Faculty Working Papers

PRICING OF LIQUIDITY FOR PREFERRED STOCKS ON THE NEW YORK STOCK EXCHANGE

Frank K. Reilly, Professor, Department of Finance

#662

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ANOTHER LOOK AT INDUSTRY GROWTH PATTERNS

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Summary

The Kuznets-Burns hypothesis of retardation of industrial growth is examines against the background of macroeconomic fluctuations of the long wave type. The growth paths of 64 U.S. industries are traced, using data for the 1873-1973 period. Five sectors are distinguished: agriculture, mining, transportation, producer goods, and consumer goods. 'Pure' retardation of growth is predominant in the agriculture and consumer goods series, although the international agricultural staples have deviating growth patterns. Conversely, long wave fluctuations, superimposed on a retardation-of-growth trend, dominate the mining, transportation, and producer goods series.

1. Introduction

In the 1930's the retardation of industrial growth hypothesis became popular, after two successive studies by Kuznets [1930] and Burns [1934] had shown that the life history of the vast majority of U.S. industries was characterized by a decline in the percentage rate of growth. While noting that actual patterns of industry development were very diverse, Burns generalized that "an industry tends to grow at a declining rate, its rise being eventually followed by a decline" (Burns [1934, p. 173]).

The Kuznets-Burns hypothesis remained virtually unchallenged, until Gold [1964] reviewed their findings and extended Burns's time series to 1955. Gold rejected Burns's rule of uniformity, "by showing that progressive retardation may be far less pervasive than had been suggested by his comprehensive coverage of an earlier period; by demonstrating that undiminished rates of growth for individual series may be more frequent and persist for longer periods than he--or any other economist who comes to mind--considered likely; and by revealing that even horizontal trends may continue for long periods in a significant number of industries" (Gold [1964, p. 61]).

From our present vantage point, both the Kuznets-Burns and Gold findings are understandable. The former two authors covered the 1870-1929 period, an era in which, in terms of Rostow's stages of growth theory, the United States completed its drive to technological maturity and entered its stage of high mass consumption. Such a transition is marked by a gradual abatement of rates of growth. After the Great Depression of the 1930's and the war boom, the United States, as well as all other industrialized nations, entered a new growth era, which lasted from 1948 to 1973. The addition of 1930-1955 data to Burns's series then easily leads to the kind of conclusions Gold drew, especially if one is willing to view the early 1930's as just a severe cyclical downturn, rather than a structural phenomenon.

Considering the changes in industrial output that occurred in the 1970's, it would seem that the retardation of growth hypothesis deserves a third look. In addition to having observed a major downturn from 1973 to 1975, that is reminiscent of the post-1929 developments in a number of respects, we can also avail ourselves of time series, that for many branches cover over a century now.

But there is even more. With the 1970's downturn a long forgotten theory of economic development has come to the fore again: the theory of the long wave, better known—but in many ways unfortunately so—as the Kondratieff cycle. In this paper we will argue that the interaction of an industry's life cycle with long-wave type fluctuations that are caused by fluctuations in infrastructure investment, but perpetuated by the creation of new growth industries, provides a more adequate analytical framework for interpreting actual industry growth patterns than the simple Kuznets-Burns hypothesis alone. We will also argue that, even when long-wave influences would be dismissed, the decline phase of the industry life cycle, emphasized so much by Burns, represents only a special case of an industry's life following its maturity stage.

The organization of the remainder of this paper is as follows. In section 2 we will briefly review the Kuznets-Burns-Gold findings and amend the life cycle curve as usually depicted. In section 3 the implications of a long-wave perspective for long-term industry growth are discussed. Section 4 introduces yet another intervening factor that we feel has been underexposed in previous studies of industry growth patterns, viz the role of international trade. An account of our measurement of rates of growth is dealt with in section 5, after which section 6 presents and discusses measured and estimated growth patterns for 64 industries, organized in five categories: agriculture, mining, transportation, producer goods, and consumer goods. Finally, section 7 offers some conclusions.

2. The industry life cycle

The notion of an industry, or product, life cycle, i.e. the notion that industries and products, from their moment of introduction onwards, pass through various stages, the ultimate one being the decline phase, has a long history. In 1890 the French sociologist Gabriel Tarde formulated the three phases that every innovation, whether a new product, new idea or belief passes through: "a slow advance in the beginning, followed by rapid and uniformly accelerated progress, followed again by progress that continues to slacken until it finally stops: these, then, are the three ages of those real social beings which I call inventions or discoveries" (English translation Tarde [1903, p. 127]).

Tarde's three ages have become known as the S-shaped growth curve; in the life cycle approach a fourth, decline, phase is added. Thus the industry life cycle consists of four phases: (1) introduction; (2) growth; (3) maturity; (4) decline (Figure 1).

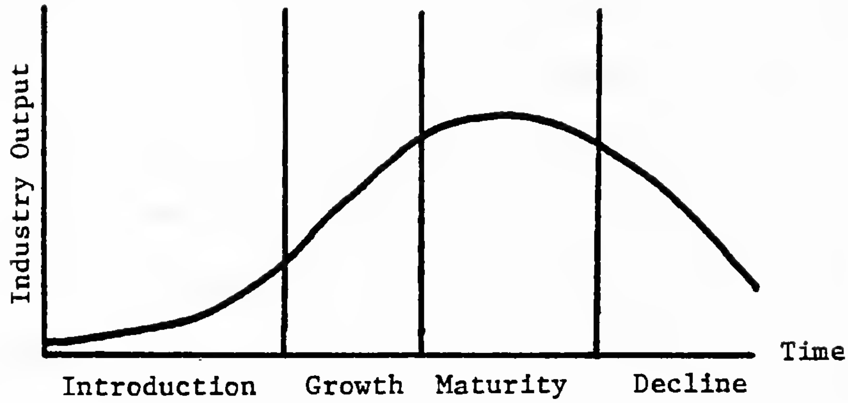

Figure 1 The Industry Life Cycle

Following Tarde's lead, major empirical work in actual industry growth patterns was done by Kuznets [1930] and Burns [1934]. Kuznets noted that an industry, rapidly developing at one time, would not continue its vigorous growth indefinitely, but would slacken its pace after some time, finally to be overtaken by another industry, whose period of rapid development had started later. Kuznets tested his hypothesis of growth retardation on production series drawn from five early industrialized countries: Britain, France, Belgium, Germany and the United States. Using the logistic curve and the Gompertz curve to fit the data—both curves imply a continually decreasing growth rate—Kuznets concluded that these curves described well the long-term movements of growing industries, and, if the signs were changed, those of declining industries.

Kuznets' work was extended by Burns [1934], who investigated growth patterns in U.S. industries, covering the 1870-1929 period. Burns fitted a logarithmic parabola to 104 series,[1] allowing him to estimate a rate of retardation and—for those cases where growth rates were indeed falling—the year in which output would reach its peak value. Abatement in the rate of growth was found for 92 series. This result led Burns to formulate his earlier quoted "rule of uniformity." His generalization, however, should be interpreted with a lot of qualifications: (1) the rule of retardation may not hold in the late life cycle stages of some industries; (2) in the introduction phase, growth may accelerate rather than abate; (3) the rule of retardation does not hold throughout for the secular trends of even established industries; (4) an industry may be invigorated or rejuvenated as a result of a structural change, such that the rule of retardation may only hold for the periods prior to and following the structural change (Burns [1934, p. 172]).

Some years ago, Gold [1964] has reviewed Burns's findings and expectations and compared them to the actual growth patterns of 35 of Burns's industries for the 1870-1955 period. Employing what he called a "tinker toy technique," which involved the fitting of log-linear trends to time-series segments, the log-linear segments being determined by visual inspection, Gold found that growth to a peak, followed by a declining trend, was exhibited by only 4 of the 35 series investigated. For all but one of those 35 series (cigarettes being the exception) Burns's 1870-1929 estimates had yielded retardation of growth, and thus

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[1] His 104 production series included 23 series in agriculture and fisheries; 22 in mining; 47 in manufacturing and construction; and 12 in transportation and trade. Despite the large number of manufacturing series, these covered only 22 percent of manufacturing output. As opposed to this, his coverage of agriculture (65 percent) and mining (83 percent) was very high.

an S-shaped industry life cycle. For the vast majority of sectors, however, the decline phase had apparently not set in as of 1955. Gold found that actual growth patterns were in fact very diverse. A simple categorization produced no less than 12 different patterns for just 35 industries, Burns's rise-and-decline pattern being just one of the 12. Gold therefore rejected Burns's rule of uniformity: there is no "law of growth" for industries, and forecasting the future development of an industry using a logarithmic parabola in his judgment would actually be an exercise in backcasting rather than forecasting.

It is easy to criticize Gold's own search for growth patterns for the arbitrariness involved in his choice of linear linkages. On the basis of visual inspection, various linear linkages can be justified for one and the same series. It is not clear which criteria, if any, were used by him to prefer a specific pattern over another. Growth patterns are all in the eye of the beholder.

By subdividing the period of observation in a number of trend periods that make sense from a macro-economic point of view, and by estimating growth rates for these trend periods, the arbitrariness of Gold's method can be overcome. We have done this below. A comparison with Gold's patterns then shows quite a few differences (Appendix B).

Yet Gold has correctly laid the finger on one weakness in Burns's approach to industry growth, namely the implied passivity with which an industry goes through its life stages. The decline phase is an intrinsic part of Burns's conception of industry growth. An industry apparently cannot influence its own future course, even though the experience of falling profits in its maturity phase might give it all the reason to at least attempt to do so.

Recall that Burns found growth retardation, i.e. S-shaped growth, to be the dominant pattern up to 1929. Prior to 1929 absolute decline had been experienced by very few industries. But his 1870-1929 period was precisely the period in which the U.S. economy completed its drive to technological maturity and in which it entered its age of high mass consumption. This Rostowian transition in what is called the "life cycle of economic development" (Forrester [1973]) can be adequately described by an S-shaped growth pattern (Rostow [1978], Van Duijn [1979]). To the extent macro-economic conditions have an impact on industrial growth then, one would expect the 1870-1929 data to reflect this influence. One would expect these data to essentially describe the introduction, growth and maturity phases for all those products, whose development coincided with the opening up of the American continent and the following, inevitable, slowdown. Obviously some products were phased differently, either being introduced much earlier (cotton textiles, pig iron) or much later (radio, aircraft), but on the whole, and considering the population growth during those years, declining industries up to 1929 would be expected to form a small minority.

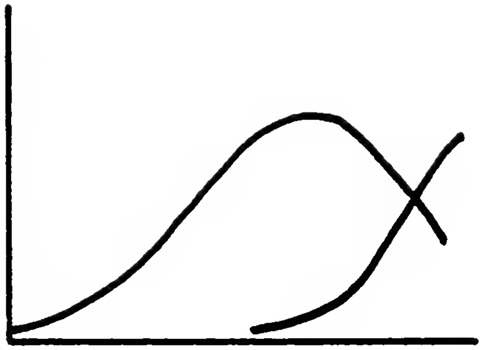
These considerations, along with Burns's results and Gold's subsequent findings, seem to suggest that <u>S-shaped growth may be a valid conceptualization of growth up to the maturity phase, but that anything might happen beyond this phase</u>. Put differently: retardation of growth curves (such as the logistic and Gompertz curves) are alright as long as absolute decline is not implied (as in Burns's logarithmic parabola).

Decline may follow, if a substitute is developed to satisfy or to satisfy better a certain want, but is not inevitable. As alternative courses, an industry may revitalize itself by finding new uses for the product it makes, or by improving its product by means of a radical change in underlying technology. The latter two reactions will typically come from within the industry; the former is most likely to come from outside the industry. In all cases, however, it is the maturity phase with its accompanying slowdown in growth that triggers the reaction. Finally, the maturity phase may simply be a very extended phase. If a product has firmly established itself as part of a nation's consumption pattern, and no clearly superior (in terms of quality vis-à-vis price) alternative develops, industry output may remain at a high plateau for a long time. Various consumer durables may fit in this category.

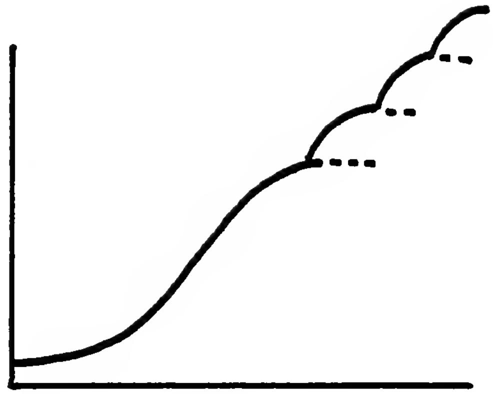
All of these variations to the simple life-cycle pattern, graphically presented in Figure 2, are well-known in the marketing literature. At the industry level, even as narrowly defined as at the 4-digit SIC-level, these variations would cover more cases than the absolute decline phase of the general life cycle.

But this is not all. When looking for industry growth patterns, it is clear that industries should be distinguished by the nature of their output; it is equally clear that international trade and international specialization should be taken into account.

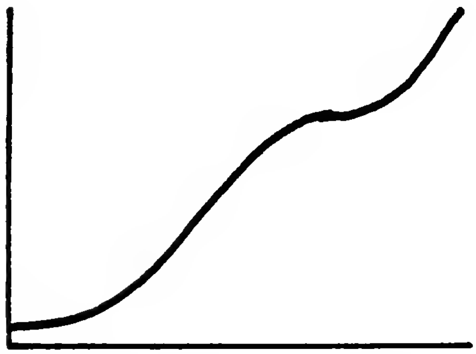
In their original, Tardian, specification, S-shaped growth and its corollary, retardation of growth, were specified for consumer goods, i.e. goods that directly satisfy human wants; not for producer goods. This is how the concept of the product life cycle is still used in the



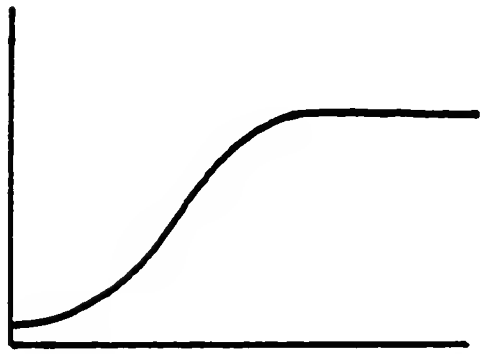
(a) Substitution



(b) Extensions of the Life Cycle



(c) Change in Technology



(d) Extended Maturity Phase

Figure 2 Variations to the Simple Life-Cycle Pattern marketing literature. The long-run growth pattern of producer goods, let alone that of the specific category of capital goods, will have to be derived from considerations that are in part unique to them and that are in part related to the long-term development of the national economy as such. Earlier we referred to one of those aspects of long-term economic development: Rostow's stages theory. The other relevant aspect, that would explain temporary, albeit quite prolonged, absolute declines in the production of producer goods, are the Kondratieff-type fluctuations, or long waves in economic activity. We turn to those now.

3. Long Waves

Whatever the names given to them, it is now increasingly recognized that capitalist economies, since at least the mid-19th century, have passed through alternating phases of rapid and slow growth. Some have labelled these fluctuations Kondratieff cycles, others prefer the somewhat looser term long waves (Van Duijn [1977] [1979]). Rostow [1978] calls them Kondratieff long cycles, but also speaks of trend periods, Maddison [1977] simply distinguishes phases of growth.

The chronologies these authors use to distinguish upswing and downswing are not identical, nor are the theoretical explanations, but all agree on the 1895-1913 and 1948-73 periods as phases of rapid growth. The disagreement is on the war-distorted parts of the 20th century: the period of slow growth is alternatively argued to have started in 1913, 1920, or 1929, and have ended shortly before or after World War II. These differences in dating more reflect the difficulties of interpreting war-related growth and recession than underlying disagreement on what constitutes a long wave upswing or downswing in real terms.

Our view would be to distinguish 1895-1913 and 1913-1929 as parts of a long wave upswing; the 1920's then become the extension of the rapid growth period that started in 1895, was interrupted by WW I, but resumed after 1920. Clearly the World War left its marks on the 1920's economies, some countries being more affected than others. Still, the rapid growth of the sectors that incorporated the major innovations of the turn of the century—the automobile industry being the most prominent—unquestionably makes the 1920's part of a long wave upswing. The subsequent downswing in our long wave chronology ends in 1948, mainly because it was then that the economies of the industrialized countries started incorporating the basic innovations that had been developed in the 1930's and 1940's.

As to the pre-1895 years: the 1873-1895 period is often seen as one of depression. In fact, it was the experience of this period, which in Europe fell in between two eras of rapid growth (1845-1873 and 1895-1913), that gave rise to the early interest in the Kondratieff cycle as more than just a price cycle.

Our long wave chronology for the mid-19th century onwards thus becomes:

1845 - 1873	upswing
1873 - 1895	downswing
1895 - 1913	upswing
1913 - 1929	war and postwar adjustment
1929 - 1948	downswing
1948 - 1973	upswing
1973 -	downswing

The lack of a theory that could explain the alternations of rapid growth and slow growth for a long time has been a major reason for the skeptical attitude of the economic community towards long waves.

The 1973 downswing, however, has led to renewed efforts to understand the economic mechanisms underlying these long fluctuations. Most explanations now hinge upon two factors: basic innovations and infrastructure investment (Forrester [1977], Mensch [1975], Van Duijn [1979], Hartman & Wheeler [1979], Graham & Senge [1979]). The incorporation of basic innovations in the economy, leading to the establishment of new growth sectors, carries the upswing. The new growth sectors require an industrial infrastructure, and therefore the early upswing will get an additional impulse from an increase in infrastructure investment. An upper turning point will be reached when the capital stocks of the new growth sectors have expanded to a capacity greater than required by demand, which is slackening anyway as these sectors reach their maturity phase.

Long waves could therefore be explained as the operation of a super multiplier-accelerator mechanism, combined with retardation of growth of the innovation-sectors in the course of the upswing. The operation of the multiplier-accelerator alone could be relied upon to explain the lower turning point. In fact, this has been done by Forrester [1977]. But most long wave economists, including Forrester, would now agree that the introduction of new basic innovations plays the key role in getting the economy on a new upswing path. Actually, the recovery can be seen as a two-step process: the need for investment to replace obsolete capital may cause the economy to turn the corner; this investment-led recovery creates the kind of prospects entrepreneurs need to introduce major new innovations.

The long-wave perspective has two major implications for the long-term growth patterns of industries:

1. Innovative industries will be characterized by high (often double-digit) growth rates in the early upswing phase, which coincides with these industries' introduction phase; these growth rates will taper off as the upswing phase winds down, but still these sectors might manage to grow through the following downswing phase.
2. Industries providing the inputs for the production of infrastructure investment, along with the transportation-related industries, will exhibit long-wave fluctuations in their growth rates, these growth rates possibly turning negative during downswing phases. The point to note here is that negative growth rates do not necessarily signal the decline phase of an industry. Basic industries such as iron and steel will revive with the next long-wave upturn.

4. International trade and the industry life cycle

A final factor which considerably affects the shape of a national industry growth curve, is international trade. The starting consideration here is that the S-shaped growth curve is derived under the assumption of a fixed market. As soon as international trade starts taking place, and international specialization occurs, this fixed market assumption is violated. National production and national consumption are not identical anymore. The latter may well display life-cycle growth; the former will not necessarily do so.

A theory relating international trade to the product or industry life-cycle was developed in the 1960's and early 1970's by members of the Vernon-School (Vernon [1966], Hirsch [1967], Wells [1972]). It argues that (1) innovations of new products and processes are more likely to occur near a market where there is a stronger demand for them than in a country with little demand; (2) a businessman is more likely to supply risk capital for the production of the new product if demand is likely to exist in his home market; and (3) a producer located close to a market has a lower cost in transferring market knowledge into product design changes than one located far from a market (Wells [1972, p. 6]). The United States is widely regarded to be well endowed with innovative skill as well as with the kind of market required for new product and process innovations, particularly those that appeal to high income consumers or those that save on expensive labor. Hence many of such innovations are likely to begin their life cycles in the United States. Other innovations, e.g. those that better meet the demands of low income consumers or save on other scarce factors, may be developed earlier in other countries. Still assuming the U.S. to be a high-income, expensive-labor economy, the U.S. trade position through the innovation life cycle can be hypothesized to be as in Figure 3. As depicted there, U.S. production will fall after some time, even though consumption is still growing towards some saturation level. The reason for this fall in production is the adoption of mass production methods in the growth and maturity phases, which favor production in countries where labor is cheaper. In addition, demand in foreign markets will grow as incomes there increase.

The essential point from an industry-growth point of view is that time-patterns of consumption and production differ. The country that is first in the 'pecking order' may experience falling production in the

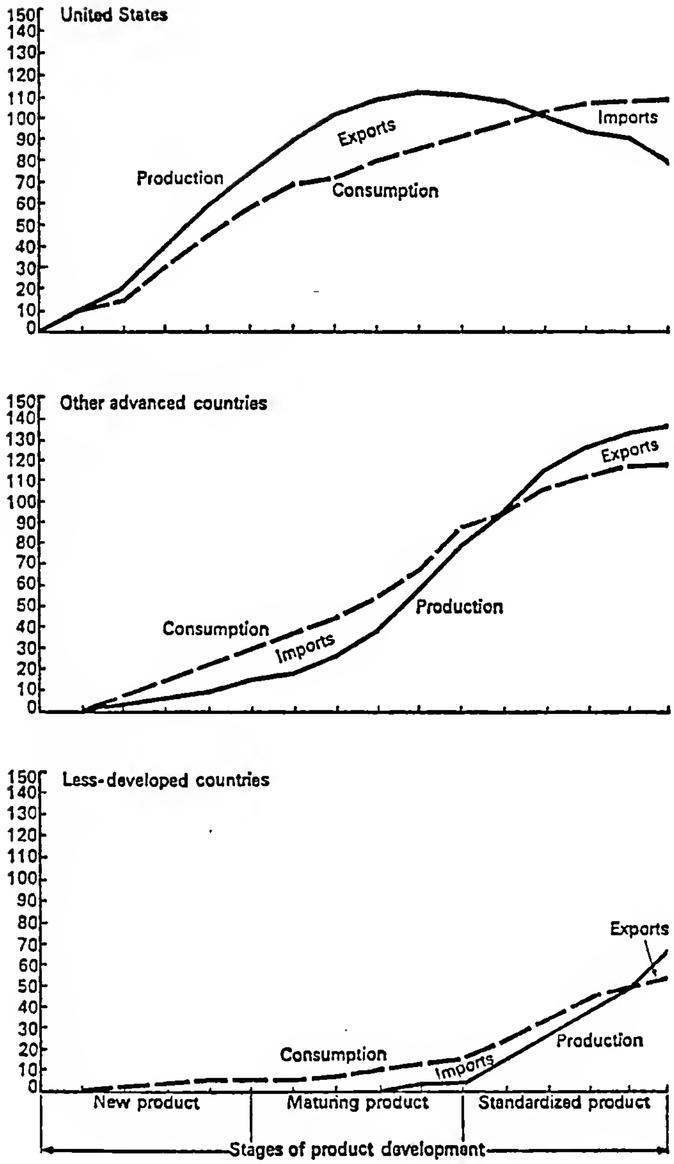


Figure 3 Trade Positions in the Innovation Life-Cycle (Source: Vernon [1966])

growth phase of consumption; countries next in line may see their production starting to exceed consumption in the maturity phase of consumption.

The Vernon-theory deals mainly with innovations in manufacturing. Its basic implication, i.e. that the time paths of national consumption and national production differ, holds in general, whether the products in question are recent innovations or not, and whether they are manufacturing commodities or agricultural, or mineral. Traditional production advantages other than innovation-related ones may play a more important role in shaping the growth patterns of the latter two categories. But in any case regular S-shaped growth of production--and therefore also gradual retardation of growth--is unlikely to result.

This international dimension of industry growth did not play a role in Gold's analysis; yet it could well provide an explanation for some of the deviating patterns he found, especially so since agricultural and mining series dominated his selection of industries. Gold might have found the archetype rise-to-a-peak-and-then-decline pattern, had he investigated U.S. consumption or--even better--U.S. per capita consumption; by focusing on production he was bound to find different patterns.

5. The measurement of the rate of growth

We are now ready to look at actual growth patterns of U.S. industries, to see to what extent a rudimentary S-shaped growth path can still be traced, with or without decline phase, and reversely, to what extent the other factors we mentioned--revival of life cycle following maturity, Rostowian development stage of the national economy, long waves, international trade--may have distorted this path. But first the issue of the measurement of rates of growth should be briefly addressed.

There are several ways to measure the rate of economic growth over a certain time period. They all yield different rates for one identical output time series, and thus the choice of method determines the resulting growth rate. In applying a particular method, one should at least be aware of its biases.

Two commonly applied methods are trend fitting and compound growth rate calculation. The former ususally involves fitting a growth curve

$$y_t = y_0(1 + g)^t,$$

rewritten as a log-linear equation, to the data observed. The percentage growth rate of course equals 100g. The advantage of this method is that it uses all data. This is not the case with the compound growth rate formula, which employs only initial and terminal years by calculating r from

$$y_T = y_I(1 + r)^{T-I},$$

where I and T stand for initial and terminal year, respectively. A main advantage of this method is that it is extremely easy to apply. Its critical weakness is the sensitivity of the outcomes to the actual selection of initial and terminal years.

This latter property would seem to make trend fitting a preferable method in all cases. Matters are not that clear cut, however. The choice of method very much depends on the nature of the series and the type of periodization one applies. In series which display a clear business-cycle pattern, calculating the compound growth rate is an acceptable method as long as business-cycle peak years are used as initial and terminal years. At business cycle peaks the economy usually operates near or at full capacity, and computing the compound growth rate then means measuring the (annual) growth rate from one (near) full-capacity point to another. The resulting growth rate is by no means an average rate, but it is an annual rate with a clear interpretation. Calculating growth rates for successive periods this way would give an indication of growth retardation, if such retardation has in fact occurred. But obviously the reliability of this method would depend on the wise choice of business cycle peak years; its applicability is restricted to industrial production series that display clear. cyclical behavior.

If such conditions are met the compound growth rate formula may be preferred over exponential trend fitting. Precisely because trend fitting takes all observations into account, exogenous disturbances such as wars and their effect on output, can have a large impact on the estimated trend, even though war-induced changes in production give no insight in the long-run behavior of an industy and should be eliminated from it. As a case in point take the 1929-1948 trend period. In many U.S. industries, output fell dramatically between 1929 and 1932/3, recovered thereafter and rose to unprecedented heights during World War II, only to fall back to more normal levels by 1948. Yet an estimated trend for this period would be determined by the 1932/3-1945 rise and evidently would be an exaggeration of the trend during the 1929-48 period. By contrast the compound interest-rate formula would connect the 1929 and

1948 business cycle peaks and correctly disregard the war disturbances. It would much better express the slowdown of growth between two expansionary trend phases.

Below we have fitted exponential-growth trends only to agricultural series and to consumer good series for the post-1948 period. Agricultural output fluctuates heavily from year to year, maybe governed by a cyclical mechanism of the cobweb type, but certainly not by regular business cycles. Selecting initial and terminal years of a trend period would become an entirely arbitrary affair here. In Table 5a below, where we measure consumer good growth rates for subperiods between 1948 and 1978, trend fitting is also applied, since here too the selection of initial and terminal years would be somewhat arbitrary.

6. Industry growth patterns

The 64 industry growth patterns, presented in this section, have been classified in five categories: agriculture, mining, transportation, producer goods, and consumer goods.

Trend period growth rates for 20 agricultural commodities are presented in Table 1. All series but one (rice) display lower growth rates for the 1895-1929 period than for the preceding 1873-95 period. This confirms Burns's findings of retardation of growth as the predominant feature of the agricultural 'industries' between the 1870s and 1929. However, the predictive value of these results for the post-1929 years is zero. Only in four series examined here does the abatement of growth continue through the next two trend periods (buckwheat, sweet potatoes, shorn wool and tobacco). Even a strongly negative 1895-1929 growth

TABLE 1

ANNUAL GROWTH RATES, TREND PERIODS: AGRICULTURE

	annual growth rates				peak year[1]
	1873-95	1895-1929	1929-48	1948-73	
Corn	2.56	0.21	1.96	2.19	1977
Wheat	2.36	1.11	3.04	1.71	1976
Oats	4.95	1.33	1.87	-2.61	1945
Barley	5.38	2.06	2.11	1.89	1958
Flaxseed	5.16	-1.18	8.77	-3.25	1948
Soybeans			19.77	7.78	1977
Sorghum			6.57	9.12	1973
Rye	2.53	2.33	-1.74	1.92	1922
Buckwheat	0.50	-0.68	-0.89	-12.10[2]	1905
Irish potatoes	2.53	1.11	1.16	1.42	1976
Sweet potatoes	1.89	1.20	-1.45	-2.50	1932
Rice	3.89	5.68	4.02	3.74	1975
Sugarcane	6.90	-3.23	4.33	3.68	1975
Sugar beets	25.94	9.82	0.86	4.44	1975
Hay	3.45	1.92	1.97	1.10	1973
Cotton	3.22	1.09	-1.31	-1.18	1937
Shorn wool	2.94	-0.01	-1.36	-1.68	1941/42
Tobacco	3.19	1.91	1.70	-0.70	1963
All cattle	7.61[3]	1.89	2.37	2.94	1973
Hogs	2.87[3]	2.05	1.97	2.21	1943

Annual growth rates are estimated by fitting a log-linear trend: $\log y = a + (\log b)t$. For data sources see Appendix A.

[1] 1977 is most recent year taken into account

[2] 1948-1964. Series discontinued thereafter.

[3] 1880-1895.

rate, as for sugar cane, gives no indication whatsoever of output changes to come.

The only generalization that can be made with respect to the agriculture series is that the 1873-95 growth rate exceeds that of all following periods.[2] Thus initial growth rates, even if estimated over a period as long as 22 years, cannot be maintained in the long run.

International specialization among agricultural staples producing countries would seem to provide a plausible explanation for the divergence in growth patterns following maturity. For instance, in 1974 the U.S. accounted for 81 pct. of world exports of soybeans, and 57 pct. of world exports of sorghum grains. Both products have been the strongest growers in the 1948-73 period. For other major staples the like percentages are: 64 (corn), 46 (wheat), 31 (cotton), 24 (tobacco) and 14 (rice). National production figures therefore give no insight in the development of national consumption. Whereas national per capita consumption patterns might well resemble a regular life cycle pattern, there is no reason to assume that national production data will.

Mining is another category for which long output series are available. As for agriculture, the major reason for the length of the series is that industry outputs are homogeneous commodities, which allows for measurement in terms of weight rather than through the construction of a composite index.

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[2]There are only two exceptions to this generalization: again rice, and flaxseed. In the latter case, however, the fitted trend value for 1929-48 is very much determined by the tremendous fall in flaxseed production during the mid-1930s.

In Table 2, as in all following tables, we have separated the 1895-1929 trend period in two subperiods: 1895-1913 (la belle Epoque) and 1913-29 (war and postwar adjustment). It makes sense to do so, since in our sequence of sectors we have moved away from agriculture to industries that will more closely reflect the ups and downs of economic activity at large. We know the 1895-1913 period to have been a long wave expansion period pur sang, and expect some slowdowns during the war and the postwar adjustment years.

For all eight series that cover the 1873-1973 century, retardation of growth is the most characteristic feature. For five of those, the 1873-95 growth rate is the highest one recorded; on the other hand, the growth of production of bituminous coal, petroleum, and iron ore--three very basic sectors--increased after 1895. These series thus exhibit some long wave influence. A similar increase in growth rates, but now for the 1948-73 expansion, is apparent in the production of natural gas, sand and gravel, stone, phosphate rock, copper and lead.

Thus long-run retardation of growth and long-wave fluctuations become intermingled here. Substitution, in this case of energy inputs, is also present: natural gas is a rapid grower in the third quarter of the 20th century; bituminous coal was one in the fourth quarter of the 19th century.

It should be noted that for most series (lead and zinc are the exceptions) the growth rates refer to U.S. domestic production, not to mill consumption. The supplementation of imported minerals (as in the case of petroleum and bauxite) has enabled mineral production to grow much more rapidly than mining output.

TABLE 2

ANNUAL GROWTH RATES, TREND PERIODS: MINING

	annual growth rates					peak year[1]
	1873-95	1895-1913	1913-29	1929-48	1948-73	
Bituminous coal	6.8	7.3	0.7	0.6	-0.0	1976
Anthracite coal	3.7	2.6	-1.3	-1.3	-8.1	1917
Petroleum	7.9	9.0	9.1	3.7	2.1	1970
Natural gas		8.4	7.7	5.1	6.3	1972
Sand and gravel			6.6	1.9	4.6	1973
Stone				2.5	6.4	1973
Phospate rock	12.4[2]	6.3	1.2	4.5	6.3	1974
Iron ore	7.1[2]	7.8	1.0	1.7	-0.6	1953
Copper	11.5	6.8	3.0	-0.9	2.9	1970
Lead	8.2	3.8	3.3	-3.3	2.0	1926
Zinc	10.7	7.8	3.8	1.2	-1.2	1969
Bauxite		15.0	3.5	7.5	1.0	1943

Annual growth rates are calculated with compound growth rate formula. For data sources see Appendix A.

[1] 1977 is most recent year taken into account.

[2] 1875-1895.

Four different modes of transportation are included in Table 3: road, rail, air and water. For the first three modes we distinguished between passenger and cargo transportation. The growth rates give an indication of the substitution over time between these modes: the pre-1895 years were the railway age; the automobile took over after World War I, while after World War II airplane travel grew most rapidly.

For both innovations introduced within the period of observation (automobile and airplane) the first trend period growth rate is by far the highest. Railway transportation, after the acceleration of the 1895-1913 expansion, has since experienced strong retardation of growth (freight) and absolute decline upon replacement by car travel (passenger), with only a temporary substitution back to railway travel during the Second World War.

The water transportation series probably more than anything else reflects the development of international trade and the U.S. involvement in it. Here both the 1895-1913 and 1948-1973 periods stand out as strong expansionary periods.

In the producer goods series (Table 4) we recognize long wave fluctuations again, imposed on a retardation-of-growth trend. The older products (pig iron and cement) display the long wave growth pattern perfectly: a step-up of growth during 1895-1913, followed by two consecutive decreases, and finally an increase again during the 1948-73 expansion.

The products and processes innovated during the hundred years covered here (raw steel, 1870s; aluminum, 1887; rayon, 1890s; acetate, 1920; non-cellulosic fibers, 1940s; plastics, 1930s through 1950s) have

TABLE 3

ANNUAL GROWTH RATES, TREND PERIODS: TRANSPORTATION

	annual growth rates					peak year[1]
	1873-95	1895-1913	1913-29	1929-48	1948-73	
Passenger cars		43.8[2]	15.2	-0.7	3.7	1973
Trucks and buses			25.4	2.4	3.1	1977
Railway passenger-miles	3.6[3]	6.0	-0.7	1.5	-5.8	1944
Railway ton-miles	6.9	7.3	2.5	1.9	1.2	1973
Passenger-miles flown				26.7[4]	13.0	1977
Ton-miles flown				46.8	13.6	1977
Capacity of vessels entered	2.3	5.5	3.1	0.5	5.5	1977

Annual growth rates are calculated with compound growth rate formula. For data sources see Appendix A.

[1] 1977 is most recent year taken into account.

[2] 1900-1913

[3] 1882-1895

[4] 1930-1948

TABLE 4

ANNUAL GROWTH RATES, TREND PERIODS: PRODUCER GOODS

	annual growth rates					
	1873-95	1895-1913	1913-29	1929-48	1948-73	peak year[1]
Pig iron	6.1	6.7	2.0	1.4	1.7	1973
Raw steel	16.8	9.4	3.8	1.9	2.1	1973
Hot rolled iron & steel	5.9	8.0	3.2	2.2	1.9	1973
Aluminum		24.3	10.2	9.4	8.3	1974
Cement	6.4	13.8	4.2	1.0	3.4	1973
Sulfuric acid		6.7[2]	5.0[3]	3.1	4.2	1977
Rayon & acetate fibers			34.4[4]	12.0	0.8	1968
Non-cellulosic fibers					20.9	1977
Plastics materials					13.7	1977

Annual growth rates are calculated with compound growth rate formula.
For data sources see Appendix A.

[1] 1977 is most recent year taken into account.

[2] 1899-1914

[3] 1914-1929

[4] 1920-1929

double-digit growth rates during their first trend period.[3] The low growth rate for rayon and acetate fibers following World War II can only be explained as the result of the substitution of non-cellulosic fibers for cellulosic ones. Here we have a case of a new technology, leading to the absolute decline (since 1968) of the previous one.

Steel offers a similar example of a succession of technologies. The innovation of the Bessemer process in the 1870s allowed for the establishment of a modern steel industry. Bessemer steel replaced crucible steel (innovated in 1811); in its turn it was replaced by steel made through the open-hearth process (Figure 4). Electric steel making

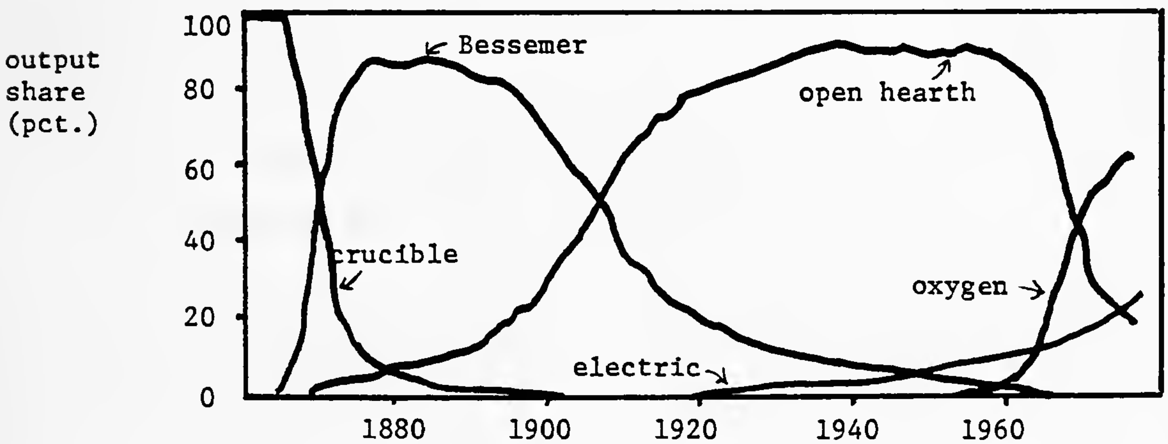

Figure 4 U.S. Steelmaking Technologies, 1860-1977

followed in the 1910s, but the real successor to the open-hearth process has been oxygen steel making, introduced in 1952. Declines for the Bessemer and open-hearth processes have not only occurred in relative terms, but also in absolute terms.

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[3]For sulfuric acid (contact process innovated in 1875, and a major product of the inorganic chemicals revolution), early output data are missing.

Finally, long-run retardation of growth is present in all series of Table 4 that cover more than one trend period.

Our last category is consumer goods (Table 5). Three types of products are included: cigarettes (a long time-series is available and Burns and Gold included cigarettes in their list), natural and artificial fibers, and consumer durables. Staple foodstuffs have been left out on purpose: their counterparts in agriculture have already been covered. Besides, the ranking of food items in the consumption hierarchy, in terms of dynamic per capita consumption patterns, is well documented. National production growth rates, with all the difficulties of interpretation if the commodity is an internationally traded one, would yield little insight.

Fourteen products are listed in Table 5; excluding three recent innovations, thirteen commodities cover two or more complete trend periods. Retardation of growth is present in all thirteen. In fact, in all but two cases the 1948-73 expansion period produces the lowest annual growth rate despite the fact that 1948-73 was a growth era without precedent.[4]

Long-wave type fluctuations seem to be absent. The two long series (cigarettes and cotton) surely do not exhibit any. The shorter series show no indication of the kind of slowdown during the 1929-48 period that characterized producer goods. This would suggest that long waves originate mainly from (infrastructure) investment. The growth pattern

[4] We should note right here that the 1913-29 data are incomplete for most products covered. The annual growth rates reported for 1913-29 for those products are therefore somewhat misleading.

TABLE 5

ANNUAL GROWTH RATES, TREND PERIODS: CONSUMER GOODS

	annual growth rates					peak year[1]
	1873-95	1895-1913	1913-29	1929-48	1948-73	
Cigarettes	25.6	7.9	13.4	6.2	1.9	1976
Cotton used in textiles	4.6	3.7	2.0	1.5	-0.8	1942
Wool used in textiles			1.8[2]	3.4	-5.9	1946
Rayon & acetate yarn			24.4	10.3	-1.3	1950
Non-cellulosic yarn					17.6	1978
Clothes washer (elec.)			12.7[3]	8.6	0.7	1973
Iron (elec.)			-0.7[3]	4.6	1.1	1966
Refrigerator			78.3[3]	11.2	1.4	1973
Vacuum cleaner			9.7[3]	5.8	3.7	1973
Phonograph[4]		8.5[5]	2.6[6]	7.6	2.8	1965
Radio			71.9[3]	5.5	4.6	1972
Television (b&w)					8.2	1965
Room air conditioner					18.5	1970
Typewriter			8.8[6]	1.0	0.4	1967

Annual growth rates are calculated with compound growth rate formula. For data sources see Appendix A.

[1] 1978 is most recent year taken into account.

[2] 1920-1929

[3] 1922-1929

[4] Including home-type radio-phonograph combinations

[5] 1899-1914

[6] 1914-1929

of consumer goods can be adequately approximated as an S-shaped curve, without interwoven long waves, but with the usual provisos for market size changes.

Still the timing of introduction of new consumer goods may be instrumental in keeping long waves alive. If major innovations are triggered by the turnabout of the multiplier-accelerator mechanism, i.e., by the technical recovery that follows any prolonged depletion of the capital stock, then these innovations, though themselves generating regular innovation life cycles, will require their own infrastructure investment, thus giving a major boost to an already expanding economy.

As before, high growth rates during one or two trend periods indicate the introduction and growth phases of new innovation life cycles. Cigarettes, rayon, acetate yarn, non-cellulosic fibers, the household electric appliances, phonograph, radio and television were all introduced in the 1873-1973 century. Monograph and radio actually benefitted from more than just the one basic innovation that established them as industries. The mechanical phonograph (1889) was followed by the electric one (1925); the industry got another boost in 1948 from the innovation of the long-playing record. FM radio (1936) followed AM (1920), and after World War II the radio became transistorized.

In contrast, the older consumer products (cotton, wool, flat-iron) have low growth rates throughout the parts of their lives reported here. These growth rates may fluctuate somewhat, but absolute decline will only follow if substitutes are developed, as in the case of textiles.

But retardation of growth remains the outstanding feature. For seven of the eleven pre-1948 products, declining growth rates are recorded for all consecutive periods. For two, retardation of growth does not occur that smoothly, but still the growth rate of the 1948-73 expansion is by far the lowest one recorded (cigarettes and wool).

A closer examination of the postwar experience (Table 5a) reveals that, by and large, retardation of growth has also been typical for the more recent innovations. The transistorized radio, black and white television, color television, the tape recorder and the room air conditioner, they all grew less after initial double-digit growth rates. Only the non-cellulosic yarns have grown at an excessively high pace throughout the postwar years.

As compared to those innovations, the older products that had become established ones by 1948, have mixed records. Cigarette production expanded slowly; cotton, wool and the rayons were replaced by the new artificial fibers; the older household appliances peaked in 1973 or around 1966, at market saturation levels of 99 pct. The phonograph and the typewriter, too, became products in decline after the 1966 business-cycle peak.

Many of the products listed in Table 5a are now in the maturity or decline phases of their life cycles. This does not imply that we should expect a continuing stagnation or decline from here on. As we mentioned earlier in this paper, there are various courses open to an industry in its late maturity phase. Decline is only one of them. It will result if a superior substitute is developed. Obviously, it will depend on the narrowness of definition of an industry, whether decline will become

TABLE 5a

ANNUAL GROWTH RATES, 1948-1978: CONSUMER GOODS

	annual growth rates				peak year[1]
	1948-56	1956-66	1966-73	1973-78	
Cigarettes	0.5	2.8	1.0	2.1	1976
Cotton used in textiles	0.5	0.3	-3.4	-3.0	1942
Wool used in textiles	-5.5	-1.3	-9.8	-2.3	1946
Rayon & acetate yarn	-1.5	1.3	-3.2	-7.7[2]	1950
Non-cellulosic yarn	21.5	15.1	17.9	2.5[2]	1978
Clothes washer (elec.)	1.0	0.5	2.7	-1.1	1973
Iron (elec.)	1.7	4.3	-1.4	-1.8	1966
Refrigerator	-3.9	4.1	4.8	-2.2	1973
Vacuum cleaner	-0.4	5.0	7.3	0.6	1973
Phonograph	5.5	4.5	-1.5	-3.7	1965
Radio	-3.4	14.7	2.2	1.4	1972
Television (b&w)	20.5	2.6	1.7	-2.4	1965
Television (color)		54.3	7.3	3.3	1978
Tape recorder		32.3	18.0	NA	1973
Room air conditioner	53.3	6.9	5.8	-6.4	1970
Typewriter	1.4	1.2	-5.8	NA	1967

Annual growth rates are estimated by fitting a log-linear trend. For data sources see Appendix A.

[1] 1978 is most recent year taken into account.

[2] 1973-1979

visible at all. Black and white tv sales are declining, but the tv industry as such is still growing. Yet the high saturation level of the color tv market (in 1978 85 pct. of all U.S. households had one) necessitates the industry to look for new life. The three-dimensional tv and the flat tv are mentioned as possible successors. If defined even more broadly, the television industry may be said to include such products as the video recorder as well. In this context the development of the video disc in another, typical maturity-stage attempt to get a new lease of life for an industry.

7. Conclusion

A simple 'law of industry growth' does not exist. The S-shaped growth curve may be a valid conceptualization of industry growth up to the maturity phase, but anything may happen beyond this phase: decline, revitalization and renewed growth, or just a long lasting 'horizontal' maturity phase. Absolute decline will only result if superior substitutes are developed.

In addition to branch-specific reactions to maturity, an industry during its lifetime will be affected by long-term macro-economic developments as well. Two kinds of influences have been distinguished: the life cycle of national economic development, and the long wave. The former can be brought to bear on the general retardation of growth of the U.S. economy between 1870 and 1929. The latter will especially affect the life cycles of basic producer goods and the transportation sector.

A final determinant of the shape of a national industry growth curve is international trade. The life cycle approach to international trade emphasizes that national consumption and production will have different time paths.

In this paper, 64 U.S. industry growth paths are traced, many of them covering a full century. Various life cycle patterns were found, but retardation of growth was apparent in all of them.

The various sequences of trend period growth rates we measured or estimated can be simplified to eight standard patterns plus a rest category. They can be grouped under three broad headings, viz. 'retardation', i.e., the purest forms of growth retardation; 'long wave', i.e., retardation interwoven with, or dominated by long wave fluctuations; and 'other', including all weak forms of retardation. Using some simple mnemonics, the groupings look as follows (γ stands for annual growth rate per trend period; trend periods 1873-95, 1895-1929, 1929-48, 1948-73 are numbered 1 through 4; 1895-1913 is period 2a, 1913-29 is 2b):

Retardation

BURNS	Burns's stylized pattern of 'growth at a declining rate, the rise being eventually followed by a decline'.
RETARD	The 'strong' retardation of growth pattern: $\gamma_1 \geqslant \gamma_2 \geqslant \gamma_3 \geqslant \gamma_4 \geqslant 0$, or, alternatively: $\gamma_1 \geqslant \gamma_{2a} \geqslant \gamma_{2b} \geqslant \gamma_3 \geqslant \gamma_4 \geqslant 0$.
RETARD/WAR	Retardation of growth, interrupted by WW II-related increase in growth: $\gamma_1 \geqslant \gamma_2 \geqslant \gamma_4$ (or: $\gamma_1 \geqslant \gamma_{2a} \geqslant \gamma_{2b} \geqslant \gamma_4$), but $\gamma_2 \leqslant \gamma_3$ (or: $\gamma_{2b} \leqslant \gamma_3$).

Long wave

RETARD/LW 2	Retardation of growth, with 'weak' long-wave pattern, i.e., growth increase during second (1895-1929) trend period: $\gamma_1 \leqslant \gamma_{2a} \geqslant \gamma_{2b} \geqslant \gamma_3 \geqslant \gamma_4$ (or: $\gamma_1 \leqslant \gamma_{2a} \leqslant \gamma_{2b} \geqslant \gamma_3 \geqslant \gamma_4$).

RETARD/LW 4 Retardation of growth, with 'weak' long-wave pattern, i.e., growth increase during fourth (1948-73) trend period: $\gamma_1 \geqslant \gamma_2 \geqslant \gamma_3 \leqslant \gamma_4$ (or: $\gamma_1 \geqslant \gamma_{2a} \geqslant \gamma_{2b} \geqslant \gamma_3 \leqslant \gamma_4$).

LONG WAVE Pure long-wave pattern: $\gamma_1 \leqslant \gamma_{2a} \geqslant \gamma_{2b} \geqslant \gamma_3 \leqslant \gamma_4$ (or: $\gamma_1 \leqslant \gamma_{2a} \leqslant \gamma_{2b} \geqslant \gamma_3 \leqslant \gamma_4$).

Other

RETARD 29 Retardation of growth up to 1929, any other pattern since.

RETARD/GR Retardation of growth up to 1929, but increasing growth rates since: $\gamma_1 \geqslant \gamma_2 \leqslant \gamma_3 \leqslant \gamma_4$.

OTHER All other growth patterns.

In Table 6 only those 52 industries are included, whose histories cover more than two trend periods. Pure retardation dominates the agriculture and consumer goods series, just as expected, but in agriculture other patterns are presented as well, especially among the international staples. Conversely, long wave influences are predominant among the mining, transportation, and producer goods series: 15 out of 23 series here can be classified as 'long wave' series. Note that the 12 'other' series still exhibit retardation of growth, if later growth rates are compared to those of the initial one or two periods; some are simply mixed series, combining weak long wave fluctuations with war influences.

From Table 6 it appears that Burns was right about retardation, but he was essentially wrong about decline. The pure BURNS pattern as such is only present in eight series. Still, retardation of growth is exhibited by all series and there is no reason to reject the general retardation of growth hypothesis.

But our results show that actual growth patterns are too diverse to be adequately typified through one such generalization. In particular,

TABLE 6

SUMMARY OF GROWTH PATTERNS

	Agriculture	Mining	Transport.	Producer g.	Consumer g.	Total
BURNS	4	2	0	0	2	8
RETARD	1	0	0	2	5	8
RETARD/WAR	4	1	0	0	1	6
Retardation	9	3	0	2	8	22
RETARD/LW 2	0	2	1	1	0	4
RETARD/LW 4	3	3	2	2	0	10
LONG WAVE	0	1	1	2	0	4
Long wave	3	6	4	5	0	18
RETARD 29	3	0	0	0	0	3
RETARD/GR	2	0	0	0	0	2
OTHER	1	2	1	0	3	7
Other	6	2	1	0	3	12

the life histories of mining, transportation and producer goods industries can only be understood if the long wave in economic life is taken into account.

APPENDIX A DATA SOURCES

The main data source for the growth rates reported in this paper has been Historical Statistics of the United States: Colonial Times to 1970, U.S. Department of Commerce, 1975. The time series employed have been updated to 1977 or 1978 by consulting recent issues of the original data sources listed in Historical Statistics, or by using recent issues of the Statistical Abstract of the U.S. In order to extend some of the series back, use was made of the statistical data contained in A. F. Burns, Production Trends in the United States Since 1870, National Bureau of Economic Research, 1934, Table 44.

Below we list the Historical Statistics series names and numbers, along with other or additional sources consulted. Listings follow the order employed in Tables 1 through 5a.

Agriculture

Corn for all purposes, production (mln bushels)	K503
All wheat for grain, production (mln bushels)	K507
Oats for grain, production (mln bushels)	K512
Barley for grain, production (mln bushels)	K515
Flaxseed, production (mln bushels)	K518
Soybeans for beans, production (mln bushels)	K521
Sorghum grain, production (mln bushels)	K524
Rye for grain, production (1,000 bushels)	K527
Buckwheat, production (1,000 bushels)	K530
Irish potatoes, production (1,000 cwt.)	K533
Sweet potatoes, production (1,000 cwt.)	K536
Rice, production (1,000 cwt.)	K539
(1873-1895: Burns, Table 44, series 11)	
Sugarcane, production, raw sugar (1,000 tons)	K542
(1873-1929: Burns, Table 44, series 4)	
Sugar beets, production (1,000 tons)	K545
(1873-1929: Burns, Table 44, series 2)	
Hay, production (mln tons)	K551
Cotton, production (1,000 bales)	K554
Shorn wool, production (mln pounds)	K559

Tobacco, production (mln pounds)	K562
All cattle, live weight production (mln pounds) (1880-1929: Burns, Table 44, series 18)	K575
Hogs, live weight production (mln pounds) (1880-1929: Burns, Table 44, series 19)	K578

Mining

Bituminous coal, total production (1,000 tons)	M93
Pennsylvania anthracite, total production (1,000 short tons)	M123
Crude petroleum, production (1,000 bbl.)	M138
Natural gas, marketed production (billions of cu. ft.) (1895-1929: Burns, Table 44, series 45)	M147
Sand and gravel, sold or used (1,000 short tons)	M193
Phosphate rock, sold or used by producers (1,000 short tons) (1873-1895: Burns, Table 44, series 32)	M203
Iron ore, production (1,000 long tons)	M205
Copper, mine production (recoverable content) (short tons)	M235
Lead, primary production, refined from domestic and foreign ores (short tons)	M243
Zinc, primary production, smelter slab zinc from domestic and foreign ores (short tons)	M250
Bauxite, domestic output (1,000 long tons)	M256

Transportation

Passenger cars, factory sales, number (1,000)	Q148
Motor trucks and buses, factory sales, number (1,000)	Q150
Railroad passenger miles (mil.) (1882-1895: Burns, Table 44, series 99)	Q307
Railroad freight traffic, ton miles (mil.) (1873-1895: Burns, Table 44, series 97)	Q340
Revenue passenger miles flown (mil.)	Q585
Ton-miles flown, express and freight (1,000)	Q586
Net tonnage capacity of vessels entered, total, all ports (1,000 net tons)	Q506

Producer goods

Pig iron, shipments (1,000 long tons)	M217
Raw steel produced (1,000 short tons)	P265
Hot rolled iron and steel produced (1,000 short tons)	P270
Aluminum, primary production, from domestic and foreign ores (1,000 short tons)	M258
Cement, shipments (1,000 bbl.)	M188
Sulfuric acid (100% H_2SO_4) (1,000 short tons)	P251
Rayon and acetate fibers, mill consumption (mil. lb.): _Textile Organon_, various issues	

Non-cellulosic fibers, mill consumption (mil. lb.): <u>Textile Organon</u>, various issues
Plastics materials and resins, volume index: <u>FRB Industrial Production Index</u>, SIC-code 2821

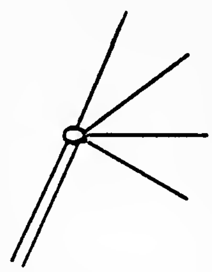
<u>Consumer goods</u>

Cigarettes, production (millions)	P241
Raw cotton used in textiles (1,000 bales)	P228
Wool used in textiles (mil. lb.)	P229
Rayon & acetate yarns available (mil. lb.)	P244
Non-cellulosic yarn available (mil. lb.)	P245
Clothes washer (elec.), number (1,000): <u>Merchandising Week</u>, various issues	
Electric iron, number (1,000): id.	
Refrigerator, number (1,000): id.	
Vacuum cleaner, number (1,000): id.	
Phonographs and home-type radio-phonograph combinations shipped, number (1,000) (1948-1978: <u>Merchandising Week</u>, various issues)	P289 + P290
Radio sets produced, including imports of foreign brands, number (1,000): <u>Merchandising Week</u>, various issues, and <u>Electronic Market Data Book 1979</u>	
Television sets (black & white) shipped, number (1,000): <u>Merchandising Week</u>, various issues	
Color tv sets, factory sales, number (1,000): <u>Merchandising Week</u>, various issues	
Tape recorders shipped (including imports): <u>Merchandising Week</u>, various issues	
Room air conditioners shipped, number (1,000): <u>Merchandising Week</u>, various issues	
Typewriters shipped, number (1,000)	P279

APPENDIX B A COMPARISON WITH BURNS AND GOLD

Burns estimated retardation of industrial growth by fitting a logarithmic parabola to his production data: $\log y = c + (\log a)t + [(\log b)/2]t^2$, where y refers to annual production and t to years.[5] The average rate of retardation <u>per decade</u>, the figure given by Burns, their equals $100(b^2 - 1)$.

Gold charted his series on semi-log paper and fitted long-term trends by visually determining linear linkages and estimating the growth rate of each linear segment using ordinary least squares. His visual inspection yielded various growth patterns, the four most 'regular' ones being:



The following 29 series are covered by Burns, Gold and the present study. Obviously one should keep in mind that Burns had data only for the 1870-1929 period; Gold extended them to 1955; we cover a century: 1873-1973. Burns's findings are summarized below by his average rate of retardation per decade and estimated peak year; Gold's by his linear-linkage growth pattern. We use our mnemonics again.

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[5] He actually used an equation, that can be derived from the logarithmic parabola: $Y = ab^t$, where Y measures decade rates of growth in ratio form, centered at quinquennial dates t (Burns [1934, pp. 97-9]).

Agriculture (15)	Burns	Gold	Van Duijn	Peak Year
Corn	- 1.0 (1916)		RETARD/GR	1977
Wheat	- 0.5 (1925)		RETARD 29	1976
Oats	- 1.2 (1923)		RETARD/WAR	1945
Barley	- 0.7 (1949)		RETARD/WAR	1958
Rye	- 0.9 (1924)		RETARD/LW 4	1922
Buckwheat	- 1.1 (1904)		BURNS	1905
Irish potatoes	- 0.7 (1926)		RETARD/GR	1976
Rice	- 0.4 (2023)		OTHER	1975
Sugarcane	- 2.8 (1903)		RETARD 29	1975
Sugar beets	- 3.4 (1944)		RETARD/LW 4	1975
Cotton	- 0.8 (1932)		BURNS	1937
Shorn wool	- 0.8 (1916)		BURNS	1941/42
Tobacco	- 0.3 (1966)		RETARD	1963
Cattle	- 1.7 (1924)		RETARD/GR	1973
Hogs	- 0.4 (1965)		RETARD/LW 4	1943
Mining (7)				
Bituminous coal	- 1.6 (1933)		RETARD/LW 2	1976
Anthracite coal	- 1.4 (1916)		BURNS	1917
Petroleum	- 0.3 (2116)		RETARD/LW 2	1970
Natural gas	- 2.1 (1943)		LONG WAVE	1972
Iron ore	- 1.9 (1929)		OTHER	1953
Copper	- 2.2 (1933)		RETARD/LW 4	1970
Lead	- 1.6 (1933)		RETARD/LW 4	1926
Transportation (2)				
Railway passenger-miles	- 1.3 (1929)		OTHER	1944
Railway ton-miles	- 1.4 (1942)		RETARD/LW 2	1973
Producer goods (4)				
Pig iron	- 1.2 (1943)		LONG WAVE	1973
Steel	- 3.4 (1929)		RETARD/LW 4	1973
Hot rolled iron and steel	- 0.7 (1968)		RETARD/LW 2	1973
Aluminum	-11.5 (1924)		RETARD	1974
Consumer goods (1)				
Cigarettes	0.3		OTHER	1976

Burns was right about retardation, he was wrong about decline. All 29 series exhibit retardation of the growth rate, if later growth rates are compared to those of the initial one or two periods, but the BURNS-pattern as such is present in only 4 series. Consequently Burns was often far off the mark with his peak-year estimates: for only 8 series he stayed within ten years; with two post-1977 peak predictions he still may eventually be right. Seventeen of the 29 series covered here had peaks in the 1970s, and may therefore be considered as still growing. Again, however, retardation of growth is present in all series.

Gold, who had the benefit of 25 more observations per series, may have been misled by the peculiar nature of this quarter century, which encompassed a major depression, a war-induced recovery, and a postwar adjustment. Gold claimed a long-term constant rate of growth for eight series, where all eight in fact exhibit retardation of growth. More precisely, from our 1980 vantage point, we would disagree with thirteen of his 29 1960-labels.

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Faculty Working Papers

INFLATION AND THE HOUSEHOLD LIQUID ASSET PORTFOLIO

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#668

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Notes

[1]We required the firms to be listed during the entire sample period. The Center for Security Price Research (CRSP) monthly tape was used to select NYSE listed firms. A firm was considered listed if it had monthly stock returns available for the entire sample period.

[2]The absolute percentage error is computed as the average of $\left|\frac{\text{Actual EPS} - \text{Predicted EPS}}{\text{Actual EPS}}\right|$. Since this error metric can be explosive when the denominator approaches zero we truncated errors in excess of ten to a value of ten. This operation was done for a very small percentage of the cases.