CHAPTER V

NET INVESTMENT IN RAILWAY ROLLING-STOCK

§ 15. The Relation tested

Acceleration principle and profit principle.

In § 9, the result was obtained that, in the case of general investment activity, the acceleration principle yields an explanatory factor of only minor importance as compared with profits. For railways, it is possible to take a slightly different view. The two facts, (*a*) that railways usually are not permitted to refuse passengers or freight offered for transport and (*b*) that, generally, they are public enterprises or under some sort of control of public authority, both tend to replace pure profit considerations by more technical considerations as far as new investment is concerned. There is some reason to assume that profit considerations are in this case wholly or partially replaced by the considerations at the basis of the acceleration principle. For this reason, three types of calculation have been made. An attempt has been made to explain the net investment in railway rolling-stock v_R by the following primary factors:

(1) The rate of increase in traffic Δu_R only (" acceleration principle ");
(2) The profit rate Z_R only (" profit principle ");
(3) Both Δu_R and Z_R (" mixed principle ").

Secondary factors; lags.

As secondary factors the same factors have been chosen as in Chapter III, viz.,

The price of iron q_i;

The long-term rate of interest m_{Lb}.

About the probable lag, some information is available in the lags between orders of locomotives and of cars and the rate of increase in total stock of locomotives and of cars with the American railways. These data show a lag of about 1 year for cars and of about 1½ years for locomotives. As the lag between any incentive to invest and the actual increase in rolling-stock may be larger than the purely technical lag between orders and increase, it seemed a fair estimate to take 1½ years for all rolling-stock. To begin with, calculations with this lag were made. Inspection of the graphs showed that the lag seemed to be somewhat shorter for the United States, especially in the case of the profit principle; perhaps somewhat longer for France, and decidedly longer (2½ years) for Germany, if for these two countries the acceleration principle was accepted as the explanatory principle. Therefore, a lag of 2½ years for Germany has been taken, whereas for the other countries the lag of 1½ years was retained, with the exception of the profit principle for the United States, where a lag of 1 year was also considered. These lags may roughly be considered as the lags giving the highest correlation.

For the profit principle, somewhat more complicated calculations (indicated as calculations 2′) were made in addition: viz., calculations in which profits with two different lags are introduced as variates. This may give somewhat more accurate indications about lags, which will be discussed together with the results.

Significance calculations. Significance calculations have been made only for some of the most typical cases. As railway rolling-stock plays a decreasing rôle in total investment, it did not seem necessary for the ultimate objects of this enquiry to go into very much detail, the more so because the results were only moderately good.

§ 16. The Statistical Material

Countries and periods. The countries and periods studied are:

France, 1876-1908 (thirty-three years).
Germany, 1874-1908 (thirty-five years).
United Kingdom ,1873-1911 (thirty-nine years)
United States, 1896-1913 (eighteen years).

All necessary data on railways are taken from the Statistical

Year-books of these countries. For the secondary factors, the data referred to in Chapter III are taken.

Computation of indices. Some preliminary work was involved in calculating the necessary indices.

Investment index. An index v_R of net investment was calculated as a weighted arithmetic average of the percentage rates of increase in locomotives, freight cars and passenger cars. As weights, there were taken the products of the number of each type of rolling-stock present at the end of 1895 (for the United States 1905) by a weight factor which was taken as

20 for locomotives,
10 for passenger cars, and
1 for freight cars.

For the United Kingdom, where no separate data for both types of car were available, one weight factor 2 was used for all cars. The influence of the weights on the shape of the investment index is not large, as the rate of increase in locomotives and cars is usually highly correlated.

Profit series. As profit series (Z_R), the following have been used:

United States: " Net operating income " as a percentage of " investment " (*i.e.*, capital invested);

United Kingdom: Ratio of net receipts to paid-up capital;

Germany: Profits as percentage of invested capital;

France: Net income per kilometre divided by cost of construction of one km.

Rate of increase in traffic. An index for the rate of increase in traffic was calculated as a weighted arithmetic average of the percentage rates of increase in passenger traffic and freight traffic. The weights chosen are numbers roughly proportional to the total receipts for passenger traffic and freight traffic at about the middle of the period studied. They are indicated in the table below, together with the exact description of the traffic series used.

Traffic series and weights used.

Country	Passenger traffic		Freight traffic	
	Series used	Weight	Series used	Weight
United States	Passengers carried 1 mile	1	Freight carried 1 mile	3
United Kingdom	Total ordinary passenger journeys	4	Total tonnage of goods conveyed	5
Germany	Passengers carried 1 kilometre	1	Freight carried 1 kilometre (tons)	2
France	Passengers carried 1 kilometre	4	Freight carried 1 kilometre (tons)	5

For pig-iron prices and long-term interest rates, the same series have been used as described in Chapter III.

Trends.

In order to eliminate trends, deviations from nine-year moving averages have been taken for all series except iron prices, where percentage deviations from nine-year moving averages were taken.

§ 17. Results

Details of the results obtained are presented in Tables V. 1 to V. 3 and Graphs V. 1 to V. 4. The following general features seem worth mentioning:

Results not better than for general investment activity.

(i) Looking at the correlation coefficients obtained, one finds that the results are not, as might have been expected, better than those obtained for general investment activity. It therefore seems that the advantage of having more homogeneous material is counteracted by the larger influence of disturbances in a more restricted field of activity.

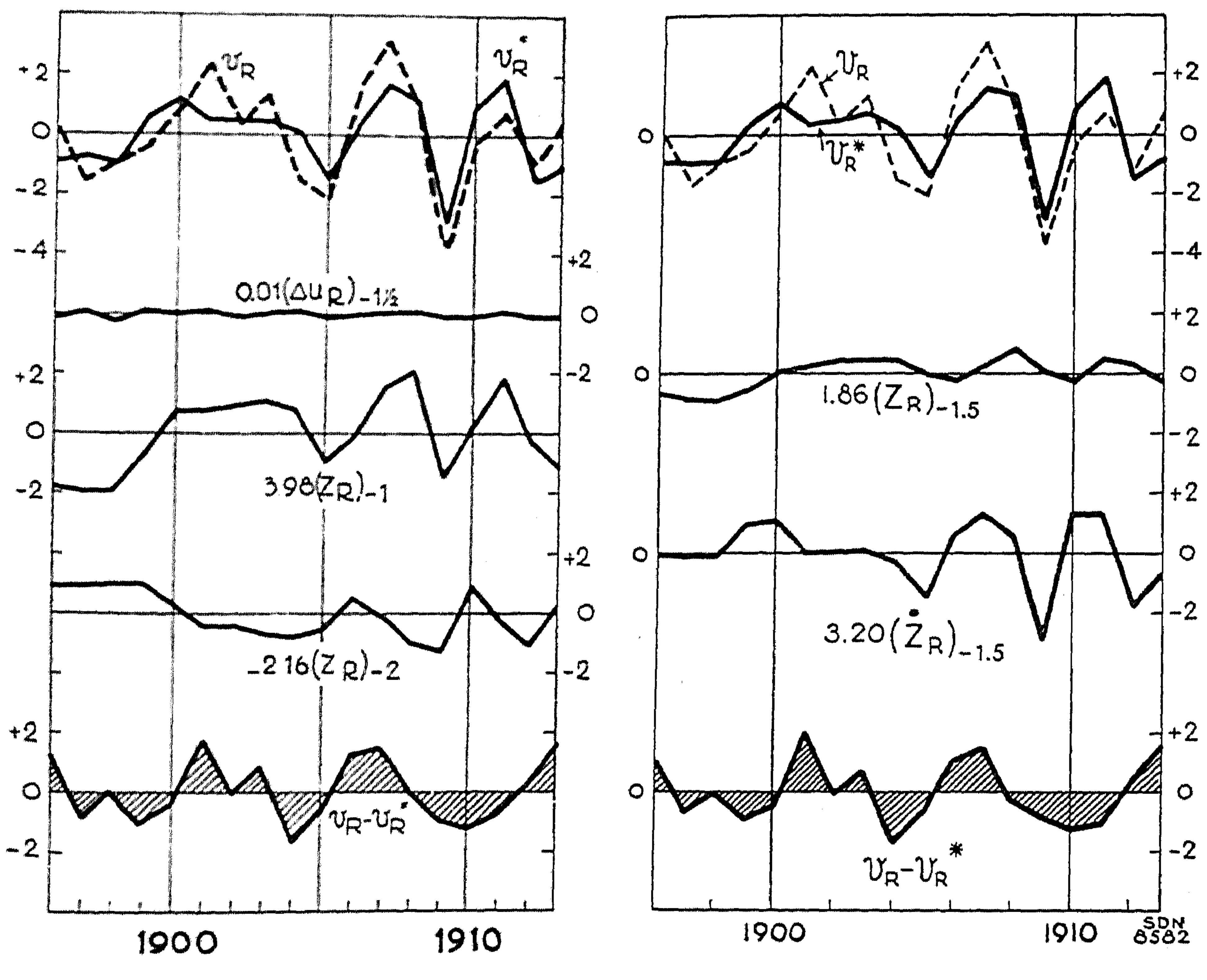
Lags.

(ii) As has been said already, the lags chosen in the case of the acceleration principle are roughly those which give the best fit. They are 1½ years for the United States, the United Kingdom and France, and 2½ years for Germany. For the profit principle, these lags were tested by the calculations summarised in columns (7) to (9), Table V. 1. In the case of the United Kingdom and France, the regression coefficients obtained for profits with 2½ years lag are small in comparison to those obtained for profits with 1½ years lag. This means that the optimum lags are near to 1½ years—somewhat more in France,

Graph V. 1.

" Explanation " of Investment in Railway Rolling-stock.
United States 1896-1913.

Left-hand side: " Mixed principle " — Right-hand side: " Profit principle ".



v_R : investment in railway rolling-stock, actual.

v_R^* : investment in railway rolling-stock, as explained by:

$(\Delta u_R)_{-1\frac{1}{2}}$: increase in traffic, lagged 1½ years;

$(Z_R)_{-1}$: profits, lagged 1 year;

$(Z_R)_{-2}$: profits, lagged 2 years;

$(Z_R)_{-1\frac{1}{2}}$: profits $\}$ lagged 1½ years.

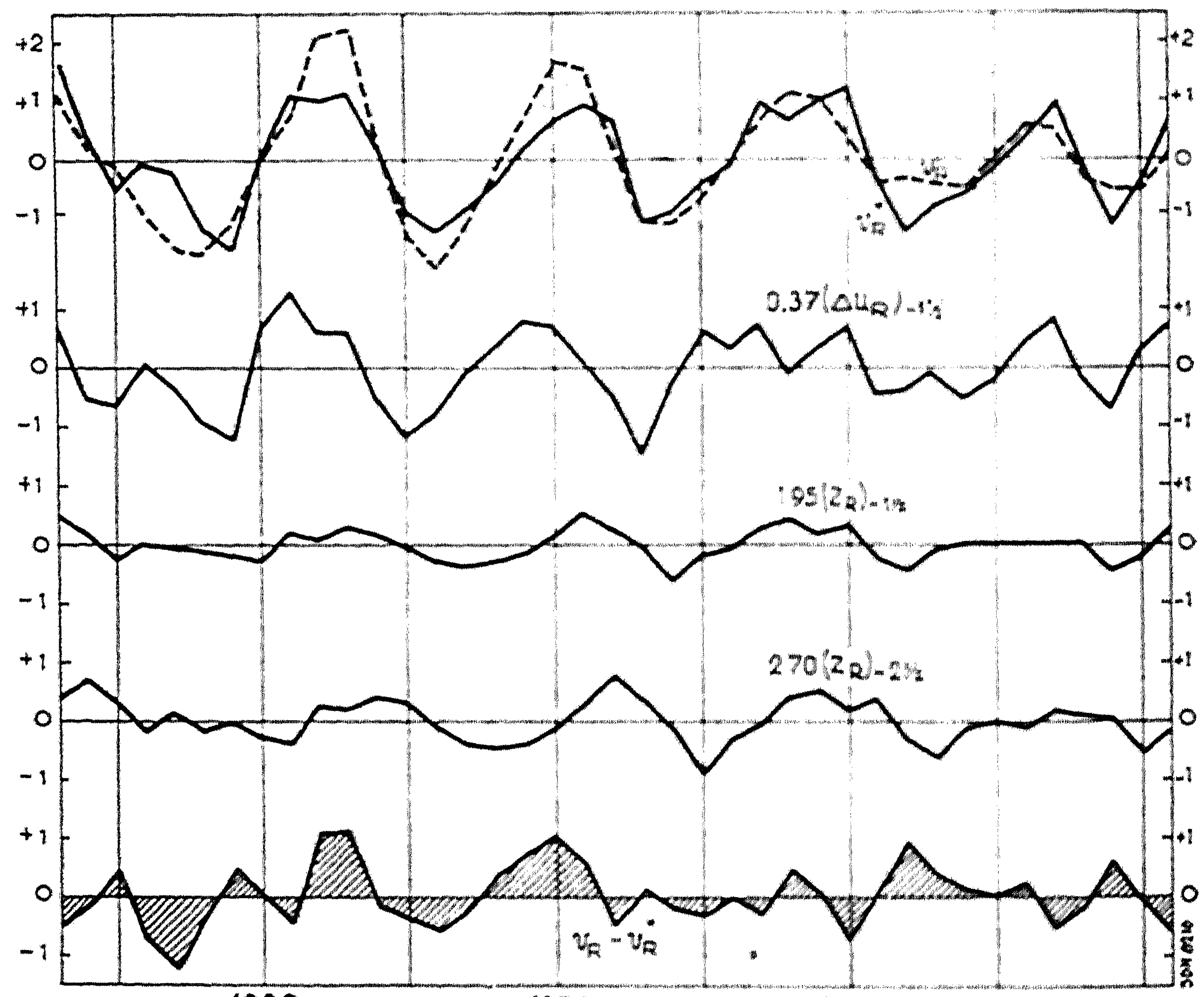
$(\dot{Z}_R)_{-1\frac{1}{2}}$: rate of increase in profits somewhat less in the United Kingdom. For Germany, both coefficients are equally important, pointing to an optimum lag of 2 years.

The regression coefficients obtained in the case of the United States indicate that a considerably smaller lag than even 1 year would be the optimum lag if profits were to be the only explanatory variate. This is, however, inacceptable, as delivery of rolling-

Graph V. 2.

"EXPLANATION" OF INVESTMENT IN RAILWAY ROLLING-STOCK.
UNITED KINGDOM 1873-1911.

"Mixed principle".



v_R :	Investment in railway rolling-stock, actual.
v_R^* :	investment in railway rolling-stock, as explained by:
$(\Delta u_R)_{-1\frac{1}{2}}$:	rate of increase in traffic, lagged 1½ years;
$(Z_R)_{-1\frac{1}{2}}$:	profit rate, lagged 1½ years;
$(Z_R)_{-2\frac{1}{2}}$:	profit rate, lagged 2½ years.

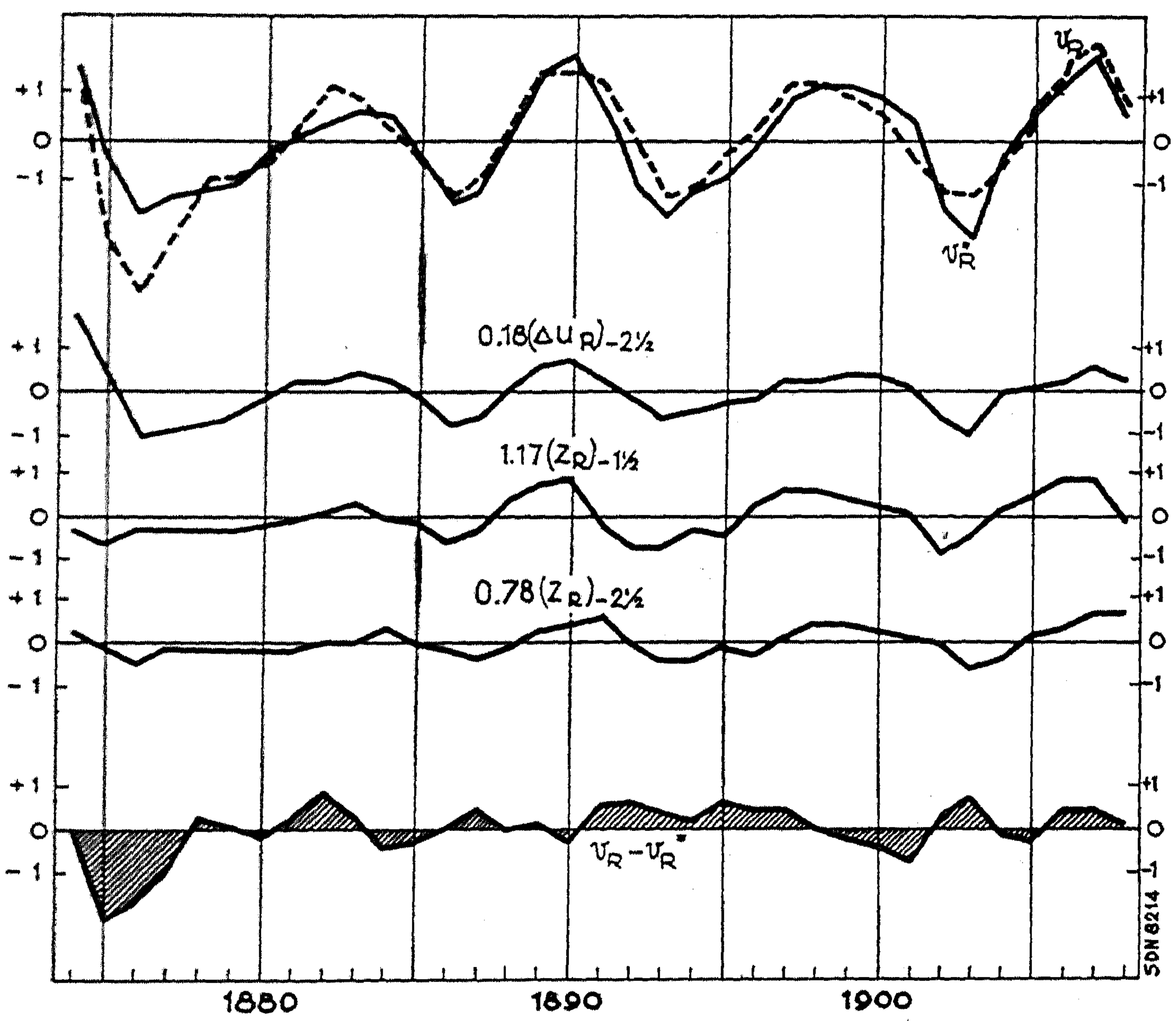
stock requires at least one year (see above). The profit principle in its simplest form—viz., that the amount of profits determines the volume of investment—is therefore inapplicable here; the regression equation yielded by this calculation could, however, be written in the form:

$$v_R = 0.93\ [(Z_R)_{-1} + (Z_R)_{-2}] + 3.20\ [(Z_R)_{-1} - (Z_R)_{-2}]$$

Graph V. 3.

"EXPLANATION" OF INVESTMENT IN RAILWAY ROLLING-STOCK. GERMANY 1874-1908.

" Mixed principle ".



v_R : investment in railway rolling-stock, actual.

v_R^* : investment in railway rolling-stock, as explained by:

$(\Delta u_R)_{-2\frac{1}{2}}$: rate of increase in traffic, lagged 1½ years;

$(Z_R)_{-1\frac{1}{2}}$: profit rate, lagged 1½ years;

$(Z_R)_{-2\frac{1}{2}}$: profit rate, lagged 2½ years.

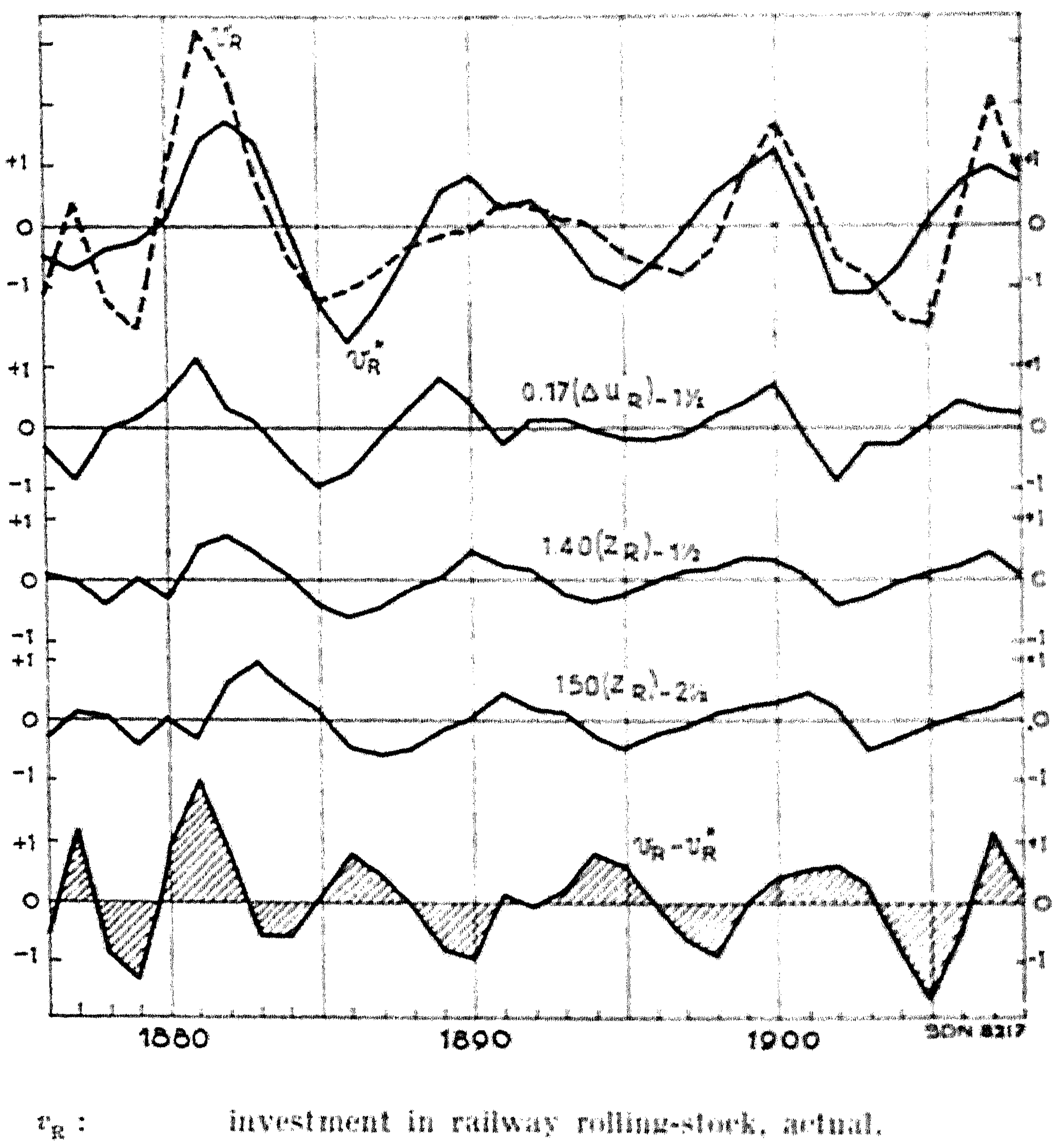
where the first expression in brackets is very near to twice profits with a lag of $1\frac{1}{2}$ years and the second expression in brackets is the rate of increase in profits with a lag of $1\frac{1}{2}$ years. Thus the rate of increase of profits, as well as profits themselves, is represented as exercising an influence on investment. Briefly, and very approximately, we get

$$v_R = 1.86\,(Z_R)_{-1.5} + 3.20\,(\dot{Z}_R)_{-1.5}\ (cf.\ \text{Graph V. 1}).$$

Graph V. 4.

"EXPLANATION" OF INVESTMENT IN RAILWAY ROLLING-STOCK. FRANCE 1876-1908.

"Mixed principle".



v_R :	investment in railway rolling-stock, actual.
v_R^* :	investment in railway rolling-stock, as explained by:
$(\Delta u_R)_{-1\frac{1}{2}}$:	rate of increase in traffic, lagged $1\frac{1}{2}$ years;
$(Z_R)_{-1\frac{1}{2}}$:	profit rate, lagged $1\frac{1}{2}$ years;
$(Z_R)_{-2\frac{1}{2}}$:	profit rate, lagged $2\frac{1}{2}$ years.

Acceleration principle and profit principle.

(iii) The correlation coefficients obtained with the calculations (1) and (2) mentioned above (§ 15) are not, on the average, very different (Table V. 1, columns (3) and (5)). So far as the differences are significant, it is remarkable that the acceleration principle gives a lower correlation than the profit principle for the United States and France, and about the same correlation as the profit principle for Germany and England.

Mixed principle.

Calculations (3) (Table V. 1, columns (10) to (13)), using both principles, show practically no influence of the rate of increase in traffic in the case of the United States; and the regression coefficients for profits are quite near to those found in columns (8) and (9).

To sum up, for the United Kingdom the correlation is considerably improved if the principles are combined; for France and Germany there is also some improvement, whereas for the United States the improvement is almost nil.

Calculations using secondary factors.

Calculations including "secondary factors" (*cf.* Tables V. 2 and V. 3) show considerable improvements in correlation if based upon the acceleration principle, and less improvement if based on the profit principle. The results obtained with the acceleration principle in table V. 2, with the exception of those for the United States, become somewhat better than those obtained with the profit principle, notwithstanding that the number of variates included is one less.

Regression coefficient for acceleration principle.

The regression coefficient obtained in case (1)—whether or not secondary factors are included makes no difference—is far lower than the acceleration principle in its simplest form [1] would suggest. In fact, it is often suggested that a given percentage increase in traffic would lead to an equal percentage increase in rolling-stock. Instead of unity, the coefficient found in Table V. 1, column (4), is, however, only one-sixth to one-third, or if the ratio between the standard deviations is taken, about

[1] As given by Haberler: *Prosperity and Depression*, pages 84 and 85.

Table V. 1. " Explanation " of Investmen

Units: Investment: Percentage increase in rolling-stock, deviations from 9 years moving average
Δ Traffic: Percentage increase in traffic, deviations from 9 years moving average.
Profits: Percentage profits,[1] deviations from 9 years moving average.

Country	Period	(1) Acceleration principle		(2) Profit principle	
		Correlation coefficient	Regression coefficient and lag of Δ traffic	Correlation coefficient	Regression coefficient and lag of profits
(1)	(2)	(3)	(4)	(5)	(6)
United States	1896-1913	*0.54*	0.15 (1½)	*0.63*	3.20 (1)
United Kingdom	1873-1911	*0.63*	0.34 (1½)	*0.66*	4.80 (1½)
Germany	1874-1908	*0.79*	0.34 (2½)	*0.74*	2.41 (2½)
France	1876-1908	*0.57*	0.24 (1½)	*0.67*	3.42 (1½)

[1] Or the best approximation to it available.

Table V. 2. " Explanation " of Investment

Introduction of iron prices and long-term interest rates as

Country	Period	1. Acceleration principle			
		Correlation coefficient	Regression coefficients and lags of:		
			traffic	iron price	interest rate
(1)	(2)	(3)	(4)	(5)	(6)
United States	1896-1913	*0.78*	0.04 (1½)	— 0.04 (1½)	— 0.09 (1½)
United Kingdom	1873-1911	*0.75*	0.27 (1½)	0.02 (1½)	— 0.04 (1½)
Germany	1874-1908	*0.88*	0.40 (2½)	— 0.04 (2½)	0.01 (2½)
France	1876-1908	*0.83*	0.19 (1½)	0.06 (1½)	— 0.05 (1½)

in Railway Rolling-stock.

Interest rates: deviations from 9 years moving average, in 0.01 %.
Iron prices: percentage deviations from 9 years moving average.
Lags: years.

(2′) Profit principle (distr. lag)			(3) Mixed principle			
Correlation coefficient	Regression coefficients and lags of profits		Correlation	Regression coefficients and lags of:		
				Δ traffic	profits	
(7)	(8)	(9)	(10)	(11)	(12)	(13)
0.77	4.13 (1)	— 2.27 (2)	*0.77*	0.01 (1½)	3.98 (1)	— 2.16 (2)
0.66	5.10 (1½)	— 0.55 (2½)	*0.84*	0.37 (1½)	1.95 (1½)	2.70 (2½)
0.83	1.52 (1½)	1.53 (2½)	*0.88*	0.18 (2½)	1.17 (1½)	0.78 (2½)
0.68	3.00 (1½)	0.71 (2½)	*0.75*	0.17 (1½)	1.40 (1½)	1.50 (2½)

in Railway Rolling-stock (continued).

supplementary explanatory factors. Units: see Table V. 1.

2′. Profit principle				
Correlation coefficient	Regression coefficients and lags of:			
	profits		iron price	interest rate
(7)	(8)	(9)	(10)	(11)
0.87	2.55 (1)	—1.80 (2)	—0.02 (1½)	—0.07 (1½)
0.70	3.80 (1½)	—1.35 (2½)	0.02 (1½)	—0.03 (1½)
0.84	2.14 (1½)	1.58 (2½)	0.01 (2½)	0.04 (2½)
0.86	1.89 (1½)	0.81 (2½)	0.03 (1½)	—0.01 (1½)
0.79	2.15 (1½)	—0.35 (1½)	0.04 (1½)	—0.05 (1½)

Table V. 3. " Explanation " of Investment
Calculations using only interest rates

Country	Period	1. Acceleration principle		
		Correlation coefficient	Regression coefficient and lags of:	
			Δ traffic	interest rate
(1)	(2)	(3)	(4)	(5)
United States	1896-1913	*0.69*	0.09 (1½)	—0.07 (1½)
United Kingdom	1873-1911	*0.67*	0.29 (1½)	—0.03 (1½)
Germany	1874-1908	*0.79*	0.34 (2½)	0.00 (2½)
France	1876-1908	*0.69*	0.19 (1½)	—0.06 (1½)

one-half,[1] which means a considerably smaller sensitivity of investment. After the introduction of the " secondary factors " and of the mixed principle, these coefficients grow less uniform, but in general still smaller, especially in the case of the United States. Nevertheless, the more general significance of the acceleration principle—viz., that percentage fluctuations in capital goods industries are larger than percentage fluctuations in consumers' goods industries—is not invalidated by these figures. The relatively low influence of the principle may be attributed to the fact that the technical necessity for its operation in its simplest form exists only if capacity is already being fully used. In all other circumstances, changes in capacity may be less than in proportion to changes in production.[2]

Influence of iron prices. Not very much evidence is found of any influence of iron prices in the European countries. The regression coefficients found (Table V. 2, columns (5) and (10)) are positive and in general unimportant. Only in the United States do they seem to be clearly negative; the elasticity of demand at the point of the demand curve corresponding to trend values of prices and quantities (which, by

[1] This figure is obtained by dividing column (4) by column (3), and is therefore:

U.S.A.	U.K.	Germany	France
0.28	0.54	0.43	0.42

[2] In the case of the mixed principle for the U.K. and Germany, the correlation would improve if a continuous fall in the regression coefficients were assumed to exist (*cf.* Graph V. 2 and V. 3).

in Railway Rolling-stock (continued).
as supplementary factors. Units: see Table V. 1.

2'. Profit principle			
Correlation coefficient	Regression coefficient and lags of:		
	profits		interest rate
(6)	(7)	(8)	(9)
0.85	2.68 (1)	—2.65 (2)	—0.07 (1½)
0.67	4.62 (1½)	—0.56 (2½)	—0.02 (1½)
0.84	1.76 (1½)	1.71 (2½)	0.03 (2½)
0.83	1.37 (1½)	1.59 (2½)	—0.01 (1½)
0.76	2.27 (1½)	0.87 (2½)	—0.05 (1½)

the choice of units, is indicated by 30 × the regression coefficient) would be about unity.

Influence of interest rates.

On the other hand, the influence of interest rates seems to be quite clear (Table V. 2, columns (6) and (11), and Table V. 3, columns (5) and (9)). Here, as in other cases, the United States and Germany seem to represent two extremes between which France and the United Kingdom are situated, the influence of interest rates being largest in the United States. Owing to our figures, a fall of 0.1% (being ten times the unit used) in bond yields would, in the United States, lead to an increase in rolling-stock by 0.7 to 0.9% (ten times the regression coefficient found) more than normal, whereas the corresponding figures are 0.2, 0.3 and 0.4 for the United Kingdom, 0.5 and 0.6 for France, and 0.1 to —0.4 for Germany.

The decided importance of interest rates for investment activity in the field studied may find part of its explanation in the considerable length of life of railway rolling-stock and in the large part of this investment which, in the end, is financed through the capital market in the proper sense of that word. At the same time, the fact that in Chapter III, dealing with investment in general, a larger influence of interest rates on investment activity was found for pre-war times than for post-war times may now be explained, for investment in railway rolling-stock probably plays at present a less important rôle than it did before the war.

Significance calculations.

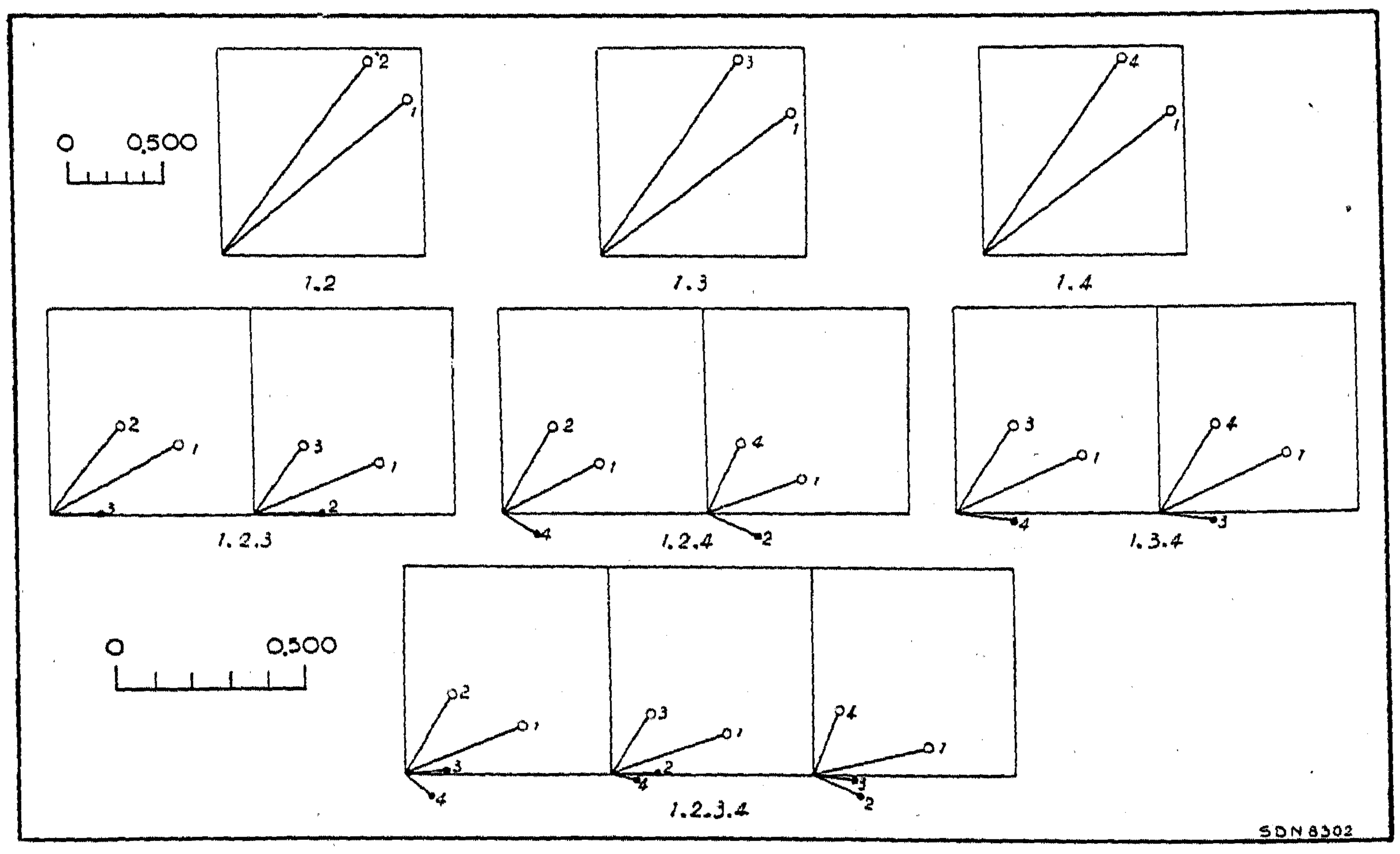
In addition to the information given in Tables V. : to V. 3, bunch maps have been calculated for fou cases—viz., two for Germany and two for the Unitec States—exhibiting the " mixed principle " without secondary factors and the acceleration principle with interest rates as a supplementary factor (*cf.* Graphs V. 5 to V. 8). These bunch

Graph V. 5.

Bunch Map.

RAILWAYS: GERMANY 1874-1908.

1 = Investment index. 2 = Δ traffic index$_{-2½}$. 3 = Profits$_{-1½}$. 4 = Profits$_{-2½}$.

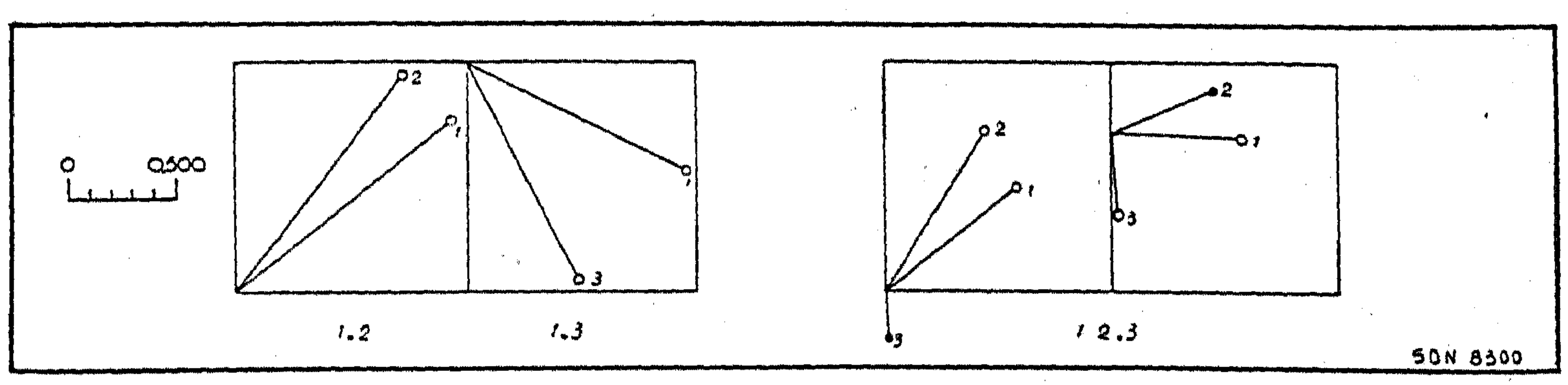


Graph V. 6.

Bunch Map.

RAILWAYS: GERMANY 1874-1908.

1 = Investment index. 2 = Δ traffic index$_{-2½}$. 3 = Interest rate$_{-2½}$.

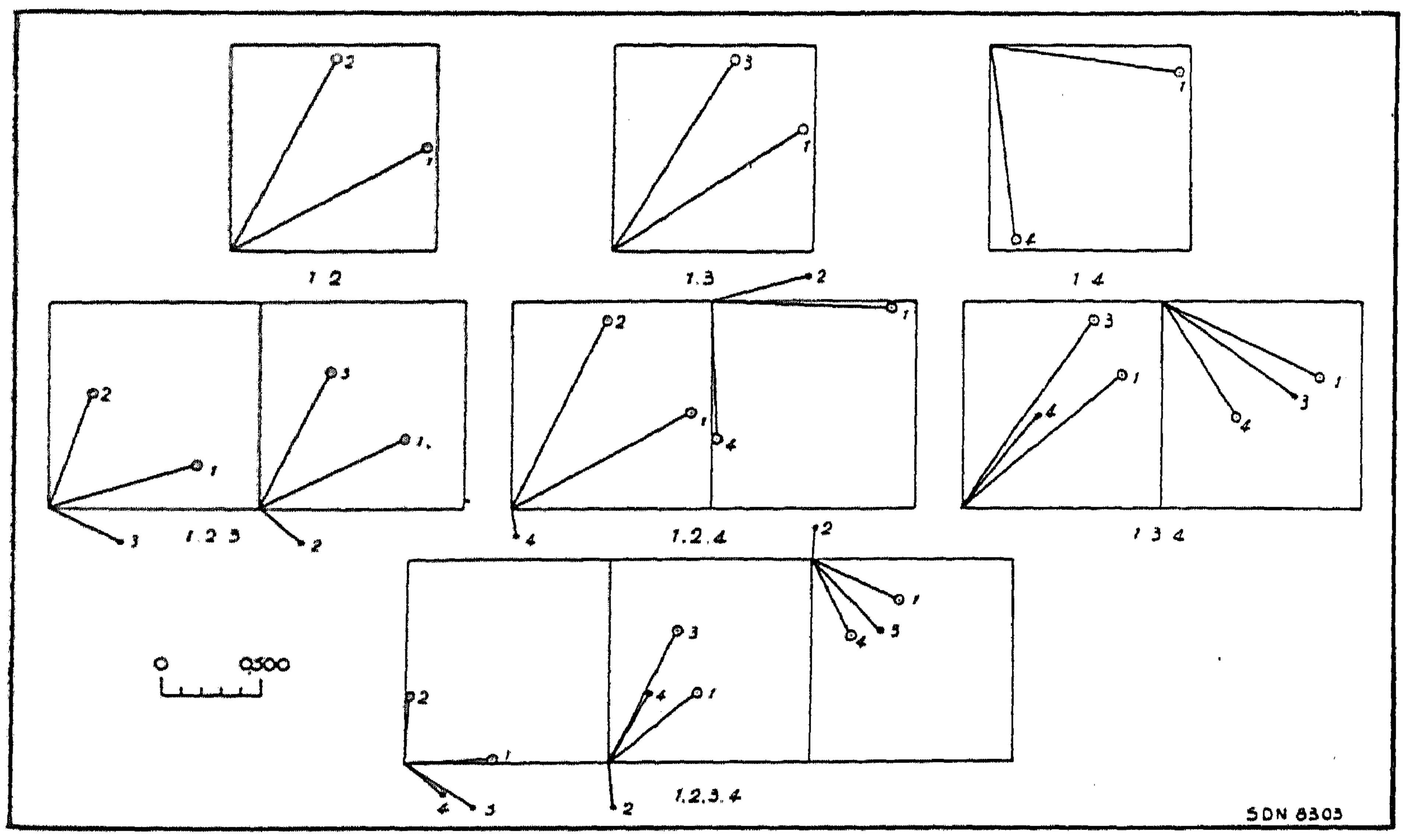


maps all seem to show that the figures obtained are very uncertain. Thus, Graph V. 6 gives a very wide spread for the beams in the right-hand part of set 123 which relates to the regression coefficient for 3 (interest rates). As 2 appears to be the most important explanatory variate in this set, beams 1 and 2 are the most important ones, which still supports our conclusion about a small

Graph V. 7.

Bunch Map.
RAILWAYS: UNITED STATES 1896-1913.

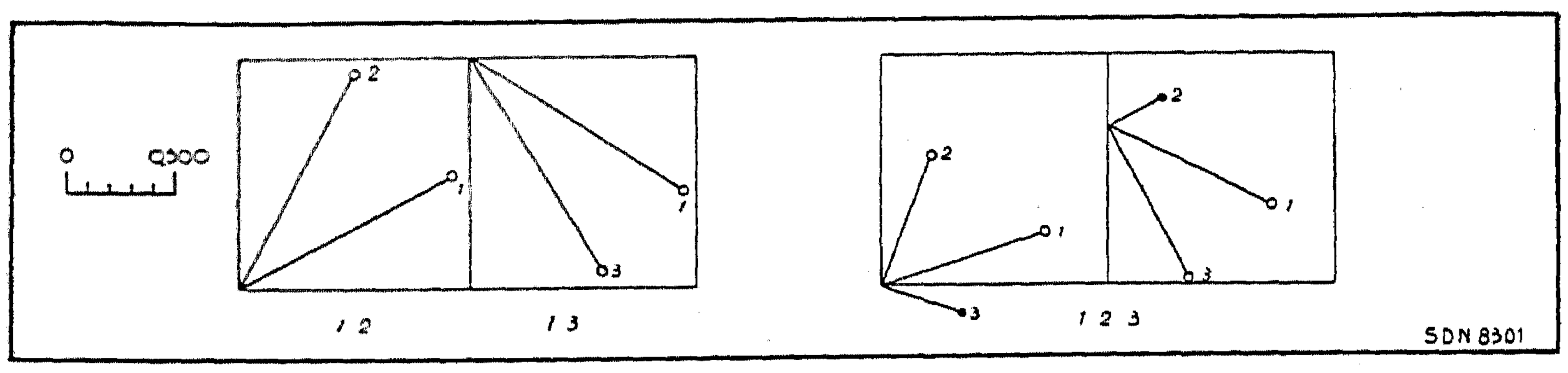
1 = Investment index. 2 = Δ traffic index$_{-1}$. 3 = Profits$_{-1}$. 4 = Profits$_{-2}$.



Graph V. 8.

Bunch Map.
RAILWAYS: UNITED STATES 1896-1913.

1 = Investment index. 2 = Δ traffic index$_{-1}$. 3 = Interest rate$_{-1}$.



influence of interest rates in Germany. In the case of the United States (Graph V. 8), beam 3 is, however, more important, supporting the view that a high influence of interest rates is present. Only if there are strong reasons for preferring the first elementary regression (which has been used in tables V. 1 to V. 3, as usually), can confidence be placed in the regression coefficients.

In this connection, it is of some interest that, among all the elementary regressions, only number 1 yields correct signs for all regression coefficients.

Explanation of differences between countries.

Most of the differences found to exist between the countries studied seem to point in the same direction. Investment in the United States reacts more quickly, and depends more on profits, interest rates and iron prices, and less on the purely technical acceleration principle, than it does in Europe, especially in Germany. This may be understood by realising that railways were, in the period investigated, more like free private enterprises in the United States and less so in the European countries; least of all in Germany, where already from 1878 onwards they were chiefly State enterprises.

Summary of findings.

To sum up, we have found that the correlations obtained for this branch of industry are on the average not higher than those obtained for general investment. The influence of interest rates seems to be rather high, except in Germany. The acceleration principle gives a somewhat better explanation than the profit principle, but the regression coefficients found are far below the theoretical values. Certain differences between the four countries included could be explained.