CHAPTER VII

Growth and Decline of Industry

1. The Automobile-Building Boom of the Twenties. Growth of industry plays an extremely important role in activating national savings and putting them in plant investment. In the United States the growth of the automobile industry undoubtedly had much to do with the prosperity during the period 1921-1929. It is, of course, not implied that labor used directly in producing automobiles brought about prosperity. In the picture must be included the labor used in the oil industry, in highway construction, in demolition of old residences to be replaced by filling stations, garages, etc., and in the building of roadside inns, tourist camps, etc. There was also the collateral activity generated in the production of machinery to equip industrial plants and utility plants.

During the period of expansion brought about by the mass production of the automobile, construction activities, services in connection with filling stations, oil drilling, etc., required vast amounts of unskilled and partly skilled labor, which commanded high wages. If a technological improvement was introduced in any consumers' goods industry, this meant that someone was available for the activities mentioned above. Those making the technological changes profited because of lower cost. Labor was only temporarily displaced since jobs in the expanding industries were plentiful. High profits in these expanding industries tempted capital, so that everyone was happy. Between 1921 and 1929 the United States spent five to six billion dollars a year on industrial and utility plant expansion alone. An analysis of the industrial activity of the country discloses the fact that during this period the production of capital goods employed approximately a third of all the industrial workers.

It seems to be unnecessary to add that the expanding economy of the United States in the period 1921-1929 offered a situation quite unlike the static equilibrium that has been so often pictured by economists. It is important, therefore, to consider the economic structure of an expanding economy, i.e., a dynamic economy. Before considering this general problem, it is desirable to consider the problem of population growth, because the problems are related.

*2. Population and Sales Growth.** The Pearl-Reed population curve (the logistic) is based upon the following assumptions:

(a) physical conditions set some upper limit U to the population growth;

(b) growth in the population y is proportional to the existing population; and

(c) growth in the population is proportional to the potential expansion of population $U - y$.

The above assumptions can be summarized in the differential equation

$$(2.1) \qquad dy/dt = ay(U - y) \ ,$$

where a is a constant.

The equation (2.1) is the fundamental differential equation of the autocatalytic theory. The derivative dy/dt is zero at $y = 0$ and at $y = U$ and between these points it is everywhere positive and traces a parabola which is symmetrical with respect to $U/2$.

It is evident that the assumptions (b) and (c) are not the only likely ones that can be made for the human population. All that can be safely asserted is that $dy/dt = 0$ at $y = 0$ and at $y = U$ and $dy/dt > 0$ between $y = 0$ and $y = U$. Thus, the equation

$$(2.2) \qquad dy/dt = a(y + by^2 + cy^3)(U - y)^d$$

is just as reasonable as (2.1).

The equation (2.1) integrates into the form

$$(2.3) \qquad y = U/[1 - e^{-k(t - t_0)}]$$

where $k = aU$ and t_0 is a constant of integration.

The logistic curve (2.3) fits the United States population fairly well, but for the population of Germany two logistics are required; that is,

$$(2.4) \qquad y = U_1/[1 + e^{-k(t - t_0)}] + U_2/[1 + e^{-m(t - t_1)}] + C.$$

*The treatment given here is based on an unpublished manuscript by Victor von Szeliski.

The first logistic term represents the evolution of the German population in the agricultural handicraft stage of development, whereas the second represents the population made possible by the industrial revolution.*

The right-hand side of (2.1) can be split into two factors, one of which proportional to y is the physiological rate of growth which for the United States is about 3.134% per annum. The other factor represents inhibitors of growth, the physical environment chiefly.

Pearl's treatment suggests that as technology progresses, the upper limit of population growth nevertheless remains constant at $U_1 + U_2 + C$. It implies that if seven very accurate population counts had been available prior to 1800 (say) the new cycle of development that made the industrial revolution possible could have been forecast prior to the invention of machinery. The upper limit U_1 certainly exists due to a set of physical inhibitors prior to the invention. However, the technological addition U_2 cannot be considered as constant throughout the course of evolution. In fact, it is probably more nearly correct to assume U to be a continuous function of the time, $U(t)$, and dependent on the existing technology and physical facilities of the moment. The differential equation then generalizes into

$$dy/dt = ay[U(t) - y] \quad , \tag{2.5}$$

where $U(t)$ is a continuous function and indeterminate from *a priori* considerations. Actually $U(t)$ depends upon many economic and technological factors variable in time. The quantity a may also depend on various economic factors.

Needless to say, when either a or U is not constant a curve different from the Pearl-Reed logistic is obtained. Thus, it is not surprising that some attempts to fit logistics to demand for new products have been unfruitful.

Suppose that automobiles are introduced into a stable population and that at the time t a certain automobile population, v, exists. For simplicity suppose that the upper limit will be one car per family and let m be the number of families. If replacements are ignored, the number of prospective purchasers is $m - v$.

It is reasonable to assume that if an automobile company has a car to sell, the probability that it will be able to sell the car is proportional to the number of prospects; i.e., $probability =$

*Raymond Pearl, *Studies in Human Biology*, Baltimore, 1924.

$a(m - v)$. The quantity a will, of course, vary as the product becomes known to the population and wants are built up. If the succeeding strata of prospects have progressively less and less money, or are progressively more and more immune to sales talk, the probability will not be a linear function of $m - v$.

The quantity a will to a first approximation depend linearly on v. Also the stimulus offered to the prospects is proportional to the number of automobiles in use. At least during the early stages of exploitation of a market there is a tendency for sales outlets to expand according to an exponential law of growth. In other words, the number of people who set up as automobile dealers probably bears a more or less constant relationship to the number who purchased during the preceding interval of time. Furthermore, advertising by magazine, radio, etc., but more likely direct contact with the product, increases the number of persons who want the product. Facilities for service, showrooms, etc., have to be built up out of profits, or out of loans which depend upon expected dollar value of profits.

It is thus seen that under quite restricted assumptions the rate of change of number of automobiles in use may be taken to be

$$dv/dt = av(m - v) ,$$

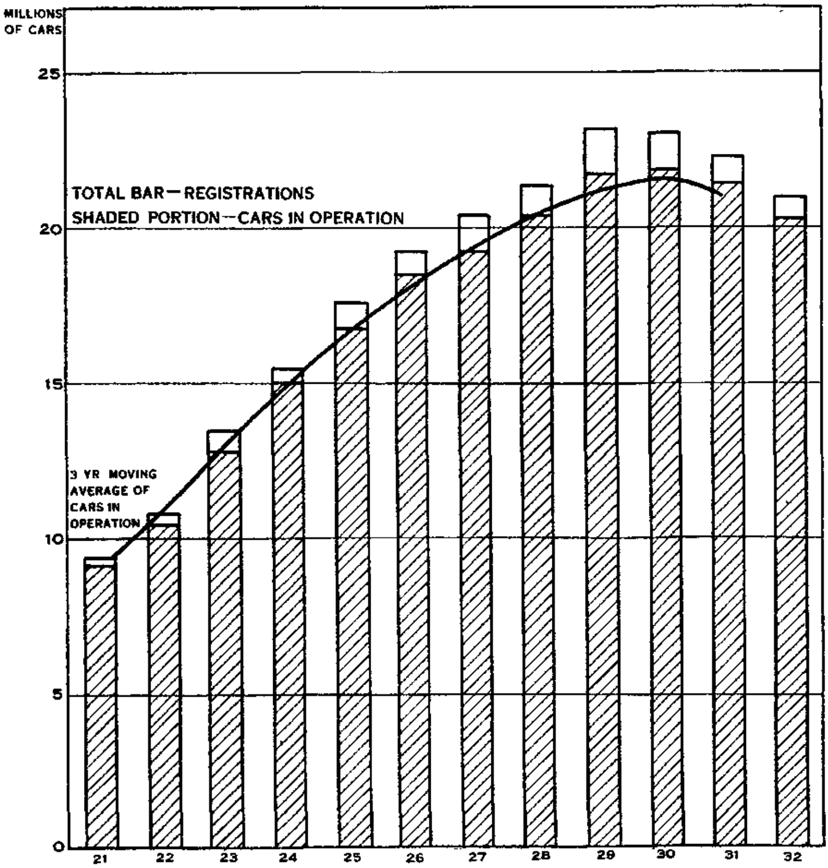
where a and M are functions of time t. Thus, a curve of growth of automobile demand should somewhat resemble a logistic curve.

3. Total Cars in Operation in the United States. In the preceding consideration of the growth in demand for automobiles, replacements were ignored. For the theory to be applicable, therefore, cars in operation must be regarded as the equivalent of v. The assumption made here is that, on the average, once a purchaser has had an automobile he will replace it or directly or indirectly influence someone else to take his place as an owner.

The best known measurement of the usage of passenger automobiles in the United States is total passenger car registrations, which is illustrated in Chart XXI. Registrations exceed cars actually in use so that corrections for this element of error should be made. The white portion at the top of each bar in this chart represents this correction and the shaded portion of the bar represents

PASSENGER CAR REGISTRATIONS

CHART XXI



Automobile registrations have shown increases from 1921-1929. The curve of growth resembles a logistic. Apparently cars in use began to stabilize (draw near to the upper asymptote) near 1929. However, stabilization is at a certain price. It is always possible for a new asymptote much higher to be set by important price concessions, new uses, etc.

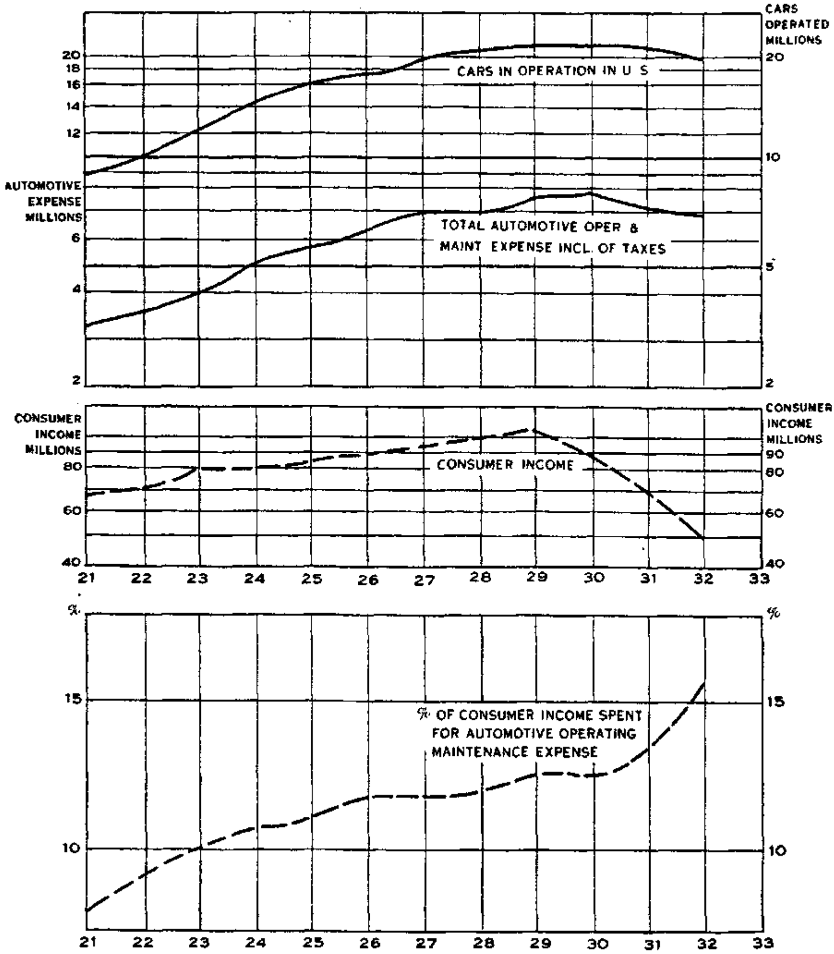
the best estimate of the cars registered which were actually in service at the end of each year from 1921-1932.*

*See Stephen Du Brul, *Analysis of the Automobile Market,* General Motors Corporation. Sections 3 and 4 of this chapter are based on Du Brul's study.

Since writing this, my attention has been called to an unpublished manuscript by Victor von Szeliski developing other aspects of the problem.

PERCENTAGE OF CONSUMER INCOME SPENT ON AUTOMOBILE OPERATION

Chart XXII



Number of cars in use and owners' expenditures for their maintenance are relatively stable, in fact, much more stable than consumer income. Automobile transportation is about as important as food and clothing in the American family's budget.

The number of cars in operation rose steadily but with decreasing rate from 1921 to 1930 when a peak was reached. Since 1930, cars in operation have been declining slightly. Earlier series show that the number of cars in operation started out slowly during the years of development of the commodity, then increased rapidly to 1925, when the increase began to taper off. An examination of the chart might indicate that, by 1929, cars in operation apparently approximated their point of stabilization. If the 1929 value approximately represents the stabilization point, rate of growth in the future will be slow and will be dependent more or less on the growth of population unless new uses are found or drastic price reductions can be made. However, severe decline in purchasing power since 1929 makes it extremely hazardous to assert that total cars in use in 1929 approximated the maximum that could be used by the population.

A comparison of cars in operation with consumer incomes shows clearly that automobile transportation is about as important as food and clothing in the American family's budget and, in many cases, even more stable than shelter. The basic demand for automotive transportation is therefore very strong — see Chart XXII.

4. New Car Domestic Sales. As pointed out, it appears that the demand for automobiles stabilized in 1929. The automobile industry is, therefore, almost entirely on a replacement basis. As Du Brul* has shown, retirements are by no means at a constant rate. On the contrary, the rate of retirement appears to vary considerably from year to year. Chart XXIII-A shows estimated car retirements, and Chart XXIII-B shows the ratio of car retirement to the straight line trend of estimated car retirement. The superimposed lines indicate the average car life corresponding to variations in the rate of retirement. In the boom year of 1929, the retirement rate was equivalent to an average car life of less than six years, whereas in 1931 the retirement rate was equivalent to an average car life of over seven years. The rate of retirement for 1932 was estimated to be equivalent to an eight year car life. Thus, the American public is able to maintain its high rate of usage in the face of a sharp drop in income by prolonging the lives of the cars that it possesses. The rate of retirement is largely a function of economic conditions.

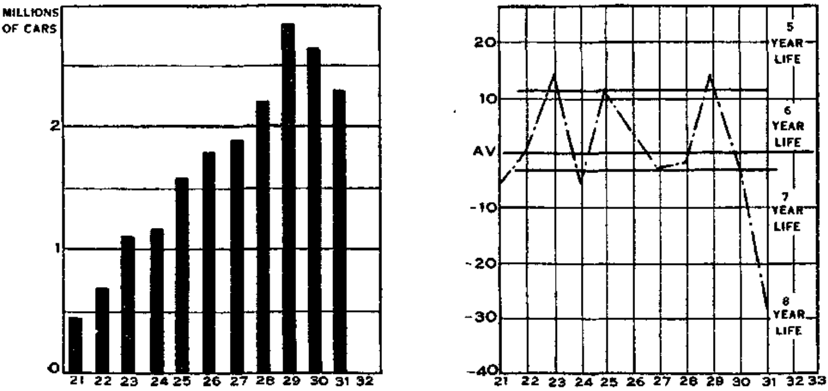
New car replacement demand is largely influenced by economic factors rather than mechanical ones. Chart XXIV contrasts total

*Stephen Du Brul, *loc. cit.*

ESTIMATED CAR RETIREMENTS

DEVIATION OF RETIREMENT FROM TREND

CHART XXIII



A B

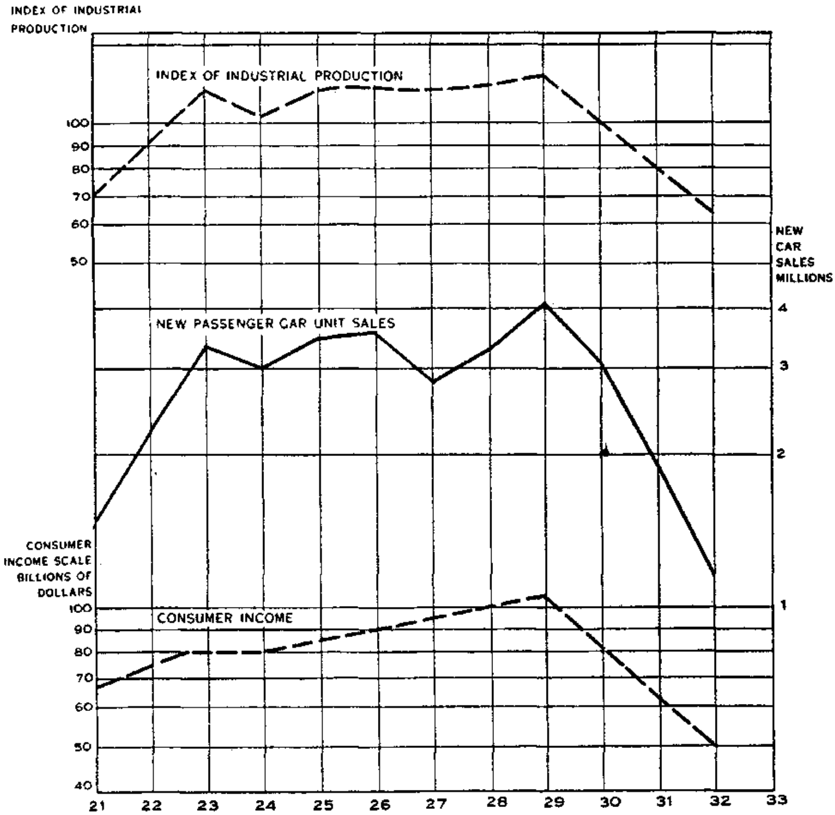
By taking the ratio of actual retirements A to the trend (average) as indicated in B it is possible to compare change in the rate of retirement more closely. For classification a series of lines have been superimposed on B to indicate the average car life corresponding to variations in the rate of retirement.

new passenger car sales from 1921 to date with consumer income during this period and an index of industrial activity. Thus, new car domestic sales depend largely upon consumer income. The percentage of total consumer income spent on new cars and the per cent of consumers' total automotive expenditures devoted to new car purchases show a substantial drop since 1929. This further indicates that new car demand is extremely sensitive to changes not only in current income but also in prospective income. This is to be expected since the purchase of a new car represents a capital expenditure to the consumer. When consumers feel confident of the future they capitalize that future in current expenditures (assisted by time payments in many cases). When, however, their future income is uncertain, they content themselves with their existing equipment.

It is possible to conclude, therefore, that the public will buy new cars when it has the money and will retire old cars more rapidly. Thus, even with stabilization in the total usage of cars, a rapid expansion in new car demand is quite possible. On the other hand,

NEW CAR SALES, CONSUMER INCOME AND INDUSTRIAL PRODUCTION

CHART XXIV



Since 1923 new car sales have followed closely consumer income. New car sales can be used as a rough index of consumer income.

a rapid contraction in new car demand can occur without any material contraction in usage.

5. *Competition of Growing and Declining Industries.* Examples of growing industries have been considered at some length. Some industries after reaching maturity may undergo a more or less steady decline irrespective of cyclical fluctuations in business. A few years ago the horse constituted the principal farm power. His

displacement by tractors and other farm machinery has been going on at a very rapid rate since the World War. Some statisticians estimate that the passing of the horse in the United States has made it necessary to retire thirty millions of acres of land that had formerly been used to grow horse feed.

Of recent years the coal industry has faced serious competitition with the oil industry. Replacement of coal power plants of steamships by oil plants has proceeded at a rapid rate. Many industrial plants and homes have changed from coal to oil or natural gas. Part of the displacement has undoubtedly been due to the inability of the coal industry to lower its price sufficiently on account of high fixed transportation costs, but much of it has been due to natural advantages of oil and gas over coal.

Lumber is an outstanding example of a declining industry. For building purposes lumber has faced serious competition with steel, cement and fireclay products. Wooden boxes have been replaced to considerable extent by paper boxes. Wooden bridges have yielded to steel structures and so forth.

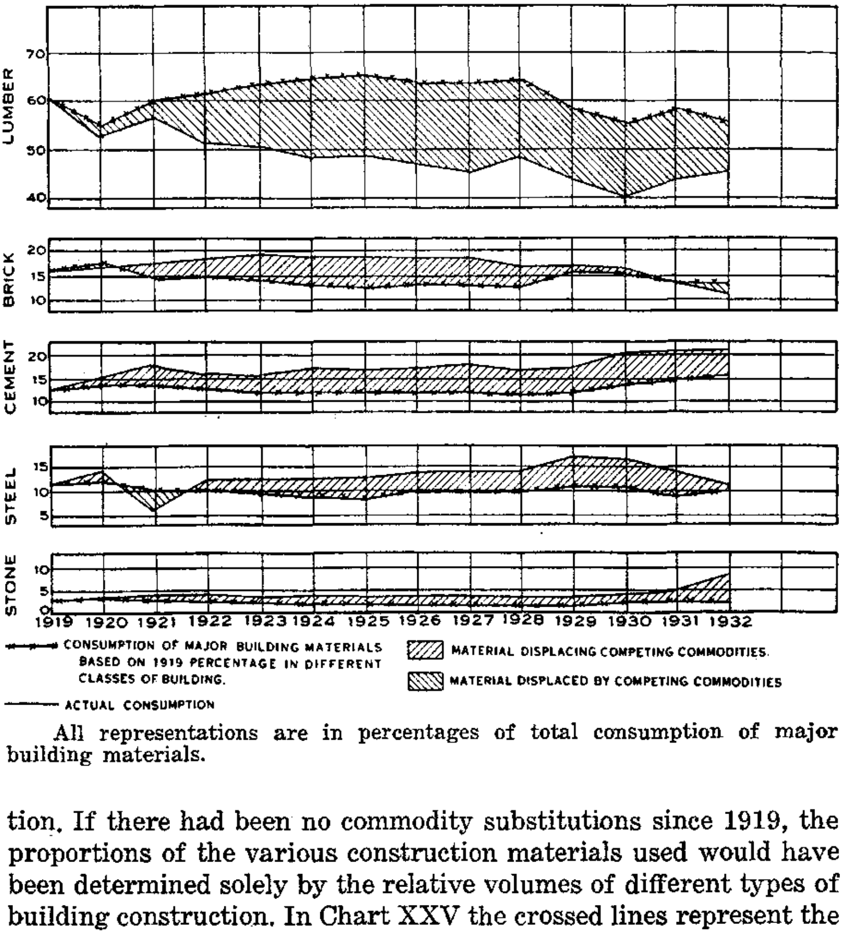
Displacement of lumber by steel, cement, stone and fire-clay products (brick, terra-cotta, tile), and other shifts between amounts of these commodities consumed, may be separated into three classifications: (1) shifts due to changes in the relative volumes of different types of building construction, (2) temporary shifts due to price competition, and (3) permanent commodity substitutions due to changes in consumer taste.* The first factor measures long term, but not quite permanent, shifts in potentialities for consumption.

An estimate of the extent of commodity substitution can be obtained by eliminating from the shifts in actual consumption the effect of shifts in types of building construction. Building can be divided into three classes: (1) residential; (2) industrial, which is here taken to include factory and commercial; and (3) public, which includes educational, institutional, Government, religious, memorial, social and recreational. The classification "public works and utilities" has been omitted since these buildings require little lumber, but in the study presented below corrections for the omissions have been made. Table X gives the percentage consumption of major building materials in the United States and Table XI gives the percentage distribution of classes of building construc-

*This study of commodity substitutions of steel, cement and clay products for lumber is based on an unpublished paper by Victor Perlo, "Displacement of Lumber in Building Construction."

SHIFTS IN RELATIVE CONSUMPTION OF MAJOR BUILDING MATERIALS

CHART XXV



All representations are in percentages of total consumption of major building materials.

tion. If there had been no commodity substitutions since 1919, the proportions of the various construction materials used would have been determined solely by the relative volumes of different types of building construction. In Chart XXV the crossed lines represent the consumption of major building materials based on 1919 percentage in different classes of building. The plain lines represent the actual consumption, and the space between represents the commodity displacement.

By 1924, twenty-five per cent of the lumber which on the basis of use in 1919 would have been used in 1924 had been displaced by competing commodities. During 1924-32 there was no significant displacement of lumber, and since 1927 there has been a trend towards lumber, which became very sharp in 1932. In the 1927-32 period the price of lumber was kept continually under its normal competitive price relative to competing commodities and there was an especially sharp decline in price in 1931, which increased 1932 relative consumption of lumber.

TABLE X
PERCENTAGE CONSUMPTION OF MAJOR BUILDING MATERIALS

YEAR	LUMBER	STEEL	CEMENT	BRICK	STONE	TOTAL
1919	59.7	10.8	11.8	15.7	2.0	100.0
1920	52.6	13.6	14.9	16.4	2.5	100.0
1921	56.4	5.9	17.2	17.3	3.2	100.0
1922	50.8	11.8	15.6	18.4	3.4	100.0
1923	50.6	11.9	15.3	19.2	3.0	100.0
1924	48.7	12.2	16.8	18.9	3.4	100.0
1925	49.1	12.2	16.3	19.1	3.3	100.0
1926	47.2	13.5	16.8	18.9	3.6	100.0
1927	45.4	13.8	18.0	19.0	3.8	100.0
1928	48.3	14.2	16.8	17.2	3.5	100.0
1929	44.1	17.2	17.3	17.4	4.0	100.0
1930	40.4	17.1	20.6	17.1	4.8	100.0
1931	44.0	14.6	21.2	14.3	5.9	100.0
1932	46.0	11.8	21.4	12.1	8.7	100.0

Brick includes common, face and vitrified brick, terra cotta, hollow building tile and fire brick. Stone includes building stone, rubble and riprap.

Stanley B. Hunt, who has studied the price competition of rayon, silk, cotton and wool fibers,* says:

> "For whereas the trend of the total poundage consumption of the four fibers as a whole has increased at a rate of about 3 per cent per annum for this period (1919-31), the individual fibers have shown decidedly different trends in that time. And while the average prices of all the fibers have declined, due principally to the general downward trend of all prices since the war, the individual fibers have shown varying declining price trends during the period.
>
> Specifically, the exhibits (Charts XXVI, XXVII and XXVIII) show that the more the price of a given fiber is

*Stanley B. Hunt, "Rayon Consumption and Price in Relation to the Other Fibers," *Textile World*, Sept. 26, 1931, p. 90-92.

reduced, the larger will be its consumption, all in relation to the other fibers, of course. This means that by certain price relationships the consumption of one fiber may be increased at the expense of another or other fibers; it does *not* mean that lower general textile prices in themselves will stimulate a demand for textiles."

TABLE XI

PERCENTAGE DISTRIBUTION OF CLASSES OF BUILDING CONSTRUCTION

YEAR	RESIDENTIAL	INDUSTRIAL	PUBLIC	TOTAL
1919	47.8	34.8	17.4	100.0
1920	37.8	35.9	26.3	100.0
1921	45.8	27.5	26.7	100.0
1922	48.0	29.8	22.2	100.0
1923	52.3	28.8	18.9	100.0
1924	54.4	25.3	20.3	100.0
1925	55.7	24.2	20.1	100.0
1926	53.0	27.6	19.4	100.0
1927	52.3	26.6	21.1	100.0
1928	54.0	27.0	19.0	100.0
1929	44.6	34.5	20.9	100.0
1930	38.2	30.9	30.9	100.0
1931	42.0	22.6	35.4	100.0
1932	36.8	21.8	41.4	100.0
1933*	38.9	36.8	24.3	100.0

*Based on data for first eleven months. Data from F. W. Dodge reports.

Note: Industrial includes Commercial and Factory Buildings.
Public includes Educational, Hospitals and Institutions, Public Buildings, Religious and Memorial, Social and Recreation, Military and Naval Buildings.

6. Wages in Expanding and Declining Industries. Wages paid for a standard type of work often differ from industry to industry. Risk or hazard of occupation, conditions of work, size of town in which the industry is located and various minor factors account for these differences in wage rates for the "same" work. There is, of course, also the question of the productivity of the labor, i.e., a comptometer operator may get paid fifteen dollars per week in one industry and another operator twenty in another industry simply because the productivity of the second operator is greater than that of the first.

In classical theories of wages the factors of production are paid according to their productivity. In actual practice this may,

PRICES OF RAYON, SILK, COTTON AND WOOL

CHART XXVI

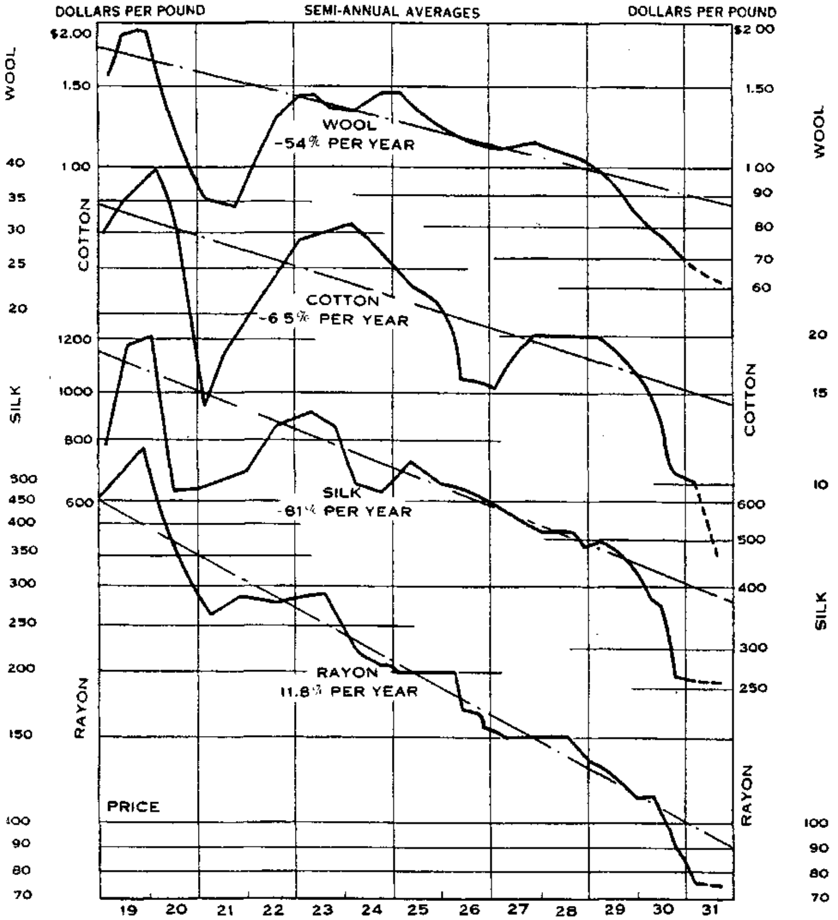


Chart shows price trends of four major fibers during the 13-year period, 1919 to 1931. Dotted lines represent estimates for concluding part of the current year. The solid lines show specific fluctuations for the 13-year period and the broken lines indicate average degree of change.

on the average, be true in a static or slowly changing economy, but it is certainly not true in a dynamic economy. In a dynamic economy the relative bargaining strength of labor and capital is of tremendous importance. Thus, in times of great depression when labor is plentiful and its productivity high it is in general paid whatever capital wishes to grant it. This may often be less than subsistence.

CONSUMPTION OF TEXTILE FIBERS

CHART XXVII

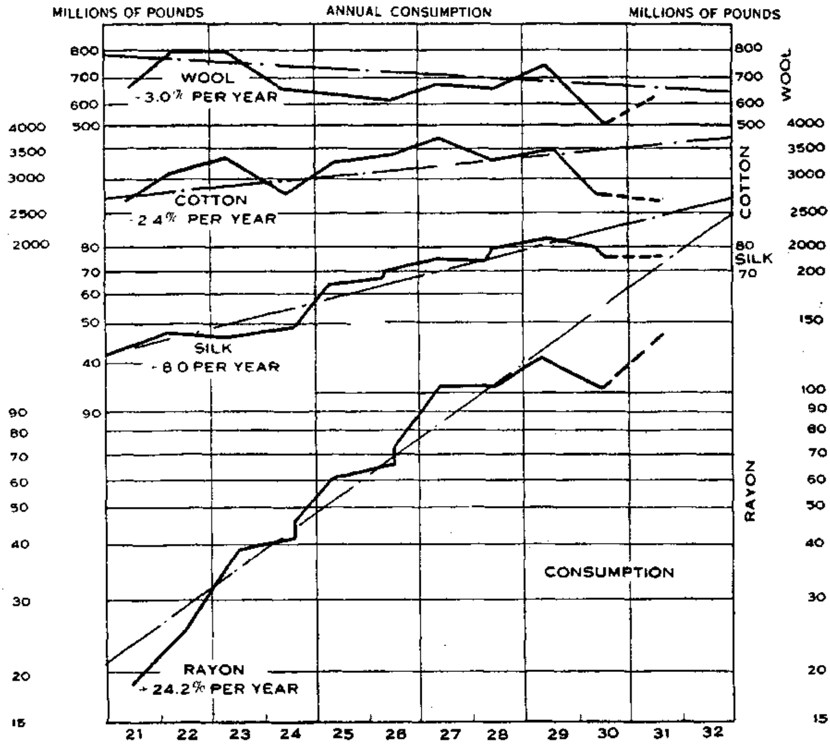
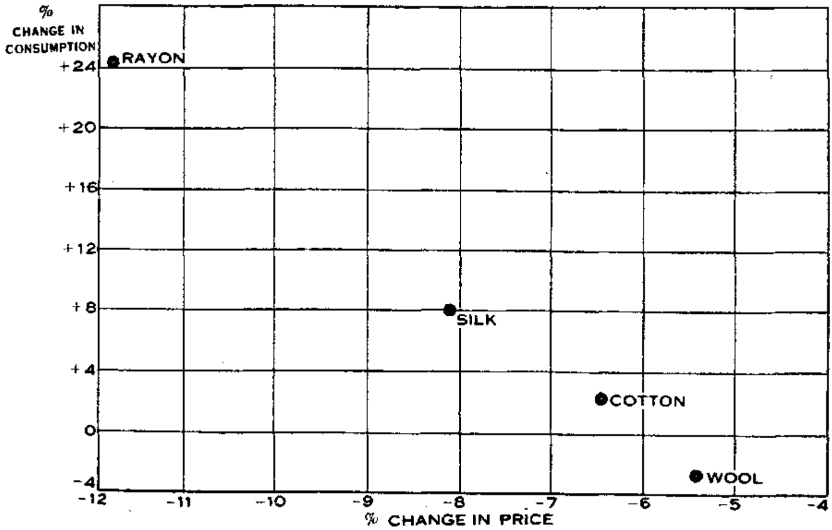


Chart shows relative consumption figures and trends of four major fibers in the decade, 1921 to 1930. Solid line traces movement of volume and dotted line represents estimates for periods for which figures are not yet available.

While an industry is growing it almost invariably pays its labor well. During periods of expansion of an industry much new labor is usually demanded by employers and such labor is almost invariably well paid, especially that part which is skilled. On the other hand, mature or declining industries usually pay low wages. Here there are almost invariably more workers than jobs and the bargaining advantage is with the employer. Workers are slow to change their occupations. Once a miner almost always a miner. Under *laissez faire* conditions it very often takes a generation to correct an oversupply of labor in a slowly declining industry, and during the period of decline wages become progressively lower except during periods of credit expansion which produce profits almost throughout the economy. Machinery installations in declining

COMPETITIVE SHIFTS BETWEEN TEXTILE FIBERS DUE TO PRICE CHANGES

CHART XXVIII



Percentage change in consumption among the competitive groups, rayon, silk, cotton and wool, seems to be proportional to percentage change in price.

or stationary industries inevitably lead to technological unemployment. Thus, for an adequate discussion of a growing economy a discussion of technological unemployment is essential. It seems advisable, however, to reserve this discussion for a later chapter.

Examples of high wage industries today are rayon, automobile, aviation and electrical. Low wage industries include cotton textiles, coal mining, shoes, and, of course, farming.

Unionization effectively increases the bargaining strength of labor. Thus, unionized labor is able in general to command higher wages than unorganized labor. Similarly, consolidations and mergers may effectively increase the bargaining strength of employers.

In small towns wages are almost invariably lower than in cities. In general, this seems to be due to the fact that numbers of employers in small towns are few and owners must compete only with the farms for the available labor supply. Building labor prices for essentially the same building are low, so that construction costs of residential building are also low. Also land values are low. Consequently, an important item of living expenses is lower in the small town, so that a "low" wage in the small town may be effectively as high as a "high" wage in the city. Also in a small town an employer may not be able to choose labor for its productivity, that is, he may constantly have to train workers.

Essentially, labor behaves like a commodity, at least so far as price is concerned. Whenever labor is scarce and there is a demand for it, it sells for a high price (at a profit to the workman), and whenever it is more plentiful than its demand it sells at a low price. The medical profession will be well paid as long as there are not enough doctors to perform the medical services demanded by the population;* engineers will command high salaries so long as new highways, new plants, new machinery are demanded in sufficient quantity to command almost all the engineering talent available, and, on the other hand, farm labor will command very low wages unless these are raised by legislative fiat.

7. *Profits.* A growing industry invariably has high profits. In fact the profit showing is what makes it possible for the industry to grow. Profits taken by the industry are in general invested in new plant and equipment, and savings from other parts of the economy are attracted into the industry. Of course, dividends can be paid in cash or in stock. If cash dividends are paid, more than the amount paid in dividends is borrowed by the industry by stock or bond issues. In a capitalistic economy the function of profit is to encourage new investment in the fields where new wants are developing.

When an industry matures, profit for the industry as a whole should theoretically be zero unless an increased velocity of circulation of money media going into goods changes the industry's markets so that it gets a new lease on life. Once the demand for a product stabilizes so that price decreases bring very little additional demand, social reasons for profits in the industry as a whole diminish or perhaps disappear entirely. Whenever productive capacity becomes sufficient to supply all demands of the economy, obviously any construction of plant in the industry other than what is necessary to replace worn out or obsolete units is social waste. Technological improvements usually provide enough profit incentive for new units to enter and force the retirement of high cost units.

*The medical profession is perhaps a rather poor example since ethical rules governing the profession almost make the profession a monoply. In other words, prices of medical services would undoubtedly decline if doctors really competed on a price basis. According to their ethics they set a fixed price (not always in the case of specialists) and compete on the basis of quality of services rendered and personality of the physician.