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By J. TINBERGEN

I

THEORETICAL INTRODUCTION

1. Much attention has recently been given to the so-called "acceleration principle" or "the Relation" as Mr. Harrod[1] calls it. Developed by Professors Aftalion, Bickerdike, Bouniatian, Carver, Fanno, Kuznets and Pigou, it has been given special attention by Professor J. M. Clark in his splendid survey *Strategic Factors in Business Cycles*[2]; and has obtained a place in many theories of the business cycle. Professor Haberler,[3] from whom part of the above references are taken, also uses it in his own synthesis of theories; Mr. Harrod regards the acceleration principle and the multiplier principle acting in combination as the chief forces in trade cycles. Quite recently Dr. Chait[4] has developed a theory implying as special cases both the acceleration principle and the multiplier principle.

2. The principle in its simplest form can be best seen in a simplified example.[5] Let the value of the yearly output of (say) shoes be 100. The cost of the fixed capital equipment required for this output may be 500, 10 per cent. of which must be replaced each year. Then, new machines at the cost of 50 must be constructed each year for replacement. Now, suppose the demand for shoes rises, so that production must be increased by 10 per cent. to 110 a year. If there is no excess capacity and if methods of production are not changed, this increase necessitates an increase of 10 per cent. in the stock of fixed capital; that is, an additional production of machinery of 50, being an increase of 100

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[1] R. F. Harrod, *The Trade Cycle*. An Essay. Oxford, 1936.
[2] Cf. also J. M. Clark, "Business Acceleration and the Law of Demand," *Journal of Political Economy*, XXV, pp. 217-235. (1917.)
[3] G. von Haberler, "Prosperity and Depression," *A Theoretical Analysis of Cyclical Movements.* Geneva, 1937, League of Nations.
[4] B. Chait, *Les fluctuations économiques et l'interdépendance des marchés.* Brussels, 1938.
[5] Taken from Haberler, *loc. cit.*, p. 84.

per cent. In this simplest form the principle states that percentage changes in the *production* of consumers' goods are equal to percentage changes in the *stock* of capital goods. As the latter is usually considerably larger than the annual *production* of capital goods, the corresponding percentage changes in the latter are much larger than the percentage changes in the production of consumers' goods. The principle has two aspects between which it is useful to distinguish :

(*a*) the correlation aspect : there must be correlation between new investment in durable capital goods and the *rate of increase* in consumers' goods production ;

(*b*) the regression aspect : the percentage fluctuations in consumers' goods production are *equal* to the percentage fluctuations in the stock of capital goods. The first aspect states something about the correlation coefficient between two variables ; the second aspect about the numerical value of the regression coefficient.

3. There is some doubt about the causal direction of the relation mentioned. Sometimes causality is not considered at all ; the principle is only meant to explain the difference in intensity between consumers' goods production and producers' goods production. In other cases, however, the principle is meant to explain investment fluctuations. Changes in consumption are then taken as given ; fluctuations in investment activity are deduced. In any case this seems to me the more interesting aspect of the matter and, at the same time, the kind of relationship we need for business cycle theory.

4. In its more rigorous form, the acceleration principle can only be true if the following conditions are fulfilled.

(*a*) Very strong decreases in consumers' goods production must not occur. If the principle were right, they would lead to a corresponding disinvestment and this can only take place to the extent of replacement. If annual replacement amounts to 10 per cent. of the stock of capital goods, then a larger decrease in this stock than 10 per cent. per annum is impossible. A decrease in consumers' goods production of 15 per cent. could not lead to a 15 per cent. decrease in physical capital as the acceleration principle would require. It is interesting that this limit is the sharper the greater the duration of life of the capital goods considered.

(*b*) There should be no abrupt changes in technique

leading to a sudden increase in the amount of capital goods necessary to the production of one unit of consumers' goods.

In its more rigorous form, the principle is equivalent to saying that a constant part of productive capacity is idle and that entrepreneurs never increase production of consumers' goods before having increased correspondingly their capacity. In the case of this constant part being zero—i.e., full occupation of capacity at any moment—this is, at least for increases, a necessity ; in all other cases this policy would have to be followed deliberately, and there are hardly enough reasons to suppose this occurs in reality.

In particular there are reasons to expect the principle to break down in times of heavy decreases in production (cf. what was said under (*a*)) as well as in the periods immediately following such decreases, until production has reached capacity again. It is only at that moment that the *necessity* of the principle's action recurs.

5. The acceleration principle may, however, be given a less rigorous form. Instead of equality of percentage changes in consumers' goods production and capital goods' stock there may be assumed to be only proportionality or even only a linear relationship. This means that there would still be correlation but that the regression coefficient would be less than one. Two reasons exist for giving the principle its less rigorous form :

(*a*) During a period of increasing production, not all firms and not all branches attain at the same moment the point of full capacity. Suppose that for the individual firms the principle acts only—and then of course in its rigorous form—when full capacity is reached ; then to a given increase in total production for all firms a smaller percentage increase in total stock of capital goods may correspond. Something similar may happen with heavy decreases in production : some firms may show decreases going beyond the critical one mentioned in section 4, sub. (*a*), others may remain within the critical boundary. Supposing that in such times all firms simply do not replace worn-out capacity, there will again be a percentage decrease in physical capital stock which is smaller than the percentage decrease in consumers' goods production. (This statement holds, of course, equally well for any individual firm going beyond the critical decrease.)

Of course, it is not at all certain in these circumstances

that the regression coefficient will have to be the same for every moment. Much depends on the distribution of decreases over firms and on the distribution of idle capacity over firms. But there will be a tendency to a regression coefficient below one. It may be added already here that in fact the material used by Professor Clark in his first exposition of the principle showed this very clearly; the regression coefficient being about one-half instead of one. It may also be added that the magnifying effect may, nevertheless, still exist. If the rigorous acceleration principle would lead to percentage fluctuations in capital goods production ten times as large as those in consumers' goods production, then in the less rigorous form these percentage fluctuations would still be five times as great.

(b) A second reason for the less rigorous form of the acceleration principle might be that even with idle capacity a firm would expand its plant proportionally to the rate of increase in consumers' goods production, but not by an equal percentage. This would mean that there would not be an immediate necessity for investment but that the willingness to invest would depend chiefly on the rate of increase in consumers' goods production.

It seems important to remind the reader that we have been considering three situations in which a firm may find itself :
(i) full capacity used and increasing production ;
(ii) heavily decreasing production, as defined under 4 (a) ;
(iii) all other situations.
If the less rigorous acceleration principle were caused only in the way indicated under 5 (a), at least part of the firms should be in the situations (i) and (ii) during most of the period studied. There is reason to doubt whether this is so for the post-war period or even for many pre-war years. If this doubt is justified, the only way in which the principle could still be fulfilled would be the one indicated under 5 (b). The behaviour of entrepreneurs assumed there seems, however, less natural than the behaviour assumed under 5 (a). Therefore I think there must be already for theoretical reasons some doubt as to the validity of the acceleration principle. In my opinion an explanation of investment fluctuations by profit fluctuations[1] is more natural, and for this reason a comparison between these two competing explanations has been made in some of

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[1] To be called shortly " the profit principle."

the cases considered. It would, however, lead us too far
to go into a detailed consideration of the relationship between
profits and investment.

6. One further amendment of the acceleration principle
may be mentioned for reasons of completeness. Dr. Staehle,
in a private discussion, suggested that the correlation would
exist between new investment activity and the *shift in the
demand curve* for consumers' goods instead of the increase
in the actual quantity demanded or produced. This seems
indeed more natural especially in the following situation :
suppose that, with full capacity used, demand increases, but
as productive capacity cannot be expanded immediately,
the quantities produced cannot rise correspondingly. Prices
will rise instead. Nevertheless it is natural to assume that
there will be new investment. Dr. Staehle's hypothesis
can be given an especially convenient form if the elasticity
of demand is unity (which, approximately, will be the case
for " all consumption ") : then the shift in demand curve
is simply equal to the change in the money value of consump-
tion or consumption outlay. Therefore his device would
simply be equivalent to saying that new investment is
correlated with the rate of increase in consumption outlay.

II
STATISTICAL VERIFICATION

7. Depending on the statistical material available, in
some cases both aspects—the correlation and the regression
aspect—have been tested, whereas in other cases only the
correlation aspect could be considered. The regression
aspect can only be investigated if figures on the stock of
physical capital goods are available and this is only the
case for individual branches. The following industries
have been taken :

(*a*) Railways : U.K., pre-war, chart 1. France and
Germany, pre-war, chart 2.

(*b*) Cotton spinning : U.K., pre-war, chart 3.

(*c*) Shipping : U.K., pre-war, chart 4.

As, however, for business cycle theories the behaviour
of industry as a whole is of considerable interest, general
indices have also been considered. Here the only possibility
seems to be comparing the *production* index of investment
goods or durable goods with the rate of increase in the index
of consumers' goods production. In many respects this is

a less reliable comparison, as production of investment goods does not necessarily—although probably—fluctuate parallel to new investment. Replacement, which is included also, may show different fluctuations. It will, however, usually show less pronounced changes.

8. The railway charts have been drawn according to the following principle. The dotted line always represents the deviations from trend (nine-year moving averages) of the percentage rate of increase in rolling stock. For each of the countries it has been drawn twice ; it has been compared with a full curve which has everywhere been drawn at such a scale as to give the best fit. The upper full curve represents the fluctuations in the rate of increase of traffic, the lower full curve the profit rate (both as deviations from their nine-year moving averages). The upper graph therefore gives " the explanation of new investment by the acceleration principle," the lower one " the explanation of new investment by the profit principle." The lag of new investment has been taken $1\frac{1}{2}$ year, except for the profit principle for Germany, where it is 1 year. These lags seem to correspond fairly well to the lags in the curves, and, what is more important, they are about equal to the lag between orders and deliveries found for American figures.
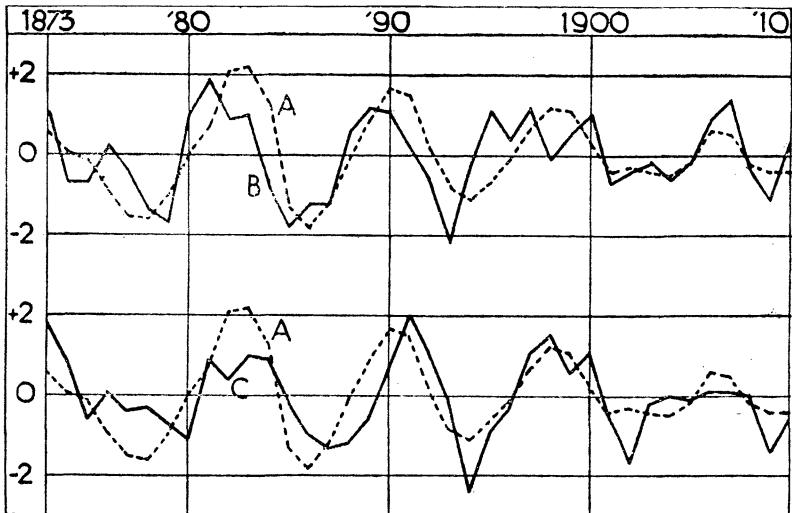

Chart 1.—RAILWAYS, UNITED KINGDOM.
  A. Percentage rate of increase in rolling stock (average of locomotives and cars weighted roughly according to their average prices in a base period).
  B. Percentage rate of increase in traffic, $1\frac{1}{2}$ year before, drawn on such a scale as to yield the best fit with A.
  C. Profit rate, $1\frac{1}{2}$ year before, drawn as B.
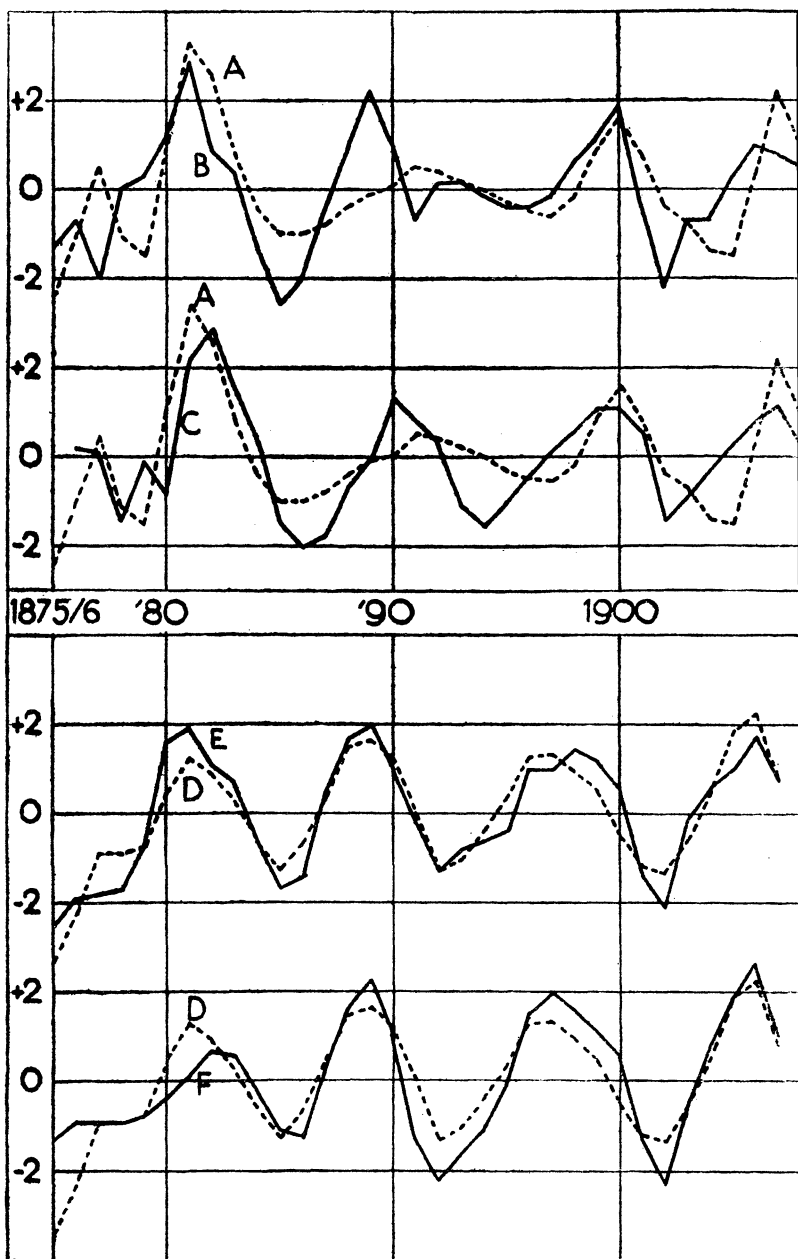
Chart 2.—RAILWAYS, FRANCE (A, B, C) AND GERMANY (D, E, F).
   A, D. Percentage rate of increase in rolling stock.
   B, E. Percentage rate of increase in traffic (B, 1½ year before; E, 2½ year before),
      drawn as B in chart 1.
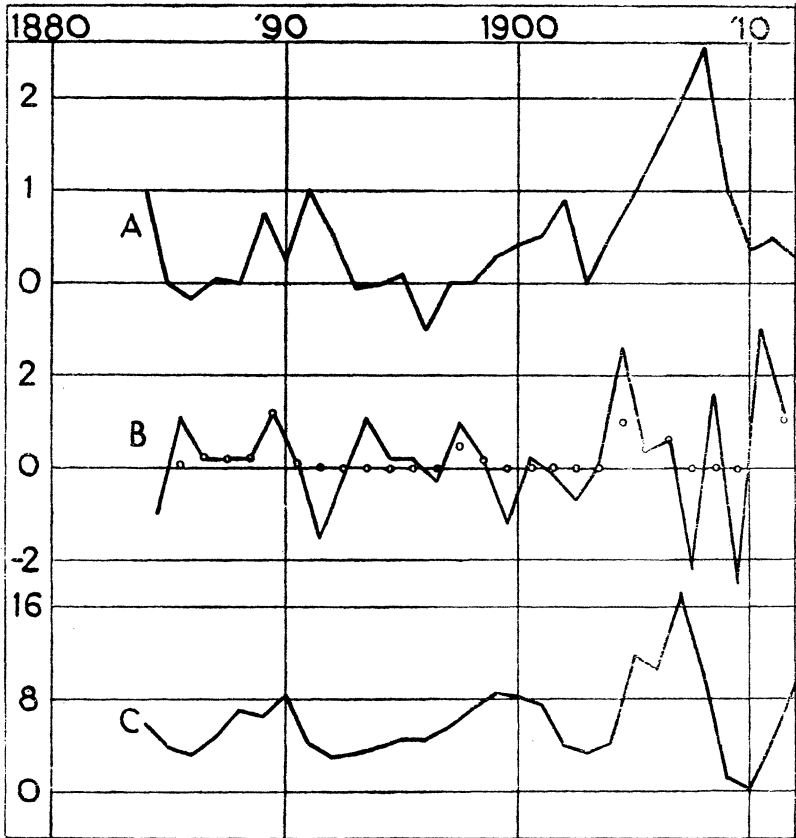   C, F. Profit rate (C, 1½ year before; F, 1 year before), drawn as B.

Chart 3.—SPINNING, UNITED KINGDOM.
  A. Net increase in number of spindles (millions).
  B. Rate of increase in cotton consumption (million cwts).
  O. " Corrected curve," i.e., (i) every negative figure replaced by zero, (ii) the subsequent positive figures replaced by zero as long as former maximum in consumption not yet reached again, (iii) the first figure after the former maximum has been surpassed replaced by difference between new maximum and former maximum.
  C. Average spinning profits (£1,000.—).
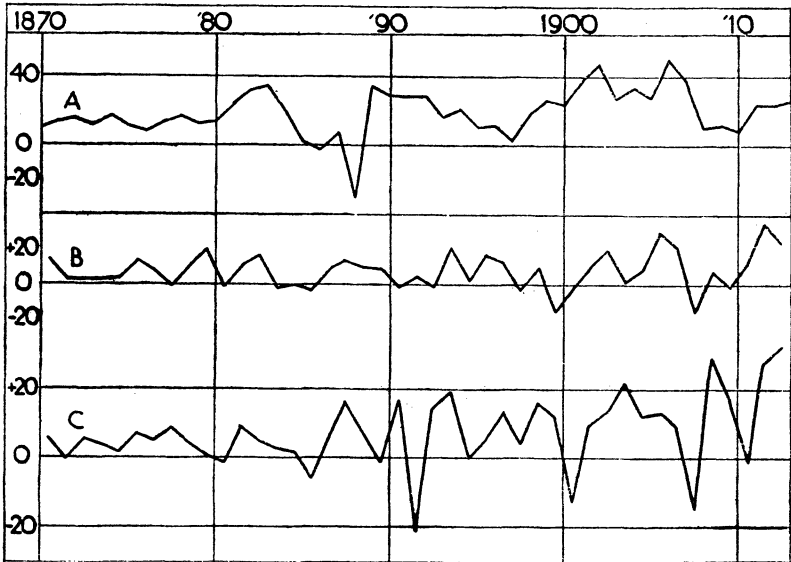Figures taken from D. H. Robertson, *A Study of Industrial Fluctuations*.

Chart 4.—SHIPPING, UNITED KINGDOM.
  A. Net rate of increase in total tonnage, 10,000 tons (sailing tons counted for one third).
  B. Net rate of increase in total British tonnage entered, million tons.
  C. Rate of increase in " transport index," indicating ton-miles of transport for chief sea transport commodities (cereals, coal, wood, oil, nitrate). Taken from *De Nederlandsche Conjunctuur*, March, 1934).
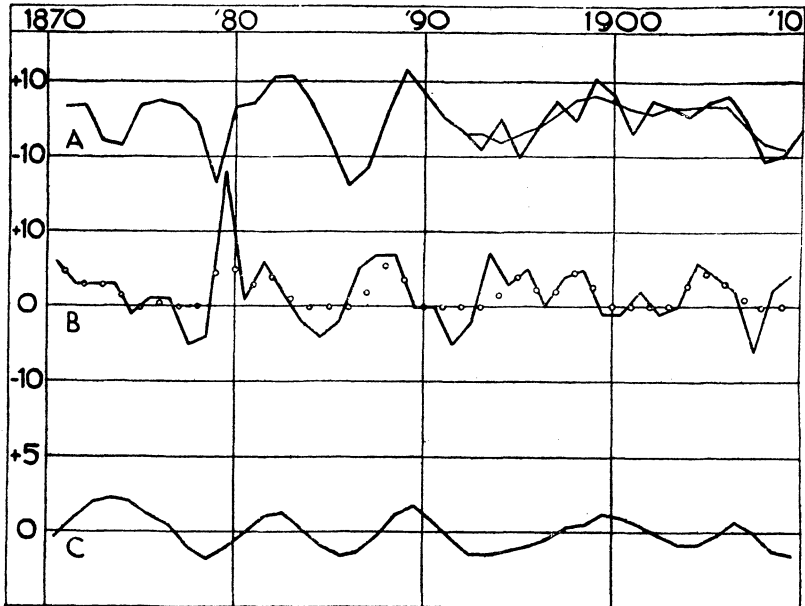

Chart 5.—GENERAL ACTIVITY, UNITED KINGDOM.
  A. Consumption of pig iron, percentage deviations from trend (nine-year moving average) ; taken account of pig iron in steel, of changes in stocks and after deduction of iron in exports.
  B. Rate of increase in industrial production (O, corrected figures, cf. chart 3, two-year moving averages); Hoffmann's index.
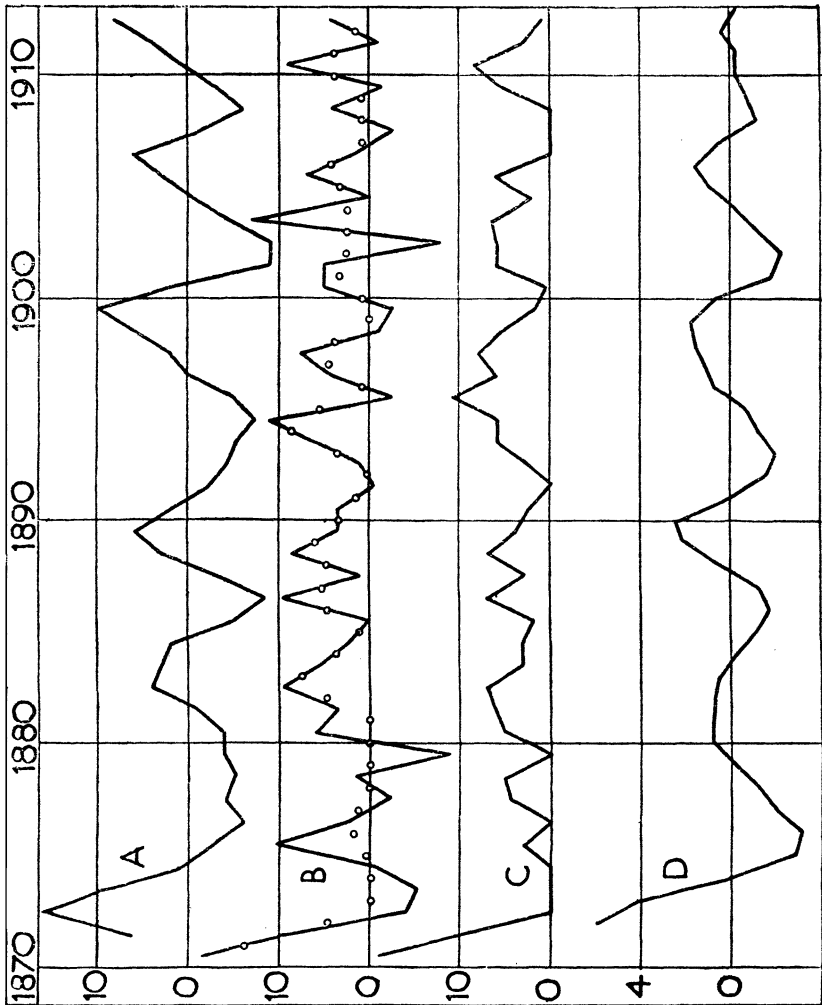 C. Non-labour income, deviations from trend (Stamp's figures for taxed income).

Chart 6.—GENERAL ACTIVITY, GERMANY.

A. Consumption of pig iron, percentage deviations from nine-year moving average, two-year moving average; taken account of iron in steel and after deduction of iron in exports.

B. Percentage rate of increase in industrial consumers' goods production (O, corrected figures, cf. chart 3, two-year moving averages).

C. Percentage rate of increase in total industrial production, corrected figures, cf. chart 3.

D. Dividends of all societies, percentage of capital, deviations from nine-year moving averages.
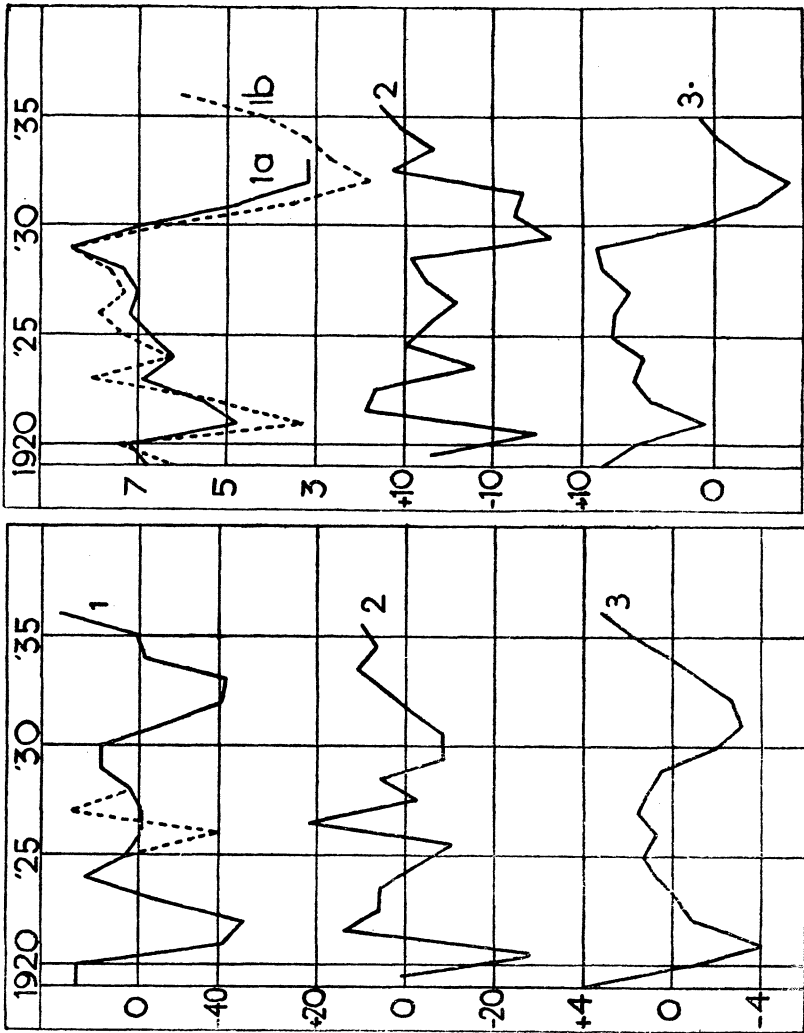
Chart 7.—GENERAL ACTIVITY, U.K. AND U.S.A.

U.K. : 1. Consumption of iron, percentage deviation from rectilinear trend ; taken account
of iron in steel, iron in exports deducted.
. . . . actual figures 1926 and 1927; – – –" corrected " figures (corrected for coal
miners' strike).
2. Rate of increase in industrial production, 1929 = 100; before 1928 taken from
Hoffmann, since from B.o.T.
3. Profits, percentage of capital, deviations from rectilinear trend ; *Economist.*
U.S.A.: 1a. Deliveries of producers' durable commodities, Kuznets, 10⁹ $ of 1929.
1b. Pig iron production in five million long tons.
2. Rate of increase in industrial production, F.R.B, 1923–5 = 100.
3. Profits of all corporations, 10⁹ $, Stat. of Income.

The scale chosen for the full line in the upper graphs depends on the regression coefficient found for the percentage rate of increase in traffic. According to the acceleration principle in its rigorous form it should be equal to 1 ; it was, however, found to be for :

U.K.	..	..	..	0.53
France		..	..	..	0.44
Germany		..	..	0.48

These figures illustrate at the same time what has been called the regression aspect of the principle. Evidently it only agrees with the less rigorous form given.

As to the correlation aspect, it is immediately seen from the charts that the correlation is only high for the case of Germany (as it was for the U.S.A. during the period studied by Professor Clark[1]) ; for the U.K. and France, however, it is rather low. But the correlations obtained for the profit principle are by no means higher.

It has been tried to improve the correlation by a correction, consisting in two sorts of changes in the figures for the rate of increase in traffic :

(i) putting equal to zero any negative number and the positive numbers following it, as long as the last maximum in traffic has not yet been reached ;

(ii) in those years where a previous maximum in traffic is passed again the rate of increase in traffic is reduced to the extent the new maximum surpasses the previous one.

This correction evidently corresponds to the difficulties mentioned under 4 (a).

In the case of railways, however, it works out very little for pre-war times, as years of decrease were seldom. In some of the other cases considered the influence of this correction is far larger.

9. In all further cases the curves have been given separately, the first always representing the investment series, the next curve (or, for charts 4 and 6, two curves) the rate of increase in production (of the goods produced with the help of the investment goods considered) and the lower curve the profits in the industry considered. An exact description has been given with the charts. Sometimes the curve in the middle has been corrected in the way already described ; the result is indicated by small circles representing

[1] It was not in the period studied by S. Kuznets : " Relation between Capital Goods and Finished Products in the Business Cycle," *Economic Essays in Honor of W. C. Mitchell*, New York 1935, p. 209.

two year moving averages of the corrected curve, in order to eliminate small and probably meaningless fluctuations.

For cotton spinning and shipping the acceleration principle breaks down completely. No correlation of any importance exists. For cotton spinning, the profit principle works. For shipping no satisfactory profit figures could be found.

Considering the four general cases, where, however, the figures for net investment are not available in any form, I think they are all rather bad for the acceleration principle. One could doubt in the case of the U.K. (pre-war), chart 5, but even there the explanation by the profit principle certainly gives better results ; and in all cases the fit obtained with the acceleration principle would certainly be poor. One has, of course, to be careful with the interpretation of the correlation between profits and investment, which could as well be such that investment determines profits, instead of the other way round. Then the mere fact that their mutual correlation is better than the one required by the acceleration principle would not prove much. There are, however, reasons for believing in the interpretation given[1] and then it seems that a better explanation of investment is possible than the poor one yielded by the acceleration principle.

10. Summarising, it may be said that the acceleration principle cannot help very much in the explanation of the details in real investment fluctuations, with the possible exception of railway rolling stock.[2] As a rather rough principle with the chief object of explaining the tendency to more intense fluctuations in durable goods production it remains of value ; but that tendency seems to be half as large as would be expected.

[1] These will be given in the report on the League of Nations investigations into the subject.
[2] Mr. D. H. Robertson draws my attention to the fact that railways have to carry any freight offered and for that reason might react more exactly in the sense of the acceleration principle.

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[Footnotes]

[2] **Business Acceleration and the Law of Demand: A Technical Factor in Economic Cycles**
J. Maurice Clark
The Journal of Political Economy, Vol. 25, No. 3. (Mar., 1917), pp. 217-235.
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