unit in all branches except one, which does not change. On the other hand, the decline in manhours per unit, available for oil and gas wells and for the total, is less steep, though still very considerable.

Because of the manner in which the detailed records were assembled, the workers covered by Table 3 are only those notably subject to accidents—the majority of all mining workers, of course. When other workers, including clerical personnel, are included in the measure of labor input, the decline in labor per unit is only slightly smaller, however, since such workers increased but little in proportion to the total. For all workers the decline in mandays per unit between 1902 and 1939 would be about 62 percent instead of the 64 in the table (see App. Table II, note).

While not all mining industries are covered in Table 3, the index for total mining represents about 90 percent of the value of total mineral production in 1899 and 1937. The decline in labor per unit may therefore safely be taken to reflect what has occurred in all mining industries combined. Men and mandays per unit declined close to two-thirds between 1902 and 1939; manhours per unit, almost three-quarters. Between 1880 and 1939, the drop in manhours per unit was five-sixths.

While the declines in labor per unit of product in the individual industries making up the mining sector of the economy have been great, their average is less than the figure for the total. The latter is affected, in addition, by a sharp relative growth in oil and gas production, in which labor input per dollar of product is considerably below the corresponding ratio for most other mining industries. Thus, in terms of constant prices (average prices prevailing in 1902 and 1937), one hour's labor in oil and gas wells yielded a dollar's worth of product in 1902; in metal mining, 78 cents; in anthracite, 72 cents; and in bituminous, 52 cents. The rise of about $1.30 in the value of mineral products per manhour from 1902 to 1939 consists of $.38 due to the increase in importance of petroleum and gas, and $.92 due to the average rise in product per manhour in individual industries. (These figures, too, are expressed in constant,

average of 1902 and 1937, prices.) The latter figure would have measured the rise for all mining only if the composition of mining output had remained the same.[11] The total decline in manhours per unit is 73 percent, as stated in Table 3; the decline free from the effect of changing composition of output, is about 66 percent.

In mining as a whole, we may conclude, and in every individual mining industry for which we have records, labor has been progressively economized. Discovery of new resources to some extent, but mainly improved technology, and the capital investment accompanying it, have more than offset the inevitable deterioration of tapped resources.

"The data we have assembled provide no real evidence that diminishing returns have already set in, in the sense that increased difficulties of extraction have failed to elicit corresponding changes of technology. On the contrary, output per worker, at the end of the period studied here, was close to its all-time high in every industry considered. If a stage of falling productivity must eventually be reached, the American mineral industry is too young, or our period of study is too short, for us to observe it."[12]

MANUFACTURING

In the extractive industries growth in production, putting pressure on limited resources, makes for an increase in the labor required to obtain a unit of product. Technological advance within these industries, new discoveries, and assistance by other industries in the form of added machinery or power may stave off such a rise. Indeed, in both American agriculture and mining, unit labor requirements have declined. Nevertheless, the potentiality is there and increase in operations tends, in some degree, to retard labor saving.

In manufacturing the situation is different. There is reason to believe that in this sector of production increase in output has tended in the main to aid and reinforce the technological and other factors making for greater labor economy. For this reason, we should expect that trends in labor per unit have been at least as sharply downward in manufacturing as in extraction.

[11] Or if the composition had altered in such a way as not to have any effect on the average ratio of labor to value of product. The figures cited are from Barger and Schurr, pp. 80-2.

[12] *Ibid.*, p. 254.

This is indeed the case. During the first four decades of this century manufacturing as a whole pushed down unit manhour requirements at an annual rate of 2.8 percent (App. Table III). Since hours of labor fell considerably, the annual rate in terms of number of wage earners is somewhat smaller, —1.9 percent. As in mining, salaried personnel rose somewhat more rapidly than the number of wage earners. Including these in the measure of labor input, the rate is reduced a bit further, to something between —1.8 and —1.6 percent, but it is still sizable.

In manufacturing, as in extraction, labor per unit has been affected by a shift toward industries with high value of product (in this case, value added) per labor unit. But the shift is much less important. Practically all the decline in labor per unit therefore reflects the average change in the corresponding ratios for the several individual manufacturing industries.[13] When this is taken into account, the mining figure, as well as the agricultural, is found to be very close to the manufacturing.[14]

A further correction for improvements in quality, if it could be applied, would probably widen the difference. No quantitative estimate is possible, of course, but there can be little question either that manufactured products have improved in quality or that the improvement has been greater than in agricultural products or minerals.[15]

Among individual manufacturing industries the rate of decline in labor per unit has varied greatly. In automobile manufacture, an extreme case, wage earners per unit dropped about 90 percent from 1899 to 1937 (Table 4).[16] For a few

[13] Of the over-all decline of roundly 50 percent in wage earners per unit, only about 2 points is due to the change in the composition of output; cf. *Employment in Manufacturing*, Table G-1, p. 335.

[14] It will be recalled that about three-tenths of the rise in value per manhour in mining was due to the shift in composition.

[15] Some quality changes are taken into account in our measures of output. Whenever statistics were given in the basic sources for a specific quality or grade of product, we treated it as a separate item. We then weighted the valuable items more than the cheap, in constructing our indexes, the weights being in proportion to prices. So far, then, as detailed statistics were available, and relative prices measured relative degrees of quality, our indexes of output reflect improvement (or deterioration) in quality. Obviously, we were greatly hampered by absence of detail in many of the Census and other records we used.

[16] For the full period for wage earners per unit, but for a shorter period for manhours per unit (because of inadequate data on hours), see Table 4.

TABLE 4

Manufacturing: Changes in Labor per Unit of Product

	TOTAL PERCENTAGE CHANGE PER UNIT OF PRODUCT						AV. ANNUAL PERCENTAGE CHANGE PER UNIT OF PRODUCT					
			1899-1937		1909-1937				1899-1937		1909-1937	
	LONGEST PERIOD						LONGEST PERIOD					
	Wage earners		Wage earners	Wage earner hours	Wage earners	Wage earner hours	Wage earners		Wage earners	Wage earner hours	Wage earners	Wage earner hours
	Period	*Change*					*Period*	*Change*				
Food	1899-1939	—34	—26		—20		1899-1939	—1.0	—0.8		—0.8	
Meat packing	1879-1939	36	12	—15	11	—17	1879-1939	0.5	0.3	—0.4	0.4	—0.6
Flour	1869-1939	—47	—10		—20	—37	1869-1939	—0.9	—0.3		—0.8	—1.6
Rice	1899-1939	—38	—34		—12		1899-1939	—1.2	—1.1		—0.5	
Fish, canned	1904-1939	23					1904-1939	0.5				
Fruits & vegetables canned	1899-1939	—72	—65		—41	—60	1899-1939	—3.1	—2.7		—1.9	—3.2
Butter, cheese & canned milk	1899-1939	—59	—54		—48		1899-1939	—2.2	—2.0		—2.3	
Beet sugar	1899-1939	—76	—73		—51	—65	1899-1939	—3.5	—3.4		—2.5	—3.7
Cane sugar	1899-1939	—28	—30		—8.2	—42	1899-1939	—0.8	—1.0		—0.3	—2.0
Corn products	1909-1939	—32			—18		1909-1939	—1.3			—0.7	
Ice	1899-1939	—70	—64		—54		1899-1939	—2.9	—2.7		—2.7	
Beverages	1899-1939	—51	—30		—27		1899-1939	—1.8	—0.9		—1.1	
Liquors, malt	1899-1939	—40	—26		—14		1899-1939	—1.3	—0.8		—0.5	
Liquors, distilled	1899-1939	—30	—39		—54	—67	1899-1939	—1.1	—1.3		—2.8	—3.9
Tobacco products	1899-1939	—83	—82		—79	—85	1899-1939	—4.4	—4.4		—5.4	—6.6
Cigarettes & cigars	1899-1939	—87	—85		—84		1899-1939	—4.9	—5.0		—6.4	
Cigarettes	1904-1939	—88			—87		1904-1939	—5.9			—6.9	
Cigars	1869-1939	—50	—44		—40		1869-1939	—1.0	—1.5		—1.8	
Chewing & smoking tobacco	1899-1939	—63	—63		—42		1899-1939	—2.4	—2.6		—1.9	

Textile products	1899-1939	—54	—37		—29		1899-1939	—1.9	—1.2		—1.2		
Cotton goods	1869-1939	—63	—30	—56	—22	—50	1869-1939	—1.4	—0.9	—2.0	—0.9	—2.4	
Woolen & worsted gds.	1879-1939	—33	—22		—13	—42	1879-1939	—0.7	—0.6		—0.5	—1.9	
Woolen goods	1909-1931	—8.8					1909-1931	—0.4					
Worsted goods	1909-1931	—2.9					1909-1931	—0.2					
Silk & rayon gds.	1879-1939	—88	—71	—81	—66	—77	1879-1939	—3.4	—3.2	—4.1	—3.7	—5.1	
Knit goods	1869-1939	—72	—54	—71	—49	—67	1869-1939	—1.8	—2.0	—3.0	—2.4	—3.9	
Carpets & rugs, wool	1899-1939	—40	—29		—22	—51	1899-1939	—1.2	—0.9		—0.9	—2.5	
Oilcloth	1904-1937	32			23		1904-1937	0.8			0.8		
Cordage & twine	1899-1939	—34	—23		—15		1899-1939	—1.0	—0.7		—0.6		
Jute goods	1899-1939	—50	—38		—26		1899-1939	—1.7	—1.3		—1.1		
Linen goods	1899-1939	11	0.3		36		1899-1939	0.2	0.0		1.1		
Hats, fur-felt	1899-1939	—43	—33		—20	—47	1899-1939	—1.4	—1.0		—0.8	—2.3	
Hats, wool-felt	1879-1939	—16	1		—20		1879-1939	—0.3	0.1		—0.8		
Wool shoddy	1889-1933	—48					1889-1933	—1.5					
Leather products	1899-1939	—24	—22		—19		1899-1939	—0.7	—0.7		—0.7		
Leather	1889-1939	—30	—40		—35	—54	1889-1939	—0.7	—1.3		—1.5	—2.8	
Shoes, leather	1869-1939	—46	—19	—46	—19	—43	1869-1939	—0.9	—0.6	—1.5	—0.7	—2.0	
Gloves, leather	1899-1939	—30	—25		8		1899-1939	—0.9	—0.8		0.3		
Rubber products													
Shoes, rubber	1899-1939	—23	—20				1899-1939	—0.7	—0.6				
Paper products	1899-1939	—62	—59		—47		1899-1939	—2.4	—2.3		—2.2		
Paper & pulp	1879-1939	—80	—55		—45	—61	1879-1939	—2.7	—2.1		—2.1	—3.3	
Printing & Publishing	1899-1939	—71	—70	—78	—53	—62	1899-1939	—3.0	—3.1	—3.7	—2.7	—3.4	

TABLE 4 (concluded)

Manufacturing: Changes in Labor per Unit of Product

	TOTAL PERCENTAGE CHANGE PER UNIT OF PRODUCT						AV. ANNUAL PERCENTAGE CHANGE PER UNIT OF PRODUCT					
	LONGEST PERIOD		1899-1937		1909-1937		LONGEST PERIOD		1899-1937		1909-1937	
	Wage earners		Wage earners	Wage earner hours	Wage earners	Wage earner hours	Wage earners		Wage earners	Wage earner hours	Wage earners	Wage earner hours
	Period	*Change*					*Period*	*Change*				
Chemical products	1899-1939	—63	—57		—49		1899-1939	—2.5	—2.2		—2.4	
Chemicals, industrial, incl. rayon & compressed gases	1899-1939	—75	—70		—61	—73	1899-1939	—3.4	—3.1		—3.3	—4.6
Cottonseed products	1899-1939	—17	—8		—14	—31	1899-1939	—0.5	—0.2		—0.5	—1.3
Soap	1904-1939	—55			—39	—55	1904-1939	—2.2			—1.8	—2.8
Wood-distillation products	1899-1937	—21	—21		—13		1899-1937	—0.6	—0.6		—0.5	
Explosives	1889-1939	—72	—67		—43	—59	1889-1939	—2.5	—2.9		—2.0	—3.1
Fertilizers	1899-1939	—50	—48		—36	—54	1899-1939	—1.7	—1.7		—1.6	—2.8
Paints & varnishes	1899-1939	—40	—33		—24	—39	1899-1939	—1.3	—1.0		—1.0	—1.8
Salt	1869-1939	—72	—47		—35		1869-1939	—1.8	—1.7		—1.5	
Tanning & dye materials	1899-1939	—65	—56		—38		1899-1939	—2.6	—2.1		—1.7	
Petroleum & coal products	1899-1939	—77	—73		—66		1899-1939	—3.6	—3.4		—3.8	
Petroleum refining	1879-1939	—88	—66		—45	—64	1879-1939	—3.5	—2.8		—2.1	—3.6
Coke-oven products	1879-1939	—74	—75		—69		1879-1939	—2.2	—3.6		—4.1	
Fuel briquettes	1909-1939	—44			—48		1909-1939	—1.9			—2.3	
Stone, clay & glass products												
Cement	1904-1939	—64			—38	—61	1904-1939	—2.9			—1.7	—3.3
Lime	1904-1939	—41			—37	—54	1904-1939	—1.5			—1.6	—2.7
Glass	1899-1939	—78	—77		—68	—78	1899-1939	—3.7	—3.8		—4.0	—5.3
Forest products	1899-1939	—2	10		—17		1899-1939	—0.1	0.3		—0.5	
Lumber-mill products	1899-1939	9	19	—10	—12	—32	1899-1939	0.2	0.5	—0.3	—0.5	—1.4
Turpentine & rosin	1899-1939	—10	15		—7		1899-1939	—0.3	0.4		—0.3	

Iron & steel prods.	1899-1939	—50	—46		—20		1899-1939	—1.7	—1.6		—0.8	
Blast-furnace prods.	1889-1939	—82	—78		—60	—75	1889-1939	—3.4	—5.9		—3.2	—4.8
Steel-mill products	1869-1939	—78	—36	—57	—11	—40	1869-1939	—2.2	—1.2	—2.1	—0.4	—1.8
Wire	1909-1939	—11			0.9	—32	1909-1939	—0.4			—0.0	—1.3
Nonferrous-metal products												
Primary nonferrous metals	1899-1939	—64	—61		—20		1899-1939	—2.5	—2.4		—0.7	
Copper	1899-1937	—66	—66		—46	—56	1899-1937	—2.8	—2.8		—2.2	—2.9
Lead	1899-1937	—68	—68		—41	—55	1899-1937	—3.0	—3.0		—1.9	—2.8
Zinc	1899-1937	—45	—45		—20	—45	1899-1937	—1.6	—1.6		—0.8	—2.1
Machinery												
Phonographs	1899-1929	—5.7					1899-1929	—0.2				
Transportation equip.	1899-1939	—74	—74		—71		1899-1939	—3.3	—3.5		—4.3	
Automobiles, incl. bodies & parts	1899-1939	—88	—88		—87	—92	1899-1939	—5.1	—5.4		—7.1	—8.5
Carriages, wagons & sleighs	1889-1939	—41	—33		—26		1889-1939	—1.1	—1.0		—1.0	
Cars, rr.	1899-1939	87	39	—2.0	4.9	—21	1899-1939	1.6	0.9	—0.1	0.2	—0.9
Locomotives	1889-1939	226	126		209	142	1889-1939	2.4	2.2		4.1	3.2
Ships & boats	1899-1939	31	61		41	0.8	1899-1939	0.7	1.3		1.2	0.0
Motorcycles & bicycles	1899-1929	—64					1899-1929	—3.4				
Misc. products												
Organs	1904-1935	—7.8					1904-1935	—0.3				
Pianos	1904-1939	—56			—47		1904-1939	—2.3			—2.2	
Total mfg. industries	1899-1939	—53	—49	—64	—42	—58	1899-1939	—1.9	—1.8	—2.7	—1.9	—3.0

SOURCE: *Employment in Manufacturing*, pp. 47-51, 54-5, 84-5, and App. F.

industries wage earners per unit rose. When adjusted for changes in the length of the work week, however, some of the rises become declines. And the remaining rises are in industries in which improvements in quality—not taken into account—have played leading roles.

As manufacturing consists of a rather large and heterogeneous collection of industries, we group them into categories and compare the corresponding rates of change. While the

WAGE EARNERS PER UNIT OF PRODUCT, 1899-1939

	Total % Change	Av. Annual % Rate of Change
Forest products	—2	—0.1
Leather products	—24	—0.7
Foods	—34	—1.0
Iron and steel products	—50	—1.7
Beverages	—51	—1.8
Textile products	—54	—1.9
Paper products	—62	—2.4
Chemical products	—63	—2.5
Printing and publishing	—71	—3.0
Transportation equipment	—74	—3.3
Petroleum and coal products	—77	—3.6
Tobacco products	—83	—4.4

change in forest products was very small, it also was downward. In no group did wage earners per unit go up between the end years covered. Moreover, the declines for foods and transport equipment would be considerably greater if the effect of change in the composition of output were removed.[17]

In the extractive industries the role played by outside industries in reducing labor per unit is unmistakable. Farming and mining have been influenced greatly not only by indigenous development—for example, hybrid corn, insect control, and feeding methods in agriculture, and methods of prospecting and oil-well drilling in mining—but also by the contribution of manufacturing in the shape of tractors and excavating implements. The same interdependence characterizes manufacturing itself. Factory industries have aided one another, and assistance has been given to manufacturing industries by producers of materials, by central power and light stations, by transportation and communication, and by the industries providing business services. The well-nigh universal decline in labor per unit

[17] *Ibid.*, pp. 38 and 335-7.

of manufactured product is due to technological and other developments throughout the economic system.

PUBLIC UTILITIES

Among the public utilities, too, we find evidence of widespread decline in labor per unit of product. Preliminary estimates of the cuts during the four decades covered range from 40 percent in workers per unit for telephones to over 80 percent for electric light and power (Table 5). For some of the categories, not given in the table mainly because the relevant data are fragmentary, the declines were even greater. In pipelines, for example, workers per unit of product fell some 70 percent between 1921 and 1939—equal to an annual rate of 6.5 percent. On the other hand, in intercity electric railways, at least for 1922-39, employment per unit rose; the explanation may lie in the industry's decline during the 1920's and '30's.[18]

The figures are complicated by various technical problems. In the case of intercity transportation, of seven major subcategories, three—motor trucking, busses, and airlines—did not exist in 1899, and one—oil pipelines—was merely in its infancy. Since steam railways and waterway transportation alone were rendering substantial service in both 1899 and 1939, a comparison of these two years means either confining the overall index to the two branches or a chain of rather miscellaneous links. The index in Table 5 is of the latter type.

Another difficulty, perhaps more serious for the utilities than for extraction and fabrication, arises in selecting the unit of output. The kilowatt hour, the message, the ton mile are not entirely satisfactory units. Somewhat greater qualification there-

[18] These electric railways do not include the electrically operated divisions of steam railways, which are classified with the latter.

There appears to be some evidence, too, that total employment rose more rapidly than number of messages in telegraph and cable utilities, between 1902 and 1937. Employment of operators rose less rapidly. In view of what is known of the industry's technological development, these figures are puzzling. However, the unit of output is obviously not one in which confidence can be put. It is highly probable that the distance traveled by the average message has increased considerably, owing to the competition of the telephone in local service. This trend would not be taken into account by a production index based merely on number of messages. Nor would the latter cover phases of the business other than the transmission of messages.

TABLE 5

Public Utilities: Changes in Number of Workers per Unit of Product

	PERCENTAGE CHANGE, 1899-1939	
	Total	Av. Annual
Electric light and power	—81[a]	—4.5
Manufactured and natural gas	—58	—2.1
Telephone	—40[b]	—1.3
Intercity transport	—42	—1.4
Total	—50	—1.8

SOURCE: The series for individual utilities are preliminary and unpublished estimates computed by Harold Barger and J. M. Gould at the National Bureau. For electric light and power the period is 1902-39.

The estimate for the total was computed for this Paper by combining the output indexes for the individual utilities (on the base 1919-38, or the closest approximation to it) using national income weights for 1919-38 derived from data compiled by Simon Kuznets (*National Income and its Composition, 1919-1938*, Part IV), and dividing this composite output index into a composite employment series.

The 1899 figures for electric light and power used in these calculations are rough extrapolations from 1902.

[a] The change in manhours per unit 1917-39 is —68 percent.

[b] The change 1880-1939 is —74 percent.

fore attaches to these measures of change in labor economy than to those presented earlier.

The transportation index is affected by the shift from rail to pipeline, motor trucking, and other nonrail forms of transport. Since the value of product (measured by transport revenue) per worker is smallest in intercity trucking,[19] one of the most rapidly growing of all transport agencies and now second in importance only to steam railroads, one might expect the over-all index of labor per unit of product for transportation to decline less rapidly than, say, the index for steam railroads. This expectation is confirmed. Despite the very rapid reduction in labor per unit in the nonrail transport agencies,[20] the labor

[19] Revenue per worker in 1939 was about $3,900 in steam railroads; $2,800, in intercity trucking. The figures for the other, less important, transport agencies are: intercity bus transport, $4,300; waterway agencies, $5,600; oil pipelines, $8,600; intercity electric railways, $3,100.

[20] Thus the decline for water transport 1906-40 is 61 percent, and, as already noted, 72 percent for pipelines, 1921-39. Precise data are not available for motor trucking, but for 1925-40, when intercity ton mileage advanced more than 1,000 percent, total truck registrations rose 86 percent. If the latter is regarded as an indicator of the change in employment in intercity trucking, the corresponding decline in truck employment per unit of product would be of the order of 83 percent for 15 years. The actual decline, though undoubtedly quite marked, is probably not so sharp.

per unit index for steam railroads declined 54 percent, 1899-1939, and the over-all transport index, only 42.

For the several public utilities in Table 5, the combined decline in employment per unit of product between 1899 and 1939 was one-half. The figure does not cover the changes in urban transport, airlines, water supply, postal service, and telegraphs; however, it does cover the most important utilities[21] and may be regarded as a fair approximation to the change in the total of all. It shows that the decline in workers per unit in public utilities 1899-1939 matches closely that for manufacturing.

But this comparison must be qualified, as these indexes too fail to take account of changes in the quality of product. Even the output of the public utilities is now of better quality. Greater certainty and constancy of electric service, for example, have contributed to the intrinsic value of electric light and power production. It is difficult to believe, however, that the product of public utilities has improved as much as that of manufacturing.

Labor per unit indexes measure the relation to output of only one production factor. Besides labor there are materials, fuel, services rendered by other industries, capital equipment, and so on. For fuel, on which some statistical data are available, the difference between the utilities and manufacturing is striking.

Increases in the efficiency of the utilization of fuel have been widespread, of course. Improved methods have generally reduced coal consumption, for example, relatively to output, and with it some part of the labor required. In the manufacture of pig iron, the quantity of coking coal consumed per ton of product was reduced 20 percent between 1912 and 1936. In a preceding stage of production, the manufacture of coke, the shift to byproduct ovens and greater efficiency in their operation reduced the quantity of coal consumed per unit of coke and byproducts turned out 27 percent between 1913 and 1936. Declines in fuel per unit between 1909 and 1935 for cement plants and refineries were 15 and 23 percent respectively.[22]

21 The utilities covered contributed approximately four-fifths to the national income produced by all utilities excluding the post office.

22 Yaworski, Spencer, Saeger, and Kiessling, *Fuel Efficiency in Cement Manufacture, 1909-1935* (National Research Project, Report E-5, April 1938), Table A-1.

Among the public utilities, however, the savings have been greater than in most other industries, including manufacturing. Even minor savings count, as fuel consumed is one of the most important items in the prime costs of public utilities, particularly electric light and power, gas, and steam railroads. In at least two, savings have been more than minor, percentagewise. Steam locomotives on railroads reduced pounds of coal burned per thousand gross freight ton miles 30 percent—from 169 in 1916 to 119 in 1936.[23] In electric light and power, the reduction was drastic. In 1902 about 275 kilowatt hours of current were generated in fuel-consuming central stations per short ton (bituminous equivalent) of fuel consumed. By 1939 it was almost 1,500, over five times as much, or a more than 80 percent reduction in fuel per unit of product.[24]

These fuel savings have also been substantial absolutely. Coal, for example, has been the source of 50-90 percent of the total energy used in the United States since 1899. In 1929 about one-third of the coal consumed went to manufacturing, one-third to transportation and other public utilities, and one-third for other purposes (including domestic consumption and export).[25] In terms of total fuel consumed (B.t.u. equivalent), steam railroads and central electric power stations took 19 percent in 1919-35.[26] Fuel savings of the percentages indicated are therefore important. The reductions in requirements of labor per unit tell only part of the story of the gain in efficiency in the public utilities.

COMPARISONS AND CONTRASTS

To compare the trends in labor per unit of product in the selected industries more closely, we first put the over-all indexes down beside one another:[27]

[23] *Ibid.*, Table A-1. The figures per net or revenue ton mile, available for a somewhat different period, reveal similar savings.

[24] Inclusion of generators driven by water power barely affects the percentage reduction in unit fuel requirements.

The computations are presented in detail in Jacob M. Gould's manuscript on the electric and gas utilities.

[25] *Energy Resources and National Policy*, National Resources Committee, Jan. 1939, p. 80.

[26] Yaworski *et al.*, p. 13.

		LABOR PER UNIT OF PRODUCT	
		Total % Change	Av. Annual % Change
Agriculture	1898/1902-1937/41	—48	—1.7
Mining	1902-1939	—61	—2.5
Manufacturing	1899-1939	—50	—1.7
Public utilities, incl. transportation	1899-1939	—50	—1.7

The outstanding impression is one of similarity among the rates of decline. In these diverse industries, affected in varying degree by the exhaustion of natural resources, by the extent to which machines can be used, by shifts to and from production requiring less labor per dollar of product, and (as we shall see) with differing rates of growth in output, total labor requirements per unit fell, between 1899 and 1939, by percentages lying within a narrow range. If account could be taken of changes in quality of product, the range might be widened, though how much is difficult to say.

In terms of manhours, too, the range would be wider. As we have seen, hours fell but slightly (no more than 5 percent, if at all) in agriculture, and perhaps most drastically (about a third) in manufacturing. Mining and the utilities[28] are between these two figures, though much closer to that for manufacturing. The above percentage decline in labor per unit for agriculture is therefore barely changed when hours are taken into account, while those for mining, utilities, and manufacturing are lowered, the last to about 64 percent, the first to about 72 percent.

We make the comparison also in terms of the averages for individual branches within the four major categories. These averages, more or less free from the effect of shifts in the composition of output, are less disparate than in the first comparison.

[27] For agriculture labor input is measured by the total gainfully occupied; for mining, by persons subject to accident, adjusted upward to cover all persons (see App. Table II, note); for manufacturing, by total employment, plus one-half of nonfactory personnel reported in the 1939 Census; for utilities, by total employment.

[28] Data on hours worked in the public utilities are inadequate. In steam railroads, the major branch, hours fell from about 60 in 1899 to 46 in 1939.

		LABOR PER UNIT OF PRODUCT	
		Total % Change	Av. Annual % Change
Agriculture	1898/1902-1937/41	—44	—1.5
Mining	1902-1939	—52	—2.0
Manufacturing	1899-1939	—48	—1.6
Public utilities, incl. transportation	1899-1939	—45	—1.5

Even they, though they may reflect faithfully the central tendency of the changes in the individual industries constituting each basic industrial category, fail to describe these changes in various other respects. For a more detailed description and comparison, it is necessary to turn to the figures for individual industries. Frequency distributions are most convenient as a form of presentation. These (Table 6), necessarily restricted to the type of measures available for individual industries, differ somewhat from the over-all measures. For the present purpose, however, the differences in concept and coverage may be neglected.

The variation within all four major categories is outstanding. In this respect, too, the several groups have a common characteristic. Indeed, the variation among industries within a major category (i.e., within columns) seems considerably greater than the variation among major categories (i.e., among columns). There is a suggestion, here, that the factors making for decline

TABLE 6

Frequency Distributions of Individual Industries by Average Annual Rate of Change in Labor per Unit of Product*

AV. ANNUAL % RATE OF CHANGE	AGRICULTURE 1909-13 TO 1937-41	MINING 1902-1939	MANUFACTURING 1899-1937	PUBLIC UTILITIES 1899-1939
2.0 to 2.9			1	
1.0 to 1.9			1	
0.0 to 0.9			6	
—0.1 to —1.0	3	1	15	
—1.1 to —2.0	7	2	10	2
—2.1 to —3.0	1	3	9	1
—3.1 to —4.0		1	7	
—4.1 to —5.0		1	1	1
—5.1 to —6.0			1	

SOURCE: Tables 1, 3, 4, and 5. For agriculture, the distribution is of regions; for electric light and power (included among public utilities), the period is 1902-39.

*For agriculture, labor input is measured by the total gainfully occupied; for mining, by number of men subject to accident; for manufacturing, by number of wage earners; and for utilities, by total employment.

in labor per unit have not differed more in their incidence among the groups than in their incidence on individual industries within the groups.[29]

A quick glance may be taken, finally, at the year by year changes. The accompanying chart indicates the fairly persistent tendency for labor per unit to decline. It shows also that in most cases measures based on the net changes between the end years studied here reflect the averages of the annual changes with reasonable adequacy.[30] Study of the rather interesting fluctuations in rate of decline in labor per unit must be left for another occasion.

TOTAL FOR SELECTED INDUSTRIES

Certain industries in the areas of production reviewed above, notably construction and intracity transport, are not covered by the preceding statistics. There is, however, some value to a summary figure that indicates the average trend in labor per unit of product for the large sample of commodity producing and public utility industries available to us.

For this important sector of our economy, the number of workers required per unit of product (ignoring quality changes) fell 58 percent between 1899 and 1939.[31] This figure is closer to the upper end of the range noted above (i.e., closer to the

[29] No final conclusion is possible because the data in Table 6 are not completely homogeneous, and therefore not fully comparable.

[30] Logarithmic parabolas fitted by J. M. Gould to indexes of labor per unit for some of the major industries indicate negligible rates of retardation in rate of decline. They provide, also, measures of annual rates of decline that differ but slightly from those presented here, except for agriculture. For this industry, the average annual rate of decline that may be computed (using the compound-interest formula, as we do) from the net change between 1898-1902 and 1937-41 is higher than the average annual rate revealed by a trend-line of the kind mentioned (fitted by the method of least squares).

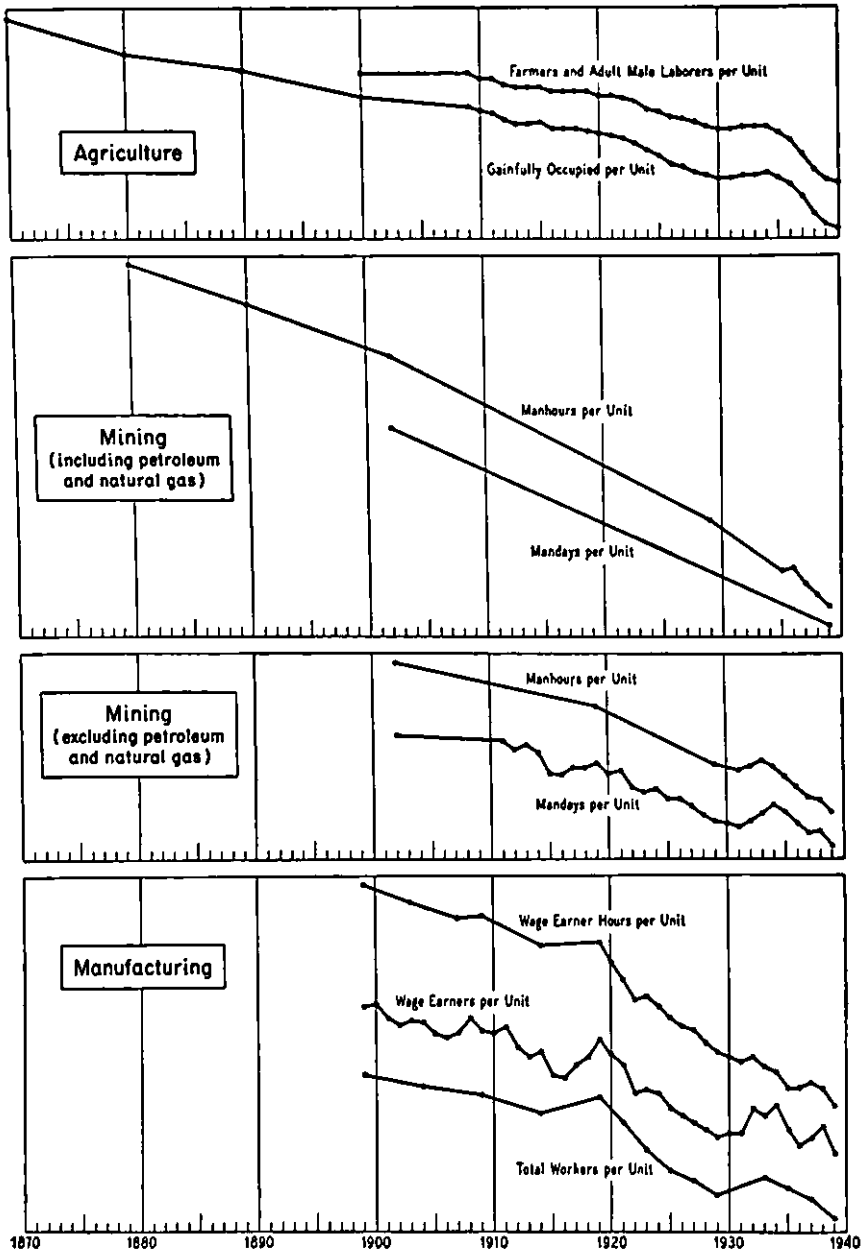
[31] The combined index of labor per unit for the selected industries was derived from the ratio of (a) an index of combined employment, to (b) an index of combined output. The weights used in constructing the latter were national income produced in 1919-38 in the industries covered, with 1919-38 as the base period. For the individual indexes of employment and output see the following sections and the Appendix tables; the weights appear in Table 7.

The figure for mining is based on an 1899 output figure given by Barger and Schurr, and an employment figure extrapolated by output. The employment figure is probably understated slightly, but the error cannot have any appreciable effect on the total.

largest decline, 61 percent in mining) than to the lower. The reason is the strong effect of the decline in the relative im-

Selected Industries

Indexes of Employment per Unit of Product



portance of agriculture, in conjunction with the relatively low value of net product per person employed in agriculture (see

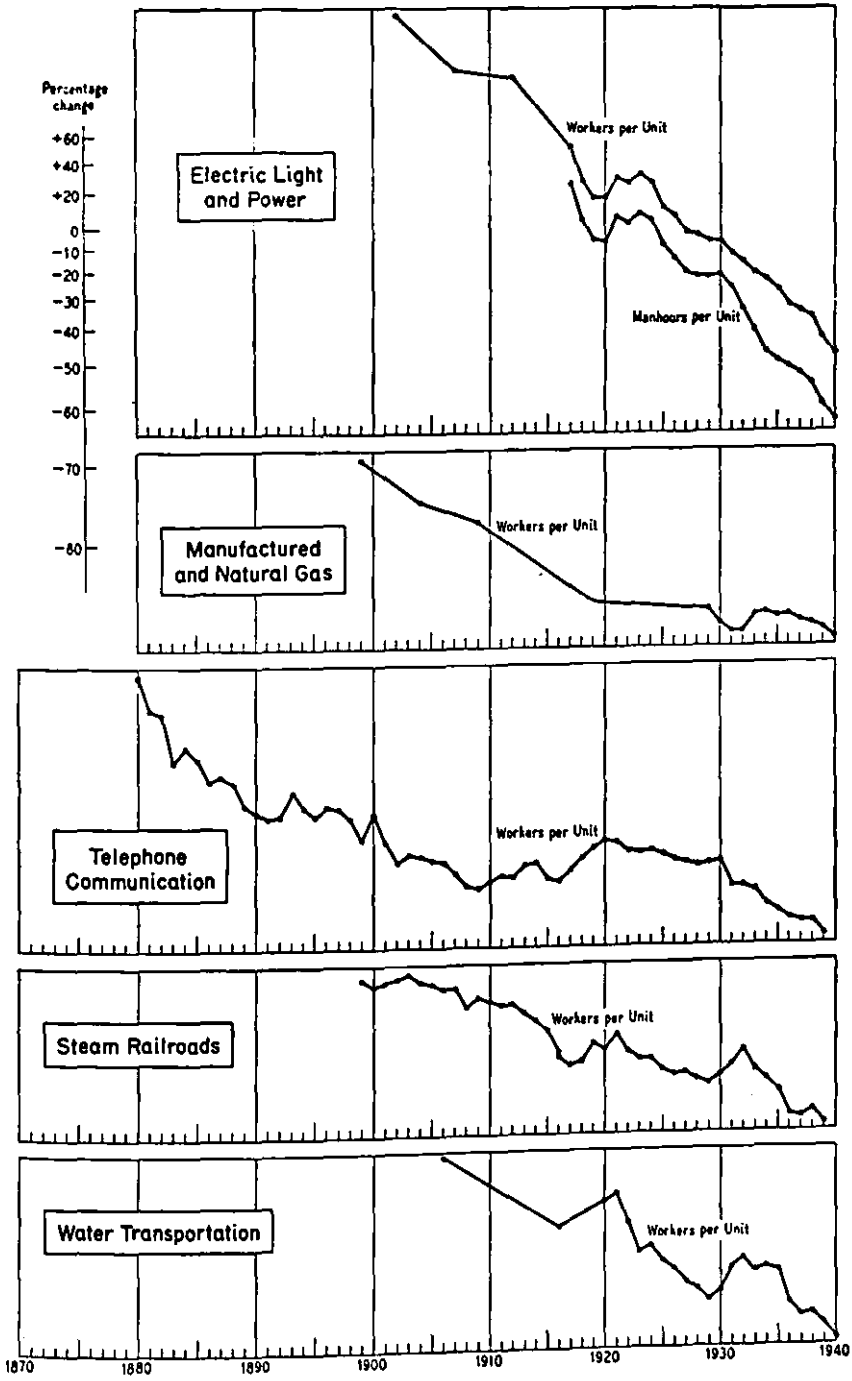


Table 7). If the immediate effect of this shift is removed, the average decline becomes 50 percent.

In terms of manhours per unit of product, no precise average can be given because of lack of full data on hours of labor in public utilities and the inadequacy of the data for agriculture. The absence of information on hours worked by nonwage earners in mining and manufacturing is another difficulty. If it is assumed that the decline in hours worked in the public utilities equals that in steam railroads, the largest employer among them, and further that hours of all workers in manufacturing and mining fell as they did in the wage earner areas of these two industries, the average decline between 1899 and 1939 in hours of labor in the selected industries is between 16 and 18 percent, say, 17 percent.[82] The increase in aggregate manhours is then about 3 percent; in number of workers, 24 percent. And the reduction in unit manhour requirements for basic industry combined is 65 percent, as against 58 percent for workers per unit.

In summary, we have the following approximate indexes for 1939 (1899=100) for the four groups of industries combined:

a	Physical output	297
b	Number of workers	124
c	Hours of labor per week	83
d	Number of manhours	103
e	Workers per unit of product (100b/a)	42
f	Manhours per unit of product (100d/a)	35

II Labor Savings and National Product per Capita

A two-thirds decline in the industries engaged in extraction, fabrication, transport, power production, and communication, in the labor required per unit of product, equivalent to a tripling of output per manhour, provides a basis for a very considerable stepping-up of the nation's level of living. Doing with less labor per unit of output in these industries means that labor is released to augment their output, to provide additional or better products of other industries, or to lengthen leisure.

[82] Even rather different assumptions concerning hours in public utilities lead to much the same results, since employment in these industries, excluding railroads, constituted only about 1 percent of the total for the four major basic industries in 1899 and 6 percent in 1939.

But the nation's level of living depends also upon what happens to unit labor requirements in industries other than those covered by the statistics cited, and on the extent to which the latter have raised their contribution to production in the covered industries. It would be rash to assume that trends in the selected industries for which detailed information happens to be available are representative of those throughout the economy. For a clear understanding of the trends underlying the rise in the national level of living it is exactly this question we must consider: how does the increase in the economy of labor in the selected industries compare with the increase in the economy at large?

An unequivocal answer is impossible. Indeed, the reader may be more impressed by the discussion of what we do not know than of what we do; and of the uncertainties surrounding the information available to us than of its accuracy. If so, one purpose of this Paper will have been accomplished. For it is well to keep in mind that many of the figures presented in this Section are approximations on the basis of which one may tentatively infer, rather than definitely conclude.

To deepen our understanding of the figures, we compare the selected industries and the entire economy with respect to trends in employment and in production, then examine the corresponding ratios between labor and product.

RELATIVE IMPORTANCE OF THE SELECTED INDUSTRIES IN THE NATIONAL ECONOMY

In terms of employment, two of the selected industries, manufacturing and agriculture, are the most important sectors of our economy. Measured by contribution to national income, manufacturing is first; and though agriculture's contribution is exceeded by those of several industries in the service and other areas, it still bulks large. Obviously, therefore, the aggregate of the four selected industries accounts for a substantial portion of total employment and income. According to averages for 1919-38 (Table 7),[33] the selected industries covered employed 51 percent of all persons at work, including self-employed individuals, and contributed 43 percent of the national income.

[33] Data for the full period back to 1899 are absent or inadequate.

TABLE 7

National Income, Employment, and Workers per Unit of Income
Major Categories of Industries, Annual Average, 1919-1938

	CONTRIBUTION TO NATIONAL INCOME		WORKERS (incl. self-employed)		WORKERS PER $1,000 OF INCOME
	$1,000,000	%	1,000	%	
Agriculture	6,367	9.6	8,325	20.6	1.31
Mining	1,431	2.2	963	2.4	.67
Manufacturing	13,973	21.1	8,697	21.5	.62
Public utilities*	6,536	9.8	2,846	6.9	.44
Subtotal	28,307	42.7	20,831	51.4	.73
Construction	2,533	3.8	1,414	3.5	.56
Trade	8,988	13.5	5,755	14.5	.64
Finance	1,975	3.0	775	1.9	.39
Real estate	5,942	8.9	432	1.1	.073
Service	8,368	12.6	6,214	15.4	.74
Government	7,702	11.6	3,171	7.8	.41
Miscellaneous	2,637	4.0	1,816	4.5	.69
All industries	66,452	100.0	40,408	100.0	.61

SOURCE: Simon Kuznets, *National Income and Its Composition, 1919-1938*, Part IV, and unpublished worksheets. The national income figures are unadjusted for capital gains and losses and inventory revaluations.

*Includes all transportation except motor trucking, buses, taxicabs, and air transportation, which are included in the miscellaneous category.

Yet these figures may seem small to those who tend to think in terms of the past, when, as we shall see below, employment in the selected industries bulked larger in proportion to total employment than during the two decades covered by Table 7. Further, the importance of farming, mining, manufacturing, and the utilities has been overemphasized because published statistics stress them. Inadequate attention has been paid to the other great employers of labor and producers of income, such as trade, personal and business services, and government; and the growth in their relative importance has escaped general notice.

While the selected industries constitute about half of our productive system, measured in terms of either workers or income, trends in them may not be assumed to represent trends in all industry combined. The question posed at the opening of this Section therefore warrants investigation.

EMPLOYMENT TRENDS: SELECTED INDUSTRIES AND THE NATIONAL ECONOMY

The time devoted to productive effort in the nation's economy depends upon three factors: (1) the proportion of the population that engages in labor, (2) the number of weeks worked per year by each person so engaged, and (3) the number of hours of labor in each work week.

The proportion of the population gainfully occupied rose appreciably between 1900 and 1940, the terminal Census years (Table 8). This rise is the net result of two opposite trends.

TABLE 8

Proportion of Population Gainfully Occupied

	1900	*1930*	*1940*
Population (millions)			
Total	76.0	122.8	131.7
14 years & over	51.4	89.1	101.1
'Gainful workers' 14 years & over			
Number (millions)	28.3	48.6	
Percentage of			
Total population	37.2	39.6	
Population 14 years & over	55.0	54.5	
'Labor force' 14 years & over			
Number (millions)		47.4	53.3
Percentage of			
Total population		38.6	40.5
Population 14 years & over		53.2	52.7

SOURCE: Derived from Alba M. Edwards, *Comparative Occupation Statistics for the United States, 1870 to 1940* (16th Census, published 1943), pp. 13, 91; and total population statistics from current issues of the *Statistical Abstract*. If the concept of gainful workers is expanded to cover persons 10 to 13 years of age, the figures become:

	1900	*1930*
Number (millions)	29.1	48.8
Percentage of		
Total population	38.3	39.7
Population 10 years & over	50.2	49.5

First, the percentage of the population in the working-age brackets (14 years and over) rose from 68 to 77 percent. Running contrary to this trend, the proportion of persons in the working-age brackets who stated that they were in the labor force declined about 2 percent. (The latter trend is itself the net difference between the rise in the proportion of women in industry and the reduction in child labor.) On net balance,

then, the fraction of our population reported in the labor force rose 12 percent.[84]

With the population growing from 76 to 132 million, the increase in the proportion gainfully occupied meant that the number gainfully occupied rose from 28 or 29 million in 1900 to 54 million in 1940, roundly 90 percent.[85] This rise is definitely larger than the increase for the selected industries. This is confirmed by Table 9, in which the statistics of gainfully oc-

TABLE 9
Industrial Composition of the Labor Force (millions)

	1900	*1940*
Selected Industries		
Agriculture	11.1	9.1
Mining	.8	1.1
Manufacturing	6.3	12.1
Public utilities	1.9	3.9
Other Industries		
Forestry and fishing	.2	.3
Construction	1.6	3.5
Trade	2.6	7.0
Finance	.3	1.5
Professional service	.7	2.7
Domestic and personal service	2.8	5.4
Public service	.9	3.0
Unclassified	..	4.7
Total	29.1	54.2

SOURCE: Daniel Carson, unpublished report covering the period 1870-1930, prepared originally for the National Research Project and revised. Carson's figures for 1930 were pushed through to 1940 by George Stigler. The basic data are from the *Census of Occupations* and *Census of the Labor Force.* Because of various adjustments made by Carson and Stigler, the totals above differ somewhat from those in Table 8.

cupied have been put together on an industry basis. The figures are rough, not strictly comparable between 1900 and 1940 in several respects, and differ somewhat in classification and otherwise from those by which we measure production and employment in the selected industries. However, the trends are so pronounced as to leave little room for doubt. Percentage increases

[84] The increase is about 10 percent if working children 10-13 years of age are counted among the gainfully occupied.

[85] The lower 1900 figure excludes persons 10 to 13 years of age, of some importance in that year.

The break in the continuity of the statistics between 1930 and 1940 is overcome by raising the 1940 figure in Table 8 slightly to render it comparable with that for 1900.

in the labor force in the selected industries were, with one exception, less than those in the other industries; in agriculture the labor force actually declined.[36] It is clear that the nation's total labor force rose more rapidly than that in agriculture, mining, manufacturing, and the utilities.

While the figures on the labor force provide one bit of information on the contrast between trends in the selected industries and in the economy at large, they do not tell us what happened to actual employment. To ascertain that, we must consider the annual work done by each person in the labor force.

To number of weeks worked per year by each person gainfully occupied, a clue is provided by the unemployment rate. In 1940 about 8.9 percent of all persons in the labor force were seeking work (not including 'emergency workers' on WPA, etc., among the unemployed). Including emergency workers among the unemployed, the percentage is 13.7[37] In 1900, not as good a year as 1899, the unemployment rate was about 5.7 percent.[38] Though these figures are not direct measures, they suggest that each person gainfully occupied worked, on the average, somewhat fewer weeks in 1940 than in 1900. While the labor force rose 90 percent, then, total employment increased about 80 percent (counting emergency workers as unemployed) or 85 percent (including emergency workers among the employed). (These figures are rounded to avoid implying an accuracy greater than they possess.) Because emergency workers are usually treated as unemployed we take 80 percent for our estimate.

Business in 1899 was somewhat better than in 1900, and in 1939 somewhat worse than in 1940, according to the annals compiled in the business cycle studies at the National Bureau of Economic Research. It is likely therefore (though no quanti-

[36] The unclassified quantity in 1940 reduces the precision of these conclusions. However, even if the majority of the 4.7 million were to be added to the selected industries alone (an extreme assumption), the picture would not be altered radically.

[37] Averages for March-Dec. 1940; see *Monthly Report on the Labor Force* (Bureau of the Census).

[38] *Economic Record*, National Industrial Conference Board, March 20, 1940, p. 78. Because of the poor statistics available at the opening of the century, this is a very rough estimate.

tative estimates are available) that employment between 1899 and 1939 rose somewhat less than between 1900 and 1940. However, the employable population rose more, percentage-wise, between 1899 and 1900 than between 1939 and 1940, owing to the relatively high immigration rate in the earlier period; this would lessen though not wipe out the difference. We may reasonably suppose that the increase in employment 1899-1939 was about 75 percent, as against 80 for 1900-40. How does this figure compare with those for the selected industries?

Between 1899 and 1939 the number employed in the selected industries (including the self-employed) rose 24 percent. The decline in agriculture was more than offset by substantial percentage rises in mining, manufacturing, and public utilities:[39]

Agriculture	—16
Mining	+41
Manufacturing	+88
Public utilities	+120
Total of above	+24

Whatever allowance is made for the crudities of the employment data for the national economy, there can be no question that total employment rose much more rapidly than employment in the selected industries.

What happened to hours of labor per week? As we have seen, they were cut about 17 percent in the selected industries. The reduction is small mainly because in agriculture hours were reduced only slightly, if at all. In the other three divisions, average reductions ranged from 27 to 32 percent. A further clue to the order of magnitude of the reduction in hours in all industries combined is given by the hours prevailing in 1939. In the three selected divisions just mentioned, hours of labor in 1939 averaged less than 40 per week. In industries other than these 'selected', hours in 1939 were more than 40. In wholesale trade, actual hours were 42, and in retail trade, 43. In 'year-round' hotels, employees worked an average of 47 hours, in laundries, 43, in dyeing and cleaning, 42.[40] On the other hand, it is likely that hours in finance, government, and similar office work were closer to 40. An outline of the entire hours situa-

[39] These percentages are based on the Appendix Tables and Table 9.

[40] A. Olenin and T. F. Corcoran, Bureau of Labor Statistics, *Bulletin* 697 (1942).

tion in March 1940 (Table 10), rougher than that just cited but covering all industry, also suggests that working hours outside the selected industries (other than agriculture) were longer than within them. While data on hours in 1899 are inadequate, it may be doubted that at that time hours in such industries as trade and the services, in relation to hours in the selected industries, were higher than in 1939.[41] There is some ground for believing, therefore, that hours of labor fell no more and perhaps somewhat less in the former than in the latter. Further, as we have seen, employment in other industries increased relatively to employment in the selected industries, i.e., industries with high levels of hours per week increased in relative importance (again with the exception of agriculture). It seems fair

[41] Some scanty information for 1895 and 1896 suggests that at the close of the nineteenth century hours per week in trade, laundries, etc., were under 60. See the *11th Annual Report of the Commissioner of Labor* (1897), Table VI.

TABLE 10
Hours Worked March 24-30, 1940, by Wage or Salary Earners at Work

INDUSTRY	HOURS WORKED BY MODAL GROUP
Agriculture	60-69
Forestry & fishery	40
Mining	14-29 in coal mining 40 in other three branches
Construction	40
Manufacturing	40 in all thirty-eight branches
Transportation & public utilities	48 in three branches 40 in other six branches
Trade	40 in one branch (wholesale trade) 48 in seven retail branches 60-69 in two retail branches 70 or more in one retail branch (filling stations)
Finance	40
Insurance & real estate	40
Business & repair services	48 in auto services 40 in all other services
Personal services	48 in all four branches
Professional services	40 in three branches 48 in one
Government	40 in all three branches

SOURCE: 16th Census, 1940, *Population*, Vol. III, The Labor Force, Part 1, p. 271. Public emergency employment is excluded.

to presume that hours in the entire economy fell less than the average of about 30 percent in mining, manufacturing, and public utilities combined. The average decline of 17 percent for all selected industries combined, including agriculture, would appear, however, to be a bit on the low side as an estimate for the entire economy. A round figure of 20 percent may not be too far from the true figure for all industry.[42]

In summary, the proportion of the population gainfully occupied rose, between 1899 and 1939, the number of weeks worked per year per worker fell, owing to a higher unemployment rate, and hours worked per week per worker also fell.

PRODUCTION TRENDS: SELECTED INDUSTRIES AND THE NATIONAL ECONOMY

Production, of course, rose more rapidly than employment in the selected industries. Measured by indexes of physical volume, in which many quality changes are ignored, output rose by percentages ranging from 59 to 340:[43]

Agriculture	59
Mining	266
Manufacturing	274
Public utilities	340
Total of above	197

Total output tripled despite the great weight of agriculture and the modest increase in its output, because the rises were so sharp in the other three groups.

According to the best estimate available for the four decades with which we are concerned, essentially Simon Kuznets' estimate of net national product in constant prices,[44] the net physi-

[42] No account can be taken of the increase in time required for travel to and from work. Agriculture, local retail trade, and local personal services are not at so great a disadvantage when closeness to residence is taken into consideration.

The information on agriculture is for hours per year, rather than per week. It is therefore assumed that the number of weeks of work in agriculture per year was unchanged between the opening of the century and the outbreak of the war.

[43] Except for public utilities, the changes are based on indexes in the Appendix Tables. For the utility index I am indebted to J. M. Gould.

[44] Kuznets has extrapolated the series presented in his *National Income and Its Composition*, which covers 1919-38, back to earlier decades; see his *Uses of National Income in Peace and War*, National Bureau *Occasional Paper 6*. I am using his revision and extension through 1939 of the series published in that Paper.

Kuznets' estimate for the earlier period is for the average of 1894-1903, not

cal output of the entire economy rose some 200 percent. Anyone familiar with the state of our statistical records, especially in the period preceding 1919, knows that this measure of total output is subject to a fairly wide margin of error. Of course, all our figures must be looked upon as approximations. The indexes for the selected industries, based largely as they are on national Censuses taken recurrently over many decades, are good approximations. The corresponding figure for the entire economy, on the other hand, is subject to a wider margin of error which may well be stated explicitly.[45] On the basis of Kuznets' own discussion, it seems reasonable to believe that the 1939 index on the 1899 base, 300, is within 10 percent of the correct figure. We may therefore say that the net physical output of the entire economy rose by something between 170 and 230 percent from 1899 to 1939. In the absence of a numerical indication of the probability attached to it, obviously out of the question in the present state of our knowledge, it is impossible to interpret such a margin of error precisely. Yet it is better to carry our discussion along in terms of this range, rather than of a single figure, in order to indicate at each point what difference would be made in our conclusions if we were to add or subtract 10 percent to the index of total output.

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for 1899. The figure for 1899 was obtained from an estimate of the ratio of 1899 to 1894-1903, based on William H. Shaw's data on commodity flow (a revision of the series originally presented in *Occasional Paper 3;* the revised figures are to be published in a National Bureau monograph).

Some reasons may be given for choosing gross national product excluding the net balance of claims against foreign countries rather than net national product, as the best measure of national output for comparison with employment. However, the difference between the two series is small for the 40 year span in which we are interested.

[45] In addition, it is rimmed by a wider penumbra of ambiguity from a conceptual point of view. (For a discussion of the concept and measurement of national product, see Simon Kuznets' *National Income and Its Composition,* especially Ch. 1 and 3.) If, for example, the physical output of domestic servants were taken to correspond to their number, then the index of output so determined would differ from the true index to the extent to which unit labor requirements in the industry had altered. In some degree, current measures of the output of such 'industries' as domestic service, and government enterprises like education, are of this kind.

The indexes of output for the selected industries are not conceptually flawless either. For example, they measure gross physical output rather than net physical output, though the latter is more appropriate for the present purpose.

Wherever the true figure within this range, it is remarkably close to the average for the selected industries. Production in the other industries appears to have risen approximately the same, for practical purposes, as the combined production of the industries for which specific data are available. In other words, the combined output of construction, trade, and the services—the preponderant categories not covered by us—rose about as much as the combined output of agriculture, mining, manufacturing, and public utilities. (In none of these measures is quality improvement or deterioration fully taken into account.[46])

Some correspondence is to be expected. For instance, a good deal of the output of the extractive and fabricational industries consists of materials, supplies, and equipment for trade, the services, and other industries. And conversely, construction and the trade and service industries cater to the selected industries. It is impossible to say, however, that no part of the correspondence is due to the rough character of the figures on production.

LABOR SAVINGS IN THE ECONOMY AT LARGE

The employment and production indexes for 1939 (on the 1899 base), presented in preceding sections, may now be brought together. Whether national product rose as much as the combined output of the four major groups of selected industries, or deviated somewhat from it, it is mainly in the widely divergent employment trends that we find the basis for a substantial difference in trends in labor per unit of product.

	SELECTED INDUSTRIES	ALL INDUSTRIES
Number of employed workers	124	175
Hours of labor per week per worker	83	80
Manhours of employment	103	140
Physical output	297	270-330

[46] An additional technical qualification, barely mentioned earlier, is that, strictly speaking, the index of national output is an index of *net* output, and as such is comparable only with indexes of the net output of individual industries or groups of industries. But the indexes for the selected industries are essentially indexes of *gross* output. (For a discussion of the difference between indexes of gross and net physical output see *The Output of Manufacturing Industries*, Ch. 2.) If net output in these industries rose more rapidly than gross output, as it would with increasing economy in the use of fuel, materials, and equipment, then in the above comparison we have understated the rise in the output of the selected industries and overstated the rise in the output of the other industries. If net output in the selected industries rose less rapidly than gross output, as

The indexes of labor economy that can be derived from the above indexes are:

	SELECTED INDUSTRIES	ALL INDUSTRIES
Workers per unit of product	42	53-65
Manhours per unit of product	35	42-52

These figures indicate that labor was not economized as rapidly in the system at large as in the selected industries. Manhours per unit fell 48-58 percent in the entire economy, and 65 percent in the selected industries; and workers per unit, 35 to 47 percent in all industries combined, and 60 percent in the selected industries.

Crudities or other inadequacies of the data, especially in the figures underlying the index of national output, cloud the comparison somewhat. To repeat, we have indications, rather than precise measurements, of an interesting phase of our economic history. But that labor per unit of product did fall more rapidly in the selected industries than in all industries combined seems hardly open to question. [47]

Quality changes may have contributed to the differences: for example, if the energy freed by greater labor economy had been devoted in trade, etc. largely to improving service, while in the selected industries it had gone to a greater extent into

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it would with increasing use of such purchased goods and services as equipment, power, communication, accounting, advertising, etc., then we have overstated the rise in the output of the selected industries and understated the rise in the output of the other industries. What the difference really is, it is impossible to say with any degree of confidence; I am somewhat inclined to believe that in agriculture and mining net output rose less rapidly than gross output, while in manufacturing and the utilities the reverse was the case. It hardly seems likely that the difference for all the selected industries combined can be large.

[47] A hypothetical computation may interest the reader. Let us assume, for example, that any error in the calculation of the national product (the 1939 index of which, on the 1899 base, is taken to be 300, in accordance with Kuznets' computations) lies entirely in the measure of output of industries other than the 'selected'. What correction would have to be applied to the index of output of those industries for the decline in the number of workers per unit of product in the total economy to equal 60 percent, as in the selected industries, rather than 40 percent, the average of the two figures in the text? The index of output would have to be multiplied by a correction factor of as much as 2 or 2.5. It is difficult to believe that the index could be so far off. Nor is it to be expected, if errors reside in both this index and the index for the selected industries (a more likely possibility, of course), that they would reinforce one another to the extent that the total error could amount to a figure equivalent to the one just assumed.

multiplying units of product. Another possibility is that the former group of industries has been affected less than the latter by certain factors forcing declines in labor per unit of product. Perhaps the processes utilized by them have, so far, been less amenable to the type of technological development predominant in the four decades covered here. Mechanical equipment, such as dish washers, facilitates operations in restaurants, bookkeeping machines expedite financial accounting, the doctor can get around more quickly in a motor car than in a buggy, of course. On the other hand, there may not have been as much scope for mechanical, chemical, and electrical innovations as in mining, harvesting, milling, refining, machining, and assembly in the extractive and fabricational industries. Elevators and escalators in department stores, for example, reduce the amount of ground needed per unit of goods handled and increase the quality of service rendered, but they hardly affect unit labor requirements. Many stores or restaurants or doctors' offices seem to be run now much as they were at the opening of the century. If this impression is true, labor per unit of product (again ignoring quality changes) could not have fallen as rapidly in the economy at large as in the selected industries; the differences found above must reflect, in part at least, real difference in labor saving trends. In the present state of our knowledge these possibilities must remain hypotheses.[48]

NATIONAL PRODUCT PER CAPITA

We may now review some of our results.

National product approximately tripled from 1899 to 1939; that is, the nation's output rose between 170 and 230 percent. Some allowance should be made for quality changes not covered by these figures, for, on the whole, in the production of both commodities and services, the quality of product was enhanced appreciably during the four decades preceding the outbreak of World War II. In terms of both quantity and quality, therefore, national output rose even more during this period than the above figures indicate.

Accompanying the rise in output was an increase of 75 per-

[48] Attention is being paid to some of these matters in the National Bureau study of the service industries.

cent in population and of 90 percent in the labor force.[49] The appreciable increase in the proportion of persons gainfully occupied was offset by greater unemployment in 1939 than in 1899. The number of persons actually working rose no more rapidly than the population—75 percent. Since hours of labor fell about a fifth, manhours of work rose somewhat less than one-half—40 percent.

Product per manhour, therefore, doubled or more than doubled; and product per person employed and per capita of the entire population rose approximately two-thirds. Despite an increase in the rate of unemployment, the average economic level rose considerably between 1899 and 1939.[50]

Some groups did not gain as much as others. The distribution of income and of the labor burden changed between the opening of the century and the outbreak of the war. We have seen, for example, that weekly hours of work fell in varying degree. Similarly, money wages and other incomes in various occupations and industries rose by different percentages; and the incidence of price changes, which affect the purchasing power of money income, varied in intensity. The unemployed, especially, gained little comfort from the rise in the average level of living. It is clear, therefore, that we have only begun the story of the level of living in this country; yet the averages presented here are the essentials of a first chapter.

In summary, the development of the economy brought something like a doubling in the commodities and services produced per manhour of labor. Some of this increase led to (and, it is fair to assume, resulted from) more leisure, hours of work per week dropping about 20 percent; another portion was dis-

[49] Because of the decline in the relative number of children in the population, it may be expected that the number of 'consuming units' rose somewhat more rapidly than the population. However, the difference is small. According to W. S. Thompson and P. K. Whelpton (*Population Trends in the United States;* McGraw-Hill, 1933, p. 169), the number of consuming units rose only about 4 percent more than population between 1890 and 1930.

A slightly greater increase, about 9 percent, occurred in the ratio of 'producing units' to population.

[50] Output, that is, national product, includes not only the flow of goods to consumers but also capital formation. If the flow of goods to consumers is taken as the appropriate measure, the rise in the level of living is perhaps 10 percent greater than the figures cited in the text.

sipated in a higher unemployment rate; the rest bore fruit in enhanced quality and greater quantity of goods. Per capita, national product rose about two-thirds.

Appendix Tables

Indexes of Production, Employment, and Employment per Unit of Product

I Agriculture (1900:100)

	OUTPUT	EMPLOYMENT		EMPLOYMENT PER UNIT OF PRODUCT	
		Gainfully occupied	Farmers & adult male laborers	Gainfully occupied per unit	Farmers & adult male laborers per unit
1870	42	63		150	
1880	63	79		125	
1890	79	91		115	
1900	100	100	100	100	100
1909	112	107	112	95	100
1910	115	106	112	93	97
1911	116	106	112	92	97
1912	120	107	113	89	94
1913	123	107	113	87	93
1914	123	107	114	87	93
1915	123	108	115	88	93
1916	125	107	114	85	91
1917	125	106	113	85	91
1918	125	105	113	85	91
1919	124	104	113	84	91
1920	126	104	112	83	89
1921	126	104	113	82	89
1922	128	104	113	81	88
1923	130	103	113	79	87
1924	136	103	113	76	83
1925	138	102	113	74	82
1926	141	101	112	71	80
1927	142	100	112	70	79
1928	144	99	111	68	78
1929	144	97	110	67	76
1930	145	96	109	66	75
1931	144	95	108	66	75
1932	139	93	105	67	76
1933	136	92	104	67	76
1934	133	91	102	68	76
1935	135	89	100	66	74
1936	137	88	98	64	71
1937	145	87	96	60	66
1938	155	85	94	55	61
1939	160	84	93	52	58
1940	159	82	91	51	57

SOURCE: Barger and Landsberg, Tables 38 and 39, and sources cited by them. Figures for 1930-40 are revisions or extrapolations based on Department of Agriculture and Bureau of the Census data.

Output figures are 5-year averages except for 1870 and 1940, which are 3-year averages. Employment figures are 5-year averages except for 1870-1909, which are for these years only; and 1910 and 1940, which are 3-year averages.

Data on hours of labor per year are inadequate. Barger and Landsberg make alternative assumptions: (1) that hours were 5 percent higher in 1909-13 than in 1932-36; (2) that hours were the same in both periods (*op. cit.*, p. 271). On these assumptions we have:

	1909-13	*1932-36*
Gainfully occupied per unit	100	74
Hours per unit		
Assumption (1)	100	70
Assumption (2)	100	74

II Mining (1929:100)*

	TOTAL INCLUDING PETROLEUM AND NATURAL GAS					TOTAL EXCLUDING PETROLEUM AND NATURAL GAS				
		EMPLOYMENT		EMPLOYMENT PER UNIT			EMPLOYMENT		EMPLOYMENT PER UNIT	
	OUTPUT	Mandays	Manhours	Mandays	Manhours	OUTPUT	Mandays	Manhours	Mandays	Manhours
1880	8.8		33		375					
1890	19		58		305					
1899	26					43				
1900	28					46				
1901	30					49				
1902	31	100	73	100	233	50	78	84	156	169
1903	35					57				
1904	36					57				
1905	40					64				
1906	42					66				
1907	45					72				
1908	42					65				
1909	48					74				
1910	51					79				
1911	50					77	116		152	
1912	53					82	120		145	
1913	57					87	131		149	
1914	53					79	112		143	
1915	58					87	111		128	
1916	67					101	127		127	
1917	70					105	138		132	
1918	[illegible]					104	137		132	
1919	61					84	113	114	135	135

1920	71					96	124		128	
1921	[illegible]8					70	91		130	
1922	62					72	86		119	
1923	86					100	116		116	
1924	80					91	107		118	
1925	83					92	103		112	
1926	90					102	114		112	
1927	92					96	104		108	
1928	92					95	97		103	
1929	100		100		100	100	100	100	100	100
1930	88					86	85		99	
1931	74					67	65	65	97	97
1932	60					49	49	49	100	99
1933	65					52	54	53	104	102
1934	71					59	64	58	109	99
1935	76		59		77	63	66	59	105	94
1936	89		69		78	77	76	68	99	89
1937	100		72		72	84	79	70	94	84
1938	86		58		68	64	61	54	95	83
1939	95	101	61	36	64	76	67	59	88	78

SOURCE: Barger and Schurr, pp. 343, 77, for 1899-1939; extrapolated to 1880 by data in V. E. Spencer, Production, Employment, and Productivity in the Mineral Extractive Industries, 1880-1938 (National Research Project, *Report S-2*, June 1940), pp. 8-9 (arithmetic mean of the two output indexes given). As the data on employment are only for persons "subject to accidents," they exclude most salaried employees and some proprietors. Including all salaried persons and proprietors, the employment indexes for 1939 relative to 1902 would be about 5 percent greater than the above indexes (cf. Barger and Schurr, pp. 69-71).

*Base for mandays and mandays per unit, mining including petroleum and gas, is 1902.

III Manufacturing (1899:100)

	OUTPUT	EMPLOYMENT		EMPLOYMENT PER UNIT		WAGE EARNERS	
		Wage earners	Total*	Wage earners	Total*	Man-hours	Manhours per unit
1899	100	100	100	100	100	100	100
1900	102	104	. .	101	. .	. .	. .
1901	115	109	. .	94	. .	. .	. .
1902	129	118	. .	91	. .	. .	. .
1903	132	122	. .	93	. .	120	91
1904	124	115	116	92	94	. .	. .
1905	148	128	. .	87	. .	. .	. .
1906	159	134	. .	85	. .	. .	. .
1907	161	140	. .	87	. .	136	84
1908	133	124	. .	94	. .	. .	. .
1909	158	139	143	88	90	134	85
1910	168	145	. .	87	. .	. .	. .
1911	161	145	. .	90	. .	. .	. .
1912	185	151	. .	81	. .	. .	. .
1913	198	152	. .	77	. .	. .	. .
1914	186	146	152	79	82	136	73
1915	218	153	. .	70	. .	. .	. .
1916	259	179	. .	69	. .	. .	. .
1917	257	191	. .	74	. .	. .	. .
1918	254	195	. .	77	. .	. .	. .
1919	222	188	197	84	89	164	74
1920	242	188	. .	78	. .	161	67
1921	194	144	152	74	78	119	61
1922	249	160	. .	64	. .	137	55
1923	280	183	190	65	68	158	56
1924	266	170	. .	64	. .	141	53
1925	298	175	183	59	61	148	50
1926	316	179	. .	57	. .	152	48
1927	317	175	184	55	58	148	47
1928	332	175	. .	53	. .	147	44
1929	364	187	197	51	54	156	42
1930	311	162	. .	52	. .	129	41
1931	262	137	. .	52	. .	104	40
1932	197	117	. .	59	. .	82	41
1933	228	129	136	57	59	89	39
1934	252	151	. .	60	. .	95	38
1935	301	160	167	53	56	107	35
1936	353	174	. .	49	. .	124	35
1937	376	191	198	51	53	134	36
1938	295	160	. .	54	. .	104	35
1939	374	176	181	47	48	121	32

SOURCE: *Employment in Manufacturing*, p. 331.

*Excludes nonfactory personnel, 1935-39. The following indexes (1899:100) cover all personnel:

	1935	*1937*	*1939*
Employment	174	201	195
Employment per unit	58	54	52

IV Electric Light and Power (1929:100)

	OUTPUT		EMPLOYMENT		EMPLOYMENT PER UNIT	
	Total	Comparable with employment	Workers	Manhours	Workers	Manhours
1902	3.6	3.3	10	. .	320	. .
1907	7.5	6.8	16	. .	240	. .
1912	13	11.8	27	. .	230	. .
1913	14	. .	. .	. .	. .	. .
1914	15	. .	. .	. .	. .	. .
1915	17	. .	. .	. .	. .	. .
1916	21	. .	. .	. .	. .	. .
1917	24	22	36	36	162	161
1918	31	29	39	38	136	134
1919	36	33	41	40	125	121
1920	39	36	45	43	125	120
1921	36	34	47	46	139	136
1922	41	38	52	51	135	132
1923	50	47	67	65	141	138
1924	55	53	72	71	135	134
1925	64	62	74	73	119	118
1926	74	73	83	80	114	110
1927	82	82	86	84	105	103
1928	90	90	92	90	103	100
1929	100	100	100	100	100	100
1930	104	104	103	104	100	101
1931	102	102	96	97	94	95
1932	93	93	84	79	90	85
1933	93	93	78	71	85	76
1934	99	99	82	68	82	68
1935	108	108	84	71	78	65
1936	123	123	90	77	72	63
1937	136	136	96	83	70	61
1938	137	137	93	80	68	58
1939	152	152	93	79	61	52
1940	168	168	95	81	56	48

SOURCE: J. M. Gould, report prepared for the National Bureau of Economic Research. The index of total output covers electric light and power departments of electric railways, as well as central power stations operating primarily as public utilities. The measures of labor input, and the index of output comparable with labor input, cover only the latter. Workers and manhours relate to salaried as well as nonsalaried persons.

V Manufactured and Natural Gas (1929:100)

	OUTPUT	WORKERS	WORKERS PER UNIT
1899	16	34	216
1904	26	45	174
1909	38	59	157
1919	67	70	104
1929	100	100	100
1930	101	94	93
1931	99	88	89
1932	92	82	89
1933	88	85	97
1934	92	90	98
1935	96	91	96
1936	100	97	97
1937	104	98	94
1938	101	94	93
1939	106	95	90
1940	115	100	86

SOURCE: J. M. Gould, report prepared for the National Bureau of Economic Research. Workers include salaried as well as nonsalaried persons.

VI Telephone Communication (1929:100)

	OUTPUT	EMPLOY-MENT	EMPLOY-MENT PER UNIT		OUTPUT	EMPLOY-MENT	EMPLOY-MENT PER UNIT
1880	0.3	0.8	267	1910	44	40	92
1881	0.4	0.9	225	1911	46	44	95
1882	0.5	1.1	220	1912	49	46	94
1883	0.7	1.2	172	1913	50	50	100
1884	0.7	1.3	186	1914	50	50	101
1885	0.8	1.4	175	1915	54	50	93
1886	0.9	1.4	156	1916	60	55	92
1887	1.0	1.6	160	1917	63	61	97
1888	1.1	1.7	155	1918	61	63	103
1889	1.3	1.8	138	1919	59	65	109
1890	1.5	2.0	133	1920	63	71	113
1891	1.7	2.2	129	1921	65	73	112
1892	2.0	2.6	130	1922	69	74	107
1893	1.9	2.8	147	1923	75	79	106
1894	2.2	3.0	136	1924	78	84	107
1895	2.7	3.5	130	1925	81	86	105
1896	3.1	4.2	136	1926	86	88	102
1897	3.9	5.3	135	1927	89	90	101
1898	5.3	6.8	128	1928	93	93	99
1899	8.0	9.2	115	1929	100	100	100
1900	9.5	12	131	1930	97	98	101
1901	13	15	113	1931	100	89	89
1902	17	18	102	1932	93	83	89
1903	19	20	106	1933	87	76	87
1904	21	22	105	1934	88	72	81
1905	26	27	103	1935	91	71	78
1906	31	32	102	1936	97	73	75
1907	36	34	96	1937	103	77	74
1908	39	35	90	1938	105	77	74
1909	41	36	89	1939	110	76	69

SOURCE: Basic data from the American Telephone and Telegraph Co.

VII Steam Railroads (1929:100)

YEAR ENDING JUNE	OUTPUT	EMPLOYMENT	EMPLOYMENT PER UNIT
1899	31	55	175
1900	35	60	169
1901	37	63	172
1902	40	70	175
1903	44	78	179
1904	45	77	172
1905	48	82	170
1906	54	90	166
1907	60	99	166
1908	56	85	151
1909	56	89	158
1910	65	100	155
1911	65	99	152
1912	67	102	152
1913	75	109	146
1914	72	101	140
1915	69	92	133
1916	82	98	119
YEAR ENDING DECEMBER			
1916	87	101	116
1917	96	106	111
1918	99	112	113
1919	93	116	124
1920	102	123	120
1921	78	101	130
1922	83	98	119
1923	98	112	114
1924	92	106	114
1925	97	105	108
1926	102	107	105
1927	98	105	106
1928	98	100	102
1929	100	100	100
1930	86	90	104
1931	69	76	110
1932	52	62	119
1933	55	59	107
1934	60	61	102
1935	63	60	96
1936	76	65	85
1937	81	68	84
1938	66	58	87
1939	75	60	81

SOURCE: Harold Barger and J. M. Gould, unpublished figures prepared for the National Bureau of Economic Research. For the years after 1921 the data are for Class I, II, and III line-haul companies, switching and terminal companies, and Pullman and Railway Express companies. For 1899-1921 the data are for line-haul and Pullman companies.

VIII Water Transportation (1929:100)

	OUTPUT	EMPLOYMENT (excl. longshoremen)	EMPLOYMENT PER UNIT
1906	31	67	214
1916	50	74	148
1920	74	125	168
1921	60	105	175
1922	73	110	151
1923	84	108	129
1924	81	108	133
1925	84	103	123
1926	90	106	118
1927	93	102	110
1928	96	102	106
1929	100	100	100
1930	91	95	105
1931	73	86	118
1932	62	78	124
1933	70	81	116
1934	74	87	118
1935	77	89	116
1936	87	85	98
1937	98	90	92
1938	86	80	93
1939	95	84	88
1940	104	84	81

SOURCE: The output figures are those of Harold Barger and J. M. Gould; they are tentative estimates prepared for the National Bureau of Economic Research. The employment indexes for 1906-20 on the 1929 base are Barger's and Gould's estimates; they were interpolated between 1920 and 1929 by Kuznets' series (*National Income and Its Composition*, p. 676), and extended through 1940 by unpublished estimates of the Department of Commerce.

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