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PART III

Summary

CHAPTER

CHAPTER 5

The Electric and Gas Utilities Trends and Contrasts

THE ELECTRIC AND GAS UTILITIES are treated together in this study because they satisfy closely related demands for a readily accessible and flexible source of energy. We have indicated how the manufactured gas industry, whose product during the 19th century was designed solely for illumination, turned to the satisfaction of other domestic and industrial needs as the electric light and power industry emerged a competitor. For cooking and certain specialized industrial uses, gas (manufactured and natural) is dominant today, as is electricity for illumination and power. In the past, however, gas and electricity competed for the satisfaction of these and other energy needs, and will continue to compete. The similar character of these needs warrants treating the two utility services as an entity,[1] and in this Chapter we summarize our findings with respect to the movement of utility output and productivity in the form of indexes for the combined electric and gas utility industry.

1 Output Trends

But first, some comparisons between the two utilities are in order. In 1902–42 the output of the electric light and power industry increased about 5,800 percent, and the output of the gas industry 518 percent. This marked divergence partly reflects the fact that we are considering electric light and power at its most vigorous stage — from its birth to the present. The manufactured gas industry, on the other hand, had been growing for more than half a century when

[1] In practice, gas and electric service frequently constitute departments of a single utility company.

our record begins in 1899.[2] Does our study of the manufactured gas industry not yield an incomplete picture, concerned as it is with the later stages of its growth? The lack of adequate statistical data prior to 1899 of necessity limits our study to these later stages, but it may even be argued that there is a serious break in continuity between the manufactured gas industry of the 19th and 20th centuries. The change from the use of gas as an illuminant to its consumption in cooking marked a profound transition in the industry. The subsequent growth (at an annual rate of about 7 percent in 1910) is typical of a new industry, rather than of one in existence for more than 60 years. However, retardation soon set in, and in recent years growth has tended to give way to decline (Chart 20).

Application of the growth curve analysis introduced in Chapter 1 yields average annual rates of growth at ten year intervals, which trace the secular trends of the indexes of output for the gas and electric utilities (Tables 40 and 41).

Differences in trends immediately emerge: electric light and power and natural gas were still gaining rapidly at the close of the '30's; manufactured gas had passed its peak. Retardation of growth has not been nearly as marked for natural gas as for electric light and power and manufactured gas. The indexes for the latter are subject to about the same average annual rate of retardation: −0.30 and −0.29 percent. However, the difference between their secular trends lies in the wide disparity between their average rates of growth; the electric light and power rate of increase, averaged for the entire period 1902–42, was 2.7 times as great as that of manufactured gas. Thus, at the turn of the century, when the newly-born electric light and power industry was advancing at the phenomenal annual rate of 17.8 percent, the rate for manufactured gas was only 10.1 percent. The annual rate of retardation, −0.29 percent, applied to a relatively moderate initial average growth rate, brought the annual increase for manufactured gas down to 3.8 percent by 1920, and to less than zero after 1930. At the close of the last decade under review, gas was declining at an annual rate of 2 percent.

Differences among the gas indexes are of interest. At the turn of the century natural gas was rising at an annual rate of 6.7 percent; manufactured gas at 10.1 percent; the rate for the two industries

[2] Though the Census of Manufacturers first canvassed the industry in 1849, it did not report physical output data until 1899.

TABLE 40
Electric and Gas Utilities, 1899–1942
Indexes of Output (1929:100)

	ELECTRIC LIGHT AND POWER	MFD. GAS	NATURAL GAS	COMBINED MFD. AND NATURAL GAS	COMBINED ELECTRIC AND GAS	
					Unweighted	Weighted
1899		15.6	17.0	15.8		
1900	...	...	18.1	...		
1901		23.7	20.2	22.7		
1902	3.6	21.6	21.5	21.4	7.0	7.6
1903		24.7	22.8	24.0		
1904		26.6	23.7	25.6		
1905		27.0	26.8	26.7		
1906		30.2	29.7	29.8		
1907	7.5	33.3	32.5	32.8	12.6	13.4
1908		35.9	33.2	34.8		
1909		38.0	38.1	37.7		
1910		39.6	41.2	39.8		
1911		42.2	41.9	41.8		
1912	13.0	47.3	46.1	46.6	20.6	21.0
1913	13.6	50.0	46.2	48.5	22.0	21.9
1914	15.2	52.8	48.4	51.1	24.2	23.9
1915	16.6	53.1	51.6	52.3	26.2	25.3
1916	21.1	58.8	59.5	58.8	32.6	30.4
1917	24.5	65.8	63.7	64.7	37.8	34.6
1918	31.4	66.0	60.5	63.8	42.9	39.6
1919	36.0	71.2	60.8	67.2	47.6	44.1
1920	39.3	71.6	65.4	69.0	50.2	47.1
1921	36.3	69.2	52.3	62.9	45.8	43.3
1922	41.2	73.2	59.4	67.9	50.5	48.3
1923	50.0	79.5	64.7	73.7	59.6	56.4
1924	54.9	82.0	68.2	76.5	63.6	60.8
1925	63.5	83.6	69.2	77.8	69.6	67.4
1926	73.5	92.2	76.4	85.8	78.3	77.0
1927	81.7	97.3	80.2	90.4	84.9	84.2
1928	89.5	98.2	87.3	93.8	90.9	90.7
1929	100.0	100.0	100.0	100.0	100.0	100.0
1930	103.5	100.6	102.3	101.4	99.1	102.9
1931	101.9	98.0	99.9	98.9	94.6	101.0
1932	92.7	90.6	94.9	92.5	86.2	92.6
1933	92.8	85.4	92.1	88.4	87.8	91.5
1934	99.2	85.9	100.0	92.0	95.0	97.1
1935	108.2	85.9	107.9	95.5	102.5	104.5
1936	123.4	81.0	124.8	100.0	115.5	116.4
1937	136.3	81.9	132.1	103.7	124.8	126.3
1938	136.8	81.9	126.0	101.1	120.0	125.9
1939	151.6	83.6	135.8	106.3	133.1	137.5
1940	167.7	88.5	150.0	115.3	147.6	151.4
1941	190.5	90.9	159.9	120.9	169.0	168.4
1942	212.0	96.8	178.4	132.3	189.6	186.6

The weighted indexes of output for electric light and power, manufactured, and natural gas are taken from Tables 13 and 30. The construction of the combination indexes for electric and gas is discussed in Appendix A. The combined electric and gas 'unweighted' index of output is based on the separate unweighted indexes in Tables 13, 26, 28, and 29. The method of combining these indexes is indicated in Appendix Table A18.

TABLE 41

Electric Light and Power, Manufactured and Natural Gas Indexes of Weighted Output

Rates of Increase, at Ten-Year Intervals, 1900–1940

	AVERAGE ANNUAL RATE OF INCREASE (%)					AVERAGES FOR ENTIRE CURVE-FITTING PERIOD	
	1900	*1910*	*1920*	*1930*	*1940*	An. rate of gain (%) *	An. rate of retardation (%)
Electric light and power	17.8	14.4	11.1	7.9	4.7	9.87	−0.30
Mfd. gas	10.1	6.9	3.8	0.9	−2.0	3.72	−0.29
Natural gas	6.7	5.8	5.0	4.1	3.3	4.96	−0.08
Mfd. and natural gas	8.4	6.4	4.4	2.4	.5	4.30	−0.19
Electric and gas combined	13.1	10.8	8.5	6.2	4.0	7.60	−0.21

The annual percentage rates of increase at ten year intervals are obtained in the course of fitting a growth curve of the type $y = ka^x b^{x^2/2}$ to the output indexes, as outlined in Appendix D.

The results of the curve fitting process may be summarized as follows:

	Period of Fit	*Value of a*	*Value of b*	*Peak Year*
Electric light and power	1902–1942	1.0898	.99705	1952
Mfd. gas	1899–1942	1.0399	.99709	1935
Natural gas	1899–1942	1.0500	.99919	1979
Mfd. and natural gas	1899–1942	1.0448	.99810	1942
Electric and gas combined	1902–1942	1.0698	.99790	1958

The theoretical peak years are obtained by solving the expression $ab^{x+.5} = 1$ for x (see Ch. 1, note 26).

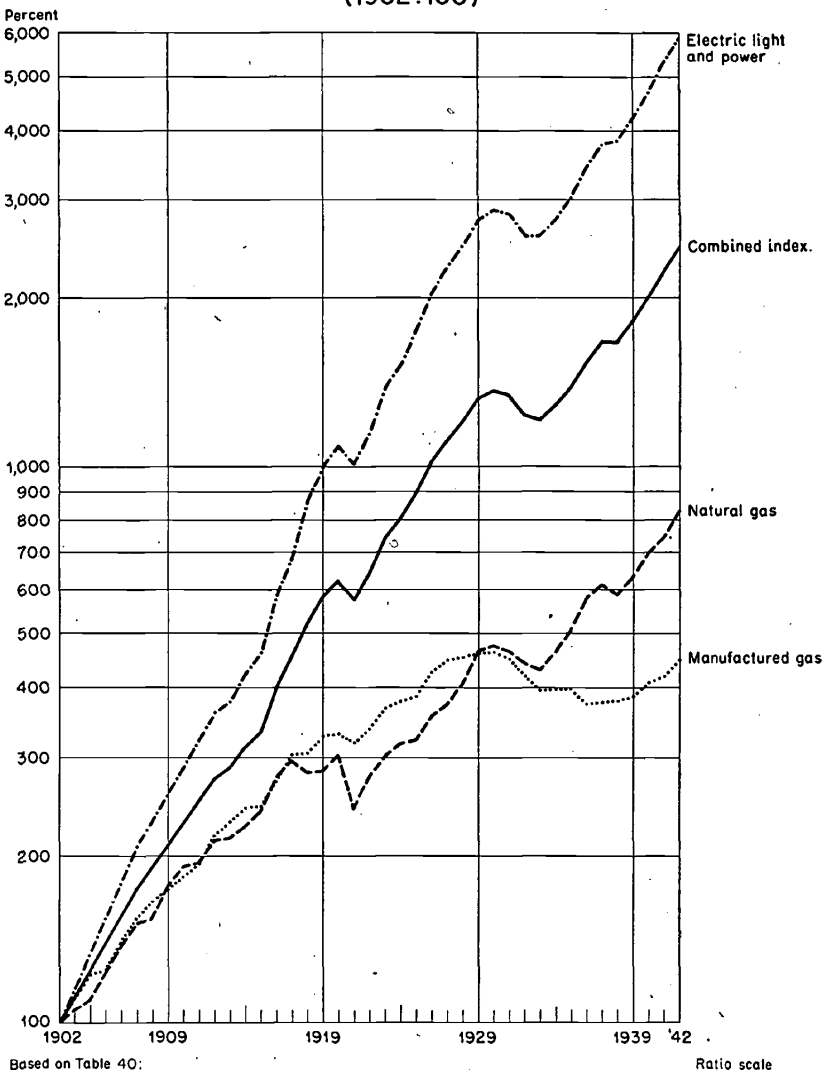
* Obtained from the value of r in fitting an exponential curve of the form $y = cr^x$ to the respective output indexes.

combined was 8.4 percent. The average annual rate of retardation for natural gas, however, was −0.08 percent, sufficiently lower than that for manufactured gas to give it a radically different secular trend. In other words, the index of natural gas output maintained its initial impetus far longer than the index of manufactured gas output; in 1940, when the trend of manufactured gas output was downward, natural gas was still increasing at the vigorous rate of 3.3 percent. The annual rate of increase for the combined industry, averaged for the entire period 1899–1942, was 4.3 percent; the average retardation rate −0.19 percent, midway between the retardation rates for the two industries. The secular trend of the output of manufactured and natural gas was still rising at the close of the fourth decade, but almost negligibly.

The theoretical peaks attained by the various fitted growth curves may serve to indicate the degree of 'maturity' of the three utilities,

CHART 20

Electric Light and Power, Manufactured and Natural Gas, 1902 – 1942
Weighted Indexes of Output
(1902 : 100)



subject to certain qualifications (see Ch. 1, Sec. 5). Thus, manufactured gas, with a theoretical peak in 1932, appears most 'mature', and natural gas, with a peak in 1979 appears 'younger' than the electric light and power industry, with a theoretical peak in 1955, although the production and consumption of natural gas as a utility

preceded the emergence of the electric light and power industry. The theoretical peak year for the combined (weighted) electric and gas output index is 1958, sufficiently in the future to preclude regarding the combined utility industry as mature — that is, considerable secular gains may still be expected. It should be re-emphasized here that the use of such theoretical peak years as indicators of maturity has uncertain validity for purposes of prediction, but merely helps to summarize the growth and retardation trends within the fitted period.

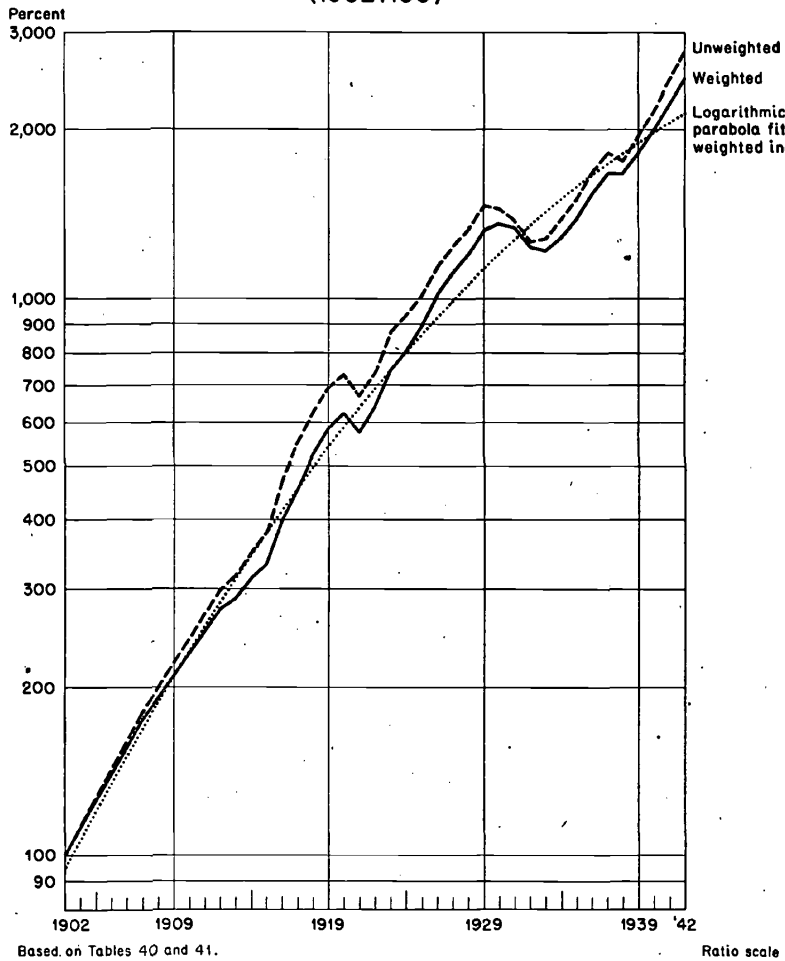
When all three indexes are merged in a combined (weighted) index of utility output, the resulting pattern most clearly resembles that of electric light and power, the dominant component. The average annual rate of growth, as indicated by fitting an exponential curve to the weighted index of electric and gas output for 1902–42, was 7.6 percent; the corresponding annual gain for electric light and power alone was 9.9 percent; for manufactured gas (1899–1942), 3.7 percent; for natural gas (1899–1942), 5.0 percent. Thus the net effect of including the gas indexes is to reduce the over-all rate of advance in utility output. The decline in the output of manufactured gas after 1929 contrasts sharply to the upward trends of the other components.

The combined utility index considered above (Table 40 and Chart 21) is based on price-weighted indexes of electric and gas output. Another combined index may be based on the unweighted aggregates of electric current and gas sales presented in Chapters 1 and 3. The unweighted combined index is necessarily price-weighted so far as the component electric and gas indexes are combined by means of unit value weights obtained from the revenues earned in each industry. Divergences between the two combined indexes would reflect shifts in the consumption of high- and low-valued services within each utility industry, although such divergences are minor (Chart 21) and are due mainly to a greater than average increase from 1902 to 1920 in the low-valued power sales. The tendency for the unweighted index of output to rise somewhat more rapidly than the weighted has been counteracted in part since 1920 when an added impetus in the high-valued domestic sales component closed the gap between the over-all rates of advance between high- and low-valued services. For 1902–42 as a whole, there is little difference between the two combined indexes. The

1902–42 percentage increase in the unweighted index is equivalent to an average annual rate of 8.7 percent; for the weighted, 8.4 percent. In either case, the rate of advance is sufficient to accord the electric and gas utilities a noteworthy place among American industries.

CHART 21

Electric and Gas, 1902–1942
Unweighted and Weighted Indexes of Output
(1902:100)



2 *Productivity Trends*

A summary of the changing relation of output to input for the combined electric and gas utility industry is impeded by the absence of

natural gas employment data for early years. Total utility employment as depicted in Table 42 rests in part on crude straight-line interpolations of our fragmentary gas employment data, but these figures may help to indicate at least the general trend (Chart 22). The employment patterns in the electric and gas utilities are similar in that sharp rises in the first three decades of the century are followed by a plateau or even decline. But the rates of advance differ markedly. In 1902 employment in the gas industries was about 85 percent greater than in electric light and power. The latter industry expanded so rapidly that after 15 years employment in the two was about the same. By 1929 electric employment was 110 percent greater than in gas. After 1929, however, it declined more rapidly. Omitting 1942, a year affected by labor shortages, the index of electric employment in 1941 was 3.4 percent below the 1929 peak; gas employment declined only 0.3 percent; the reason, as we saw in Chapter 4, was the rapid growth of natural gas distribution in the '30's.

TABLE 42
Electric and Gas Utilities, Selected Years, 1902–1942
Output, Employment, and Output per Man (1929:100)

	WEIGHTED OUTPUT INDEX	EMPLOYMENT (thousands)			INDEXES OF EMPLOYMENT			WEIGHTED OUTPUT PER MAN INDEX
		Electric light and power	Mfd. and natural gas	Total	Electric light and power	Mfd. and natural gas	Total	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1902	7.6	30.3	56.2	86.6	10.4	40.4	20.1	38.0
1907	13.4	47.6	75.1	122.7	16.3	53.9	28.4	47.0
1912	21.0	79.3	95.0	174.4	27.1	68.3	40.4	51.8
1917	34.6	105.5	107.7	213.2	36.1	77.4	49.4	69.9
1919	44.1	120.2	110.6	230.7	41.1	79.4	53.5	82.4
1925	67.4	215.2	127.6	342.8	73.6	91.7	79.5	84.9
1929	100.0	292.3	139.2	431.5	100.0	100.0	100.0	100.0
1930	102.9	301.8	131.1	432.9	103.3	94.2	100.3	102.5
1931	101.0	281.0	124.5	405.5	96.1	89.4	94.0	107.5
1932	92.6	244.6	114.3	358.9	83.7	82.1	83.2	111.4
1933	91.5	229.5	119.2	348.7	78.5	85.6	80.8	113.3
1934	97.1	238.4	125.9	364.3	81.6	90.4	84.4	115.0
1935	104.5	244.8	127.1	371.8	83.7	91.3	86.2	121.3
1936	116.4	262.3	135.3	397.7	89.8	97.2	92.2	126.3
1937	126.3	281.3	135.6	416.9	96.3	97.4	96.6	130.7
1938	125.9	272.5	131.6	404.1	93.2	94.6	93.7	134.4
1939	137.5	271.0	132.7	403.7	92.7	95.3	93.6	147.0
1940	151.4	277.4	138.2	415.5	94.9	99.3	96.3	157.2
1941	168.4	282.2	138.8	421.1	96.6	99.7	97.6	172.6
1942	186.6	263.4	121.9	385.3	90.1	87.6	89.3	209.0

Column 1 from Table 40; column 2 from Table 21; column 3 based on Tables 36, 37, and 38, though straight line interpolations were performed when necessary to get estimates for 1902–25.

Totaling the electric and gas employment data enables us to consider the index of total electric and gas output per man (Table 42). It records a remarkable advance in productivity, the end year observations being equivalent to an average annual gain of about 4.4 percent.

This is a remarkable achievement, as is evident from a consideration of productivity gains in other sectors of the economy. Indexes of output per man in manufacturing, agriculture, mining, and railroading have been prepared for other books in this series.[3] Exponential growth curves have been fitted to these indexes to get average annual rates of increase that are not greatly affected by differences in the time spans of the various indexes. These rates of

INDEXES OF OUTPUT PER MAN

	PERIOD	AVERAGE ANNUAL RATE OF INCREASE
Manufacturing	1899–1939	1.88
Agriculture	1900–1938	1.10
Mining	1902–1938	1.64
Railroads	1899–1939	1.85

increase are much lower than those characteristic of the electric and gas utilities. An exponential growth curve fitted to the output per man index for electric light and power 1902–39 yields an average annual gain of 4.1 percent; for manufactured gas, the average annual gain 1899–1939 is 2.4 percent.

Retardation is characteristic of the growth of output, as we have seen. Is the growth of productivity likewise subject to retardation?[4] There is little evidence of retardation in our index of total electric and gas output per man (Chart 22).[5] In the electric light and power industry, acceleration, rather than retardation, seems to characterize the growth of output per man and per manhour (Charts 9 and 10). On the other hand, retardation clearly affects the growth of output per man in the manufactured gas industry (Chart 19).

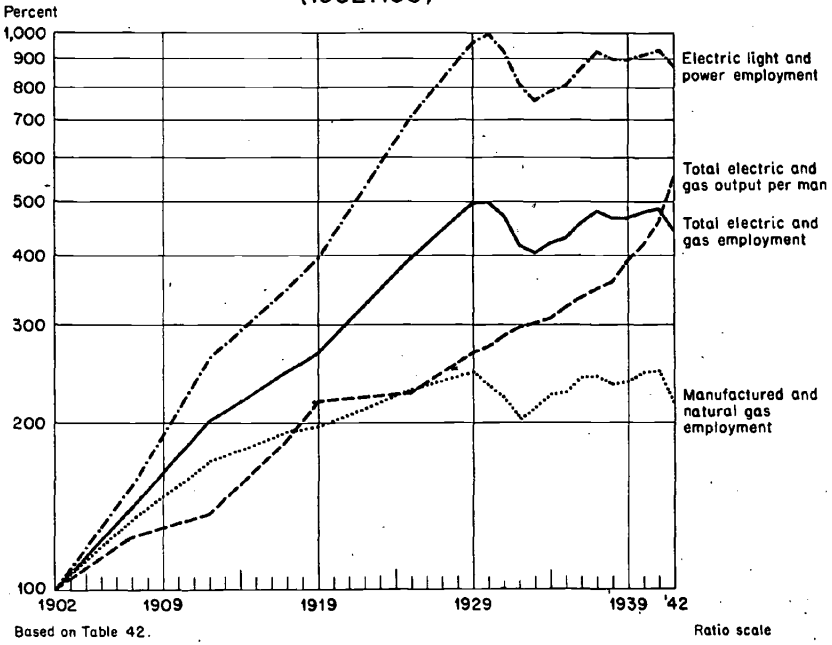
[3] Solomon Fabricant, *Employment in Manufacturing, 1899–1939* (1942), p. 331; Barger and Landsberg, *American Agriculture, 1899–1939* (1942), p. 251; Barger and Schurr, *The Mining Industries, 1899–1939* (1944), p. 343. The railroad index is from a study (in preparation) on productivity trends in the transportation industries.

[4] Following the usage adopted by Arthur F. Burns in *Production Trends in the United States Since 1870* (National Bureau of Economic Research, 1934), we use the term 'retardation of growth' synonymously with 'decline in the rate of growth'.

[5] Fitting a logarithmic parabola to the index may yield a precise measure of the change (in this case, slight acceleration) in the annual rate of advance, but the highly conjectural character of the pre-1929 employment estimates on which the index rests would render such precision of doubtful value.

CHART 22

Electric and Gas, 1902–1942
Indexes of Employment and Weighted Output per Man
(1902:100)



It is interesting to speculate about the pattern of changes in the rate of growth in productivity trends. On the one hand, it is difficult to conceive of *accelerated* growth in the movement of output-input ratios as anything except a short term phenomenon. Can any other general pattern be postulated for the secular movement of output-input ratios? If acceleration is ruled out, other possibilities are that either the trend of productivity may be generally characterized by a constant rate of increase or the rate of increase (which is usually vigorous at some early stage of an industry) eventually falls off. If the 'falling off' is sustained and systematic, declining productivity will be reached as the rate of increase falls to zero and becomes a rate of decline.

Some light may be thrown on this problem by applying our growth curve analysis. As noted in Chapter 1, the curve form $y = ca^x b^{x^2/2}$ has the virtue of indicating by the value of b the average rate of change to which the rate of growth is subject during the period considered. The degree to which b approaches unity

indicates the degree of uniformity in the annual growth rates during the entire period; and the degree to which b falls above or below unity, the degree to which the successive annual rates of growth are subject to acceleration or retardation respectively.

The rising output per man indexes for the manufacturing, agricultural, mining, and railroad industries reveal on the whole a rather remarkable absence of either retardation or acceleration of growth rates.[6] Despite different average annual rates of growth, these rates for each industrial group, as determined by the fitting of growth curves to the indexes, have been maintained with marked constancy during the last four decades. For the manufacturing,

INDEXES OF OUTPUT PER MAN

	PERIOD	AVERAGE ANNUAL RATE OF INCREASE	AVERAGE ANNUAL RATE OF RETARDATION (OR ACCELERATION)
Manufacturing	1899–1939	1.88	+.004
Agriculture	1900–1938	1.10	+.032
Mining	1902–1938	1.64	+.002
Railroads	1899–1939	1.85	−.009

agriculture, and mining labor productivity indexes the rates of change in the growth rates are actually rates of acceleration (as indicated by the plus sign), but in all except agriculture they are so small as to lessen the statistical significance of the positive or negative sign.[7]

On the average then, when divergences of individual industries are canceled, progress in labor productivity in the basic industrial sectors has been strikingly steady. The output per man indexes for the electric and gas utilities, however, do not conform to this pattern of a constant rate of advance.

A logarithmic parabola fitted to the index of electric light and power output per man 1902–42 reveals an acceleration of growth at an annual rate of .045 percent, too high to be attributed to random causes. The marked acceleration in electric light and power

[6] For individual industries, rather than the combined groups considered here, output per man indexes may of course show pronounced acceleration or retardation of growth.

[7] E.g., when plotted on log paper, all productivity indexes except that for agriculture may be represented with reasonable goodness of fit by straight lines.

A more precise test of the statistical significance of the value of b is afforded by the method of orthogonal polynomials, which may conveniently be applied to time series in which the independent x variable is equally spaced. Such a test, for example, when applied to the productivity index for manufacturing, indicates that the fitting of a second degree polynomial to the logarithms of the index values for successive years does not 'explain' or account for more variation in the dependent y variable than could be regarded as chance or random variations from a linear regression.

productivity, together with its extremely high average rate of gain, may perhaps be attributed to the industry's relative youth, although such a reason could not account for the slight acceleration in the labor productivity index for agriculture. The possibility that electric light and power productivity gains will taper off as the industry matures is suggested by the retardation — at the statistically significant annual rate of −.102 percent — revealed by a logarithmic parabola fitted to the output per man index for manufactured gas, an industry whose declining output in recent years warrants its designation as more 'mature'. However, we do not have sufficient evidence to elaborate any theory that productivity gains are correlated with an industry's stage of development. Some industries, such as the railroads, suffered secular declines in output in the '30's, but continued to achieve considerable gains in output per worker. On the other hand, many more industries in the field of manufacturing suffered losses in productivity after passing peak output levels in 1929. The relation of output levels to productivity rates is obscured by cyclical factors, which in the short run can greatly affect both output and productivity. To determine the secular relation between output and productivity we require a greater body of recorded experience than we now have for industries that have clearly and without doubt entered into stages of decline. For this purpose the behavior of our utility indexes can be little more than suggestive.

The growing efficiency attending the production and distribution of electricity and gas is inadequately, as we saw in Chapters 2 and 4, depicted by output per worker indexes, and we attempted to relate utility output to the consumption of fuel and the employment of capital equipment. It is interesting to note the effects of retardation in these measures of the efficiency of resource use, all of which reveal substantial gains since the turn of the century. The increases registered by our index of output per unit of fuel for electric light and power have clearly fallen off (Chart 5). The index of gas output per 1,000 Btu. of fuel input, excluding purchased gas, too has fallen off (Chart 18), and in any case retardation may be expected as perfect thermal efficiency is approached. Similar natural limits may be set for our indexes of electric light and power output per unit of fuel consumption and of capital equipment. So far the latter shows marked acceleration rather than retardation (Chart 7), but its very

nature imposes definite technical limits to its upward advance, so that increases must fall off when capital equipment is fully utilized, day and night, throughout the year. In manufactured gas retardation is evident in the index of output per mile of gas main, which has been declining for many years. The experience of the utilities suggests then that retardation may, sooner or later, be expected to affect the rise in the output-input ratio, though it is not yet evident in the index of utility output per man, an index that does not have, on a priori grounds, a ceiling beyond which no further gains can be expected.

We do not have the data to consider the movements of an over-all index of utility output per manhour, but it is clear from electric light and power and manufactured gas that the prospects of continued gain in output per manhour in the utilities are good. This fact carries twofold implications. In general, a continuing advance in output per unit of labor is a prerequisite for a rise in living standards. But such a trend contains the challenge that output must proceed to higher and higher levels if employment is not to decline. The implied judgment, of course, is valid only for the functioning of the economy at large, not for such a small sector as the electric and gas utility industry.

Nevertheless, future employment prospects in the electric and gas utilities are of interest. The record of the '30's is not too encouraging, for despite a slight increase in the natural gas component, employment in the expansion years of the late '30's never exceeded, or even equaled, the peak levels of 1929, despite a notable advance in output, which by 1940 was rising at an annual rate of 4 percent. The indications are that only with a great expansion in the consumption of electricity and gas, at a rate approaching that achieved in the first two decades of the century, can the utilities be regarded as a large source of new employment. Such an expansion cannot, however, be ruled out, as the rejuvenation of the manufactured gas industry in the early 1900's suggests. Moreover, the war imposed many restrictions on the industry's expansion and the extension of utility services beyond today's limits will undoubtedly give rise to employment in the capital equipment industries catering to the utilities. Within the latter, whether or not previously established output trends continue, growth in employment will lag behind output.