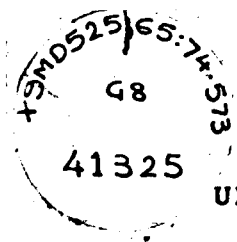


JOHAN EINARSEN

Reinvestment Cycles

and their Manifestation in the
Norwegian Shipping Industry



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AND THEIR MANIFESTATION IN THE NORWEGIAN
SHIPPING INDUSTRY**

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BY
JOHAN EINARSEN

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P R E F A C E

The plan of the present investigation I first presented to Professor Dr. Ragnar *Frisch* in November 1932. Mr. Frisch at once declared that I could use all my time as a research assistant in his department of the recently established University Institute of Economics in Oslo on this investigation and also placed at my disposal the necessary assistance and expert help from the staff of the Institute. I hereby express my deepest gratitude to Professor Frisch because in this way he made it possible for me to complete the present work.

The manuscript of the book — in Norwegian — was finished at the end of the year 1935. Since then no substantially new parts have been introduced, nor have reference to later publications been incorporated.

The translation into English was made mainly by the author and was afterwards checked by a Norwegian philologist. Since a non-economist cannot be supposed to have any particular knowledge of the special economic terminology I must myself assume responsibility for this and ask for indulgence for whatever linguistic shortcomings there may be.

Works which are only published in Norwegian, Danish or Swedish I have quoted in English without each time expressively saying that the translation is made by the author.

At the preliminary statistical work cand. oecon. Erik *Sæther* worked for one and a half year as my assistant. In making the actuarial part (Part IV, Life Characteristics) I had expert assistance from Messrs cand. act. Harald *Holme* and cand. oecon. Tobias Elias *Hansen*. I want to thank all of them for their interested cooperation.

The printing of the present book was made possible by generous grants from several Norwegian shipowners. I hereby express my sincere thanks to these contributors, and especially to Messrs Leif *Høegh*, Shipowner, and John O. *Egeland*, Secretary of Norges Rederforbund, for generous help.

Short summaries of the main results of the investigation have been published in the article «Reinvesteringssykler. Særlig bygget på data fra norsk skibsfart.» in *Nordisk Tidsskrift for Teknisk Økonomi*, Løbe Nr. 7, March 1937 and in the article «Reinvestment Cycles» in *The Review of Economic Statistics*, Volume XX, Number 1, Februar 1938.

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Johan Einarsen.

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INTRODUCTION

§ 1. The Business Cycle Problem and its Setting.

1. *The Business Cycle Problem can be Subject to Exact Solution.* The business cycle problem, the problem of the cause of the conjuncture cycles, belongs to those which can be subject to exact and objective solutions as distinct from solutions based on value-judgement.

The importance of this distinction is due to the fact that the problems which can only be subject to value-judgement have no absolutely «correct» solutions. This is the case in questions concerning right and justice, as for instance most problems in the science of law and in the social part of economics. The solution can only be built on the feeling of what is right in the mind of the person in question; and various individuals will often have diverging estimates, thereby creating many solutions of the problem. Fundamentally, these solutions have the same value, so we are unable to maintain one solution as the correct one and the others as false.

In the problems which can be subject to exact solution, as for example most problems in the physical sciences, only one solution is aimed at, namely the one which is correct and always has been so.¹

The fact that many different factors combine to cause business cycles, so that they cannot be explained by a single causal connection, does not of course change the nature of the problem as being subject to an exact solution. On the other hand the complication of causal relations usually has effected a somewhat inexact formulation of the business cycle problem, the purpose being to seek the «main cause» or the «proper cause» of the business cycles.²

¹ Compare «Kritische Bemerkungen zur wissenschaftlichen Grundlage der Ausbeutungslehre» (in Zeitschrift für Nationalökonomie, Wien 1932) by the present author.

² That this view of the problem — to find the main cause of the business cycles — is different from the exact view of the problem is admitted by *Joseph Schumpeter*. Comp. «Die Wellenbewegung des Wirtschaftslebens» (in Archiv für Sozialwissenschaft und Sozialpolitik, 39. Band, Tübingen 1915, p. 5): «Deshalb müssen wir uns stets klar sein, welches von zwei verschiedenen Problemen

It is clear that when one in this way, from a complex of causes, takes out one or some few factors, and then characterizes them as a main cause, while the rest of the cooperating causes are only considered as subordinate causes or secondary causes, one will here, even with full knowledge of all actual facts, make the solution dependent on an estimation, where subjective factors may have a certain influence. When the knowledge of the actual facts is defective such a determination of the main cause will naturally have to depend on more or less arbitrary guessing.

2. *It is Necessary to Have Certain Presumptions as Working Hypotheses.* The ultimate purpose of investigations of the business cycles is to find out the exact solution of the problem, that is to show which factors may have influence, to explain in which way the different factors cooperate, and to measure the quantitative importance of each factor. However, we cannot expect to reach this exact solution for some time, primarily because the necessary statistical material is defective.¹

It is clear that during the work towards the ultimate solution it will be advantageous to put up certain presumptions concerning which factors probably are most important. We need such presumptions as working hypotheses.

In the more complicated problems of the exact sciences such guessings will as a matter of fact nearly always have to precede the ultimate solution. Very seldom does there come any result of a planless compilation of statistical material.²

We must, however, be aware that in a problem where so many different factors are cooperating as in the business cycle problem, a great many presumptions can be made, all of them having a certain degree of

wir lösen wollen: ob wir einen Katalog aller jener Momente aufstellen wollen, die in Wirklichkeit in konkreten Aufschwungsperioden jemals wirksam waren oder sein können, oder ob wir unter Abstraktion von allem, was nicht wesentlich ist, den Grundvorgang blosslegen wollen.»

¹ Comp. *Jevons*, «Theory», p. 11: «I know not when we shall have a perfect system of statistics, but the want of it is the only insuperable obstacle in the way of making economics an exact science».

² Comp. Ragnar *Frisch's* review of: «Om det ekonomiska livets rytmik» by Johan Akerman (in *Statsvetenskaplig Tidskrift*, Lund 1931, pp. 281—282):

«Statistics in economics do not tell anything if they are not used on the basis of a broad theoretical analysis. — If the explanation is clear, no scientific analysis is needed. And in the problems where the explanation is not clear, it always appears that the key of the phenomena is an idea *not* lying in the material of the observation but on the contrary an idea which, through a heroic guessing, will have to be put into it beyond the observations».

plausibility. So long as our knowledge of facts is still defective, we can, therefore, not expect to be able to decide in which direction the ultimate solution is to be found. Nevertheless, when we make such theories, we do so in order to have some certain lines for our further work. But it is always of importance to keep in mind that the aim must be to try and, if possible, to verify these working hypotheses, and not to persuade other people to believe that one's own are the only correct ones. A certain degree of modesty will here be appropriate.

This, however, must not be understood to mean that we do not consider it important that investigators discuss their different theories and try to convince each other about the most probable theory. When some hypotheses, on the basis of the present material, have been found as the most plausible ones, then we can concentrate our work in this direction. Further, in practical politics, one cannot wait until the ultimate solution of the problem has been found, but one must be content to act on the basis of that solution which to our present knowledge is most plausible. The main thing is, however, that one must not believe that this persuasion is the real purpose of the business cycle investigation.

3. *Criticism of Previous Business Cycle Theories.* A characteristic feature in business cycle investigations up to the present time has been rather a planless guessing. Nearly every investigator has advanced a new theory or a new variation of former theories about the proper cause of the business cycle phenomenon. Many theories have been maintained and discussed.¹

From these discussions we learn that most investigators have not been content to merely set forth working hypotheses for the purpose of pointing out the direction for further investigation. Nearly every theorist has been seriously convinced that only his theory gives the ultimate solution of the business cycle problem, while the causes which other theories put stress upon are of only secondary importance. Each investigator is evidently of the opinion that he possesses a special instinct which has directed him to the correct solution.²

¹ Comp. *William Wallace*, «Business Forecasting», (London 1932, p. 20): «Almost innumerable theories have been advanced. An American committee appointed by Congress had some 150 separate theories put before it for consideration. Later, a painstaking German economist tabulated 228 possible theories.»

² Compare here the following characteristic observation of *Joseph Schumpeter* (in «Das Wesen und Hauptinhalt der theoretischen Nationalökonomie», 1908, p. 185) about the solution of the business cycle problem: «Hier richtig vorgehen, erfordert Takt und Urteil, ich möchte fast sagen, Instinkt». On page 464 he talks about: «... eine wissenschaftliche Befähigung, eine Art Takt

Already the mere fact that such a great number of theories have been advanced and defended with conviction ought to show that it is impossible, in a planless guessing, to obtain any ultimate and satisfactory solution. Even if an investigator should have guessed at the «correct» solution, and have put up his theory in a logically indisputable formulation, it is not probable that other theorists would agree. With our present knowledge of facts it would be possible to make a series of other theories which could claim the same degree of validity.

We must be aware of the many different circumstances which, consciously or not, may be directing the theorist, when he chooses that which he considers to be the «proper» cause of business cycles. We will here mention some of the most important circumstances which may have a motivating influence:

a) He who points out a previously unrecognized factor or previously unknown causal connection will always be inclined to overestimate the importance of his discovery and will always maintain that it gives the ultimate solution of the business cycle problem.

b) Secondly, the special studying field of the author in question may have some influence (monetary theory, theory of value, capital theory), so that he preferably tries to find the main cause within his field. In the same way theorists often wish to have a business cycle theory which fits in with a theoretical system comprising the whole economic theory.¹

c) Thirdly, the contemporary economic development may have some motivating influence, not only indirectly through the circumstances mentioned above in item a and b, but also directly.

Thus we may no doubt maintain that the recent dominating place of

allein». About his own statement of the business cycle theory, he says in «Theorie der wirtschaftlichen Entwicklung» (second edition, 1926, p. XIII): «Habe ich gleich, als ich es umarbeitete, mit den schärfsten Kritikern gefühlt und andere, die das Wesen des Arguments nicht erfassen, entschuldigt, weil das bei dieser Darstellung einfach nicht zu verlangen war, so habe ich dabei auch gefühlt, dass das, was ich nun zu neuerlichem Vortrag formulierte, wirklich die wahre Lösung des Konpunkturproblems ist und von allem Anfang an war».

¹ Compare *Albert Aftalion* in «La réalité des surproductions générales», («Revue d'économie politique», Paris 1908, p. 701): «Tout doit se ramener à une question de valeur, dépendre en définitive du jeu changeant de nos désirs, de nos besoins». — Compare also *Mentor Bouniatian* in «Les crises économiques», (Paris 1930, pp. 27—28): «Toute théorie des crises, digne de cet nom, doit satisfaire aux exigences suivantes: . . . enfin, elle doit être en accord avec les théories concernant les phénomènes les plus importants de la vie économique sociale et former avec elles un système complet d'économie politique».

monetary business cycle theories, to a great extent is due to the great monetary fluctuations during and after the Great War.¹

d) Finally, we will mention the influence which the social and political view of the author in question may have, consciously or not, in directing the selection of his main cause of business cycles. Socialistic authors will always be interested in proving that the business cycles are due to incurable constructive defects in the capitalistic production system itself. Conservative authors, on the other side, will try to show that the fluctuations either are due to general circumstances, which would appear under any social system, or that they are due to conditions which may be changed within the frame of the existing community.

Of course we do not mean to say that the whole work of advancing and discussing the many different theories has been in vain. On the contrary the work has no doubt been very useful in throwing light upon a whole number of factors which may play a role in the business cycle phenomenon. In this way we undoubtedly have been made aware of some circumstances and causal connections which may be of importance. The disagreement between theorists is on the other hand not so great as we at first should be inclined to believe. Broadly speaking the theorists agree concerning the factors which are involved. The disagreement is essentially concerning the question about which factor is to be considered as the main cause.²

¹ Compare *D. H. Robertson*, «Banking Policy and the Price Level», (London 1926, p. 1): «I suspect that the minds of some modern writers are unduly influenced by certain exceptional features of the great post-war boom and slump. I hold that far more weight must be attached than it is now fashionable to attach to certain *real*, as opposed to monetary or psychological, causes of fluctuations.»

Compare also *Alvin H. Hansen*, «Business-cycle Theory», (Boston 1927, p. 60): «The capitalistic-distribution theory of the business cycle ran its course particularly in the second and fourth quarters of the nineteenth century, periods of falling prices and apparently glutted markets.»

² Comp. *W. C. Mitchell*, «Business Cycles», (New York 1930, p. 11): «Recent writers upon business cycles differ from one another less in principle than in emphasis. Everyone who studies the problem with care must realise that many processes are involved in the alternations of prosperity and depression. But each investigator decides for himself the question: «What among these many processes is the prime mover in producing cyclical oscillations, and what processes merely adapt themselves as best may to changes produced elsewhere?»

Compare also *Hans Neisser*, «Die Schichtung der Konjunkturtheorie» (in *Festschrift für Arthur Spiethoff*, München 1933, p. 211): «Die «Voreiligkeit» der Konjunkturforschung . . . ist heuristisch von höchster Fruchtbarkeit gewesen, weil wir nur durch voreilige Versuche immer wieder an die Probleme der Konjunktur als einer Erscheinung des wirklichen Wirtschaftslebens herangeführt werden.»

We must, however, be aware that we cannot expect this planless guessing to infer any ultimate exact solution of the business cycle problem. Lately there are many things which indicate that the theorists are beginning to realise this. An especially strong reaction against the earlier subjective view is formed by the school within the American business cycle investigation headed by W. C. Mitchell, which is called «Institutionalism». The theorists' realization that the earlier usual ways will not do, may no doubt principally be ascribed to Mitchell's «Business Cycles» with its examination and systematizing of former theories.

The theorists have, of course, to a large extent used statistical material in their attempts to prove their theories. The mistake is, however, that they also in this field have worked rather planlessly. The above mentioned circumstance, that the investigators do not consider their theories as working hypotheses, which should be tried, but that every theorist considers it his main task to convince other persons that his theory is the only correct one, will here have a certain influence. Consequently the theorists have not faced the statistical material sufficiently objectively and without bias. They have therefore been inclined to use the material which is in accordance with their theories and to neglect that which does not fit in with them.¹

Further they have often been inclined to make too broad conclusions of the results obtained on the basis of the statistical material.²

4. *Directing Lines for Business Cycle Investigation.* We mentioned

¹ Compare *Mitchell*, «Business Cycles» (p. 48—49): «... the besetting sin of economists in this field — neglecting phenomena which do not fit neatly into preconceived schemes».

Comp. *Neisser*, (l.c. p. 210): «... die vorliegende Konjunkturforschung Sie benutzt das vorhandene Zahlenmaterial mehr zu Illustrationen und Verifikationen fraglichen Wertes als zur quantitativen Analyse der in den Elementen auftretenden Änderungen».

² Compare *Irving Fisher*, «Our unstable Dollar and the so-called Business Cycle», (*Journal of the American Statistical Association*, June 1925, vol xx, p. 191): «These correlations are so high as to leave little or no doubt that changes in the price level afford an almost complete explanation of fluctuations in the volume of trade for the above period beginning in 1915 and ending in 1923 With a correlation of nearly 100 per cent between trade and projected price-change, there is little left to explain».

To this *Mitchell* remarks, (l.c. p. 267): «It is not unlikely that by taking equal pains another worker studying the relations between the physical volume of trade and (say) reserve ratios, interest rates, profits or payroll disbursements within Professor Fisher's period might get very high coefficients of correlation, and argue that he too had found «an almost complete» explanation of fluctuations in the volume of trade — or several «almost complete» explanations».

that a reaction seemed to have appeared lately within the business cycle investigations against the former rather planless and subjective guessing, a reaction which already partly has led to a new orientation in this field. We shall here briefly indicate in which direction the new business cycle investigations are mainly moving, directions which to our opinion give hope of approaching the solution, and which will not, like earlier investigation, lead to a labyrinth of different theories.

That which is needed to enable us to approach the solution of the business cycle problem is regular and systematic work in the statistical and purely theoretical field. Statistics and theory must cooperate. We must have statistics to verify if theories are in accordance with reality, and we must have theory to know in which fields statistical investigation most probably will give a positive result, and to be able to make use of the compiled statistical material.

We shall in the following items examine the necessary demands on theoretical and statistical investigation.

A. The pure Theoretical Investigation.

a. The Making of Working Hypotheses. As maintained previously it is an important step in the business cycle investigation to make presumptions which will give rise to *working hypotheses*. They should indicate the direction in which the solution of the problem probably is to be found. Of course we may make an immense number of possible business cycle theories, the difficulty not being to make theories but to discriminate between them, that is decide which is the most probable one. We must not expect the solution to be a very simple one because probably a whole number of different circumstances cooperate to produce the business cycles. In order to get a survey it may be useful to make a systematic «catalogue» of all possible solutions.¹

b. We Need Quantitative not Only Qualitative Analysis. The point is, however, not only to point out the different factors producing business cycles, but also to measure their numerical quantity. The measurement of the actual quantity of the different factors belongs of course to statistical work, but it appears to be of importance to pure theoretical work as well, that we make certain presumptions about the quantitative relevance of the various factors. Very often the quantitative relevance of the factors will determine whether or not cyclical movements will be produced.

¹ An attempt in this direction is made by *Ragnar Frisch* in «Konjunkturbevegelsen som statistisk og som teoretisk problem» (Förhandlingar vil Nordiska Nationalekonomiska Mötet i Stockholm 15.—17. juni 1931, p. 231), where he makes a scheme of not less than 38 variables.

In other words, we need a *quantitative*, not only a qualitative economic theory. The question about quantitative or qualitative analysis in economic science is consequently not, as has been the opinion in some quarters, a question about statistical analysis contra pure theoretical work.¹

It is evident that when working out theories where the quantitative relevance of the factors is taken into consideration, it will often be necessary to express the theory in a *mathematical* form. Our next demand on the theoretical business cycle investigation, viz. that the theories must be determinate, will make the necessity of using mathematics still more evident.

c. The Theories Must be Determinate. If we want a satisfactory business cycle theory we must, in addition to the claim of taking the quantitative factor into consideration, demand that the theory shall be determinate, that is, that it forms a logically determined closed system. In mathematical language this means that there must be as many equations as there are unknowns. Only in this way will it be possible to explain how a situation grows out of the preceding one.

Theorists have often ignored this point and have constructed conjunc-

¹ Compare *Frisch*, «Konjunkturbevægelsen som statistisk og som teoretisk problem» (pp. 128—129): «As we get more insight in the mechanism of the business cycles, I think we will find out that the main point of the problem does not lie, as we have been accustomed to think, in the demonstration that some things are present in the mechanism. We will learn that the real problem lies in the quantitative relevance of some parameters characterizing economic laws».

Compare *Frisch*, «Nyorientering av den økonomiske teori. Økonomikken som eksperimentalvidenskap» (in *Statøkonomisk Tidsskrift* 1932, p. 5): «So long as one has not passed the purely qualitative stage and is still content to state that some repercussion effects will have consequences in some directions, the possibility of getting positive results is not very great. The fact is that practically all economic factors determine each other. Economic life is like a complicated net-work of reciprocal effects running in all directions. So long, therefore, as one is content to state merely qualitatively that there exist relations in some directions, economics will remain a domain where practically any theory can be defended, if only stated with enough cleverness».

Regarding different opinions about quantitative and qualitative analysis in economic science, compare also *Oskar Morgenstern*, «Qualitative und quantitative Konjunkturforschung» (in *Zeitschrift für die gesamte Staatswissenschaft*, 85 Band 1928, pp. 56): «... Die Nächstliegende Interpretation ist, dass qualitativ mit theoretisch und quantitativ mit statistisch-zahlenmässig zur Deckung zu bringen seien. ... oder es wird qualitative Forschung mit Kausalforschung gleichgestellt und die quantitativ-statistische Untersuchung als die Form der «descriptive analysis» (Mitchell) und damit als von ihm und der reinen Beschreibung verschieden bezeichnet. Man sieht also, dass von einer klaren und einfachen Terminologie nicht im entferntesten die Rede sein kann.»

ture systems that have contained more (or in some cases *less*) unknowns than there are equations. In the last case theorists have often, as *Frisch* points out (in «Konjunkturbevegelsen som statistisk og som teoretisk problem»), made the mistake when arriving at a point in the progress of the business cycles where the included factors not longer can explain the transition to the next phase of bringing in a quite new factor, which, having brought the business cycle to the next phase, in its turn is excluded from the system. (Der Mohr hat sein Dienst getan, der Mohr kann gehn.)¹

Recent investigators, mainly belonging to the econometric school, have elaborated several determinate, quantitative systems. In making presuppositions about the numerical value of the included variables, it will then be possible to calculate the period, amplitude etc., of those cyclical movements which will be produced.²

B. The Statistical Investigation.

As to the statistical work in business cycle investigation, it is necessary that investigators treat the material as objectively as possible, the purpose being to try to verify the working hypotheses. The material must be made subject to a genuine critical analysis.

The aim of the statistical work must be to procure a material so complete that it will be possible to put real data concerning the magnitude and reactions of the included factors into the quantitative and determinate theoretical systems. The solution of the conjuncture problem, when interpreted in the quantitative, exact way, is, however, so great a task that we must expect it only to be solved through cooperation of many investigators. The individual worker will have to be content to procure only a part of the necessary statistical or purely theoretical work.

The present work is an attempt to follow the above mentioned directing lines. Consequently, it does not aim at the definite solution of the business cycle problem, but only at producing a theoretically formulated development of one possible hypothesis among many, viz., of the reinvest-

¹ Compare also the discussion between professor *Frisch* and professor *Clark* in «The Journal of Political Economy» 1931 and 1932.

Compare *Frisch*, «Propagation Problems and Impulse Problems in Dynamic Economics» Publication nr. 3 of the Universitetets Økonomiske Institut, Oslo 1933 (p. 2).

² Compare *Frisch*, «Propagation Problems and Impulse Problems in Dynamic Economics» l. c.

Compare *J. Tinbergen*, «Der Einfluss der Kaufkraftregulierung auf den Konjunkturverlauf» (in *Zeitschrift für Nationalökonomie*, Band V, 1934) and his paper in «Weltwirtschaftliches Archiv» (1935).

ment theory, and to procure some material necessary to a statistical verification of this theory.

We will in § 2 give a short summary of the main points of the work.

§ 2. Summary of the Main Points in the Present Work.

The original purpose of the present investigation was only to try a statistical verification of the reinvestment theory (advanced by Marx and Schönheyder) by procuring and preparing material concerning the replacement activity in the Norwegian shipping industry. Very soon, however, it became apparent that the theory as then available, was not sufficiently elaborated for our purpose. Our first task consequently must be to try to work out a more complete statement of the reinvestment theory than has been done by our predecessors.

Part I, Dogmatic History, surveys those theories which previously have connected business cycles with the reinvestment of fixed capital.

In *Part II, Constructive Theory*, we then try to bring forth our own more complete and critically elaborated statement of the reinvestment theory. The main points of our theory are the following.

One of the causes of the business cycle phenomenon is to be found in the pure (generating) reinvestment cycles. These are due to the fact that the production of capital goods in previous business cycles for a great part has been concentrated within short periods of time, a great part of fixed capital having been produced within a short period of time also becoming ripe for replacement within a short period of time.

The main conditions which are necessary to give rise to reinvestment cycles are consequently that a great part of the capital goods will be worn out or obsolete at the same age and that the period of amortisation is arranged in accordance with this age.

A concentrated investment in fixed capital to be followed by such pure (generating) reinvestment cycles, first of all depends on the dispersion in time of the reinvestment of every single sort of capital goods. If such cycles shall be produced it is necessary that this dispersion will show concentration about one (or several) typical ages of replacement. Secondly, the reinvestment cycles of all sorts of capital goods will depend on the coincidence of the typical ages of replacement of different sorts of capital goods. Further, the amplitude of the replacement cycles will depend on how great a part of the capital goods is replaced altogether. (The per cent of maintenance or of falling off.)

Necessarily these pure (generating) cycles of reinvestment taken alone will only be able to produce a *damped* cyclical movement, firstly, because

of the reinvestment being dispersed over a longer period of time than the original investment, and, secondly, as a consequence of the per cent of falling off.

To be able to explain the existence of undamped business cycles we must therefore necessarily include into the system some new factors which may effect the maintenance of the cycles. We have in the following tried to explain the maintenance of the cycles in two different ways. Firstly by so-called automaintenance, the pure (generating) cycles of reinvestment calling forth secondary (generated) cycles in the new investment and in the reinvestment activities of the community. Secondly, the maintenance is explained by the influence of outside impulses or shocks.

In our opinion the reinvestment theory will provide a satisfactory and probable explanation of the business cycles, as it is able to explain the turning points both from depression to the period of revival and from prosperity to recession and also to explain the periodicity of the fluctuations.

In Part III, Statistical Investigation, we make a statistical research on the basis of materials concerning the Norwegian merchant fleet in the period from 1883 to 1932 in order to point out and measure the quantitative relevance of replacement cycles in the Norwegian shipping industry.

As a preliminary work we must at first tabulate all the ships, arranged in accordance with the shipowners, and follow every shipowner and every ship as long as they remain in the Norwegian register books of ships.

We then tried to measure how great a part of the ships, built for Norwegian shipowners in every quarter-year from 1883 to 1932 may be connected with the sale or loss of older ships from the same shipowner, and how great a part which cannot be connected with such a departure of older ships. The time series we obtain in this way in «replacement building» and «new investment building» show that in most cases during the time comprised in our material the replacement curve precedes the new investment curve. An analysis of the age distribution of the ships which have been sold and replaced by new constructions shows strong concentrations about the ages of 9 years and 19 years. This characteristic age distribution remains unchanged even when the material is divided in periods of time or in accordance with the phases of the business cycle.

In Part IV, Life Characteristics of the Ships, we have considered ships built for Norwegian shipowners in the same year and have observed at what ages the ships were sold or lost and how great a part of the tonnage sold or lost at the different ages was replaced by new constructions. In this section we used the methods elaborated in life insurance statistics, and found several «life characteristics» of the ships of our material, for

example, the probability of being sold or lost by shipwrecking at different ages, the probability of being replaced and the per cent of falling off. This analysis confirms the results of the analysis in Part III, showing that the greatest probabilities of being sold and of being replaced occurred at the ages of 9 and 19 years. Also here the characteristic features remained unchanged when the material was divided in periods of time or in phases of business cycles.

We have tried to construct a forecast of the shipbuilding for replacement for Norwegian shipowners on the basis of the age distribution in the Norwegian mercantile fleet by using the probabilities calculated in «Life Characteristics».

PART I. DOGMATIC HISTORY

§ 1. Introduction.

Of the great number of business cycle theories advanced the reinvestment theory is not among those which have attracted the greatest attention and gained most adherents. This theory was suggested by *Karl Marx* in volume II of «Das Kapital». This suggestion remained however for a long time an object of neglect or even misunderstanding, and the theory has only recently been subject to serious examination, viz. by *D. H. Robertson* in 1913 and by *K. Schönheyder* in 1927.

In this section we will give a description of the development of the reinvestment theory. Beside the theories which connect business cycles with «pure» reinvestment cycles, we will go into some closely connected theories which find the cause in other facts concerning the investment of fixed capital.

We will in this section merely record the opinions of other authors without explicitly expressing our own view on their theories. There are two reasons for our proceedings in this way, first, that later on we will discuss these theories in more detail in connection with our own formulation of the reinvestment theory (Part II, Constructive Theory) and secondly our point of view that as the conjuncture phenomenon has to be explained by many cooperating causes we do not consider it necessary to remove all competitive theories before advancing our own theory.

§ 2 Karl Marx.

«Das Wichtige ist mir, in den unmittelbaren materiellen Voraussetzungen der grossen Industrien ein Moment der Bestimmung für die Zyklen zu finden.»

Karl Marx in letter of March 5th 1858. (Der Briefwechsel zwischen Friedrich Engels und Karl Marx, Stuttgart 1913, p. 255.)

Marx has nowhere in his greatly planned but incomplete work given a complete description of his view of the business cycle problem. In

various places, however, he merely touches on this question during the development of his system.

Best known is perhaps his «under-consumption theory» in volume III, where he tries to find the deeper cause of the crises in the fact that production in the capitalistic system has lost direct connection with consumption, having as its only purpose the creation of profit. The capitalists will try to increase production as much as possible by reinvesting a part of their profits, but even if the absolute magnitude of profits due to this accumulation of capital may increase, a barrier will soon arise against further enlargement, because a tendency to a «falling profit rate» will manifest itself, thereby leading to a falling value of the capital. This inner contrast in the capitalistic system expresses itself, from Marx' point of view, in periodical crises, which destroy some of the capital, so that the profit rate may rise again and thereby give basis for a new expansion of production.¹

The fact that this under-consumption theory of Marx is that one of his statements of the business cycle problem which has attracted greatest attention, is probably due, first of all, to the political tendency of this theory, which seeks for the cause in conditions characteristic of the capitalistic system, and secondly to Marx's contributing hereby to the classical discussion about the possibility of a general over-production.

It seems, however, that the dogmatic history has underestimated what Marx (in Volume II) has contributed to the business cycle investigation in his thorough analysis of the reproduction of capital. As we will see later this analysis of Marx was one of the starting points for the capital investment theory of *Tugan-Baranowski*, and thereby for that school within the business cycle investigation which lays particular stress on conditions concerning capital production.

That which, however, is of special interest for us is that Marx gives the first suggestion of the reinvestment theory. In «Das Kapital» Volume II, Dritte Auflage, Hamburg 1903, chapter 9, item 4, p. 156 (later cited as Marx II. 9. 4) he says:

«In demselben Masse also, worin sich mit der Entwicklung der kapitalistischen Produktionsweise der Wertumfang und die Lebensdauer des angewandten fixen Kapitals entwickelt, entwickelt sich das Leben der Industrie und des industriellen Kapitals in jeder besonderen Anlage zu einem vieljährigen, sage im Durchschnitt zehnjährigen. Wenn einerseits die Entwicklung des fixen Kapitals dieses Leben ausdehnt, so wird es andererseits abgekürzt durch die beständige Umwäl-

¹ Compare *Karl Marx*, «Das Kapital», Buch III, Hamburg 1894, pp. 231—239.

zung der Produktionsmittel, die ebenfalls mit der Entwicklung der kapitalistischen Produktionsweise beständig zunimmt. Mit ihr daher auch der Wechsel der Produktionsmittel und die Notwendigkeit ihres beständigen Ersatzes in Folge des moralischen Verschleisses, lange bevor sie physisch ausgelebt sind. Man kann annehmen, dass für die entscheidendsten Zweige der grossen Industrie dieser Lebenszyklus jetzt im Durchschnitt ein Zehnjähriger ist. Doch kommt es hier nicht auf die bestimmte Zahl an. Soviel ergibt sich:

Durch diesen eine Reihe von Jahren umfassenden Zyklus von zusammenhängenden Umschlägen, in welchem das Kapital durch seinen fixen Bestandteil gebannt ist, ergibt sich eine materielle Grundlage der periodischen Krisen; worin das Geschäft aufeinanderfolgende Perioden der Abspannung, mittleren Lebendigkeit, Überstürzung, Krise durchmacht.¹ Es sind zwar die Perioden, worin Kapital angelegt wird, sehr verschiedene und auseinanderfallende. Indessen bildet die Krise immer den Ausgangspunkt einer grossen Neuanlage. Also auch — die ganze Gesellschaft betrachtet — mehr oder minder eine neue materielle Grundlage für den nächsten Umschlagszyklus.»

As one will see Marx here suggests a theory, in which the average duration of capital instruments determines the business cycles. It is, however, no more than a suggestion. Marx has not gone further into the question and has not tried to cooperate this suggestion with the remaining elements in his crisis theory.

We shall try to interpret the single items in Marx' suggestion of the reinvestment theory, by throwing light upon them through supplementary observations from other places in his works.

Marx points out the importance of the reproduction of «fixed» capital, of its characteristic «Umschlagszyklen» for the crisis phenomenon. Firstly we must determine Marx's meaning of the expressions «fixed» capital and «reproduction». The expression «*fixed*» capital is to be understood contrary to «flüssiges» (liquid) capital. Marx gives the following explanation of what is meant by fixed capital («Das Kapital», volume II, p. 127):

«Ein Teil des konstanten Kapitals behält die bestimmte Gebrauchsform, worin es in den Produktionsprozess eingeht, gegenüber den Produkten, zu deren Bildung es beiträgt. Es verrichtet also während einer kürzeren oder längeren Periode in stets wiederholten Arbeitsprozessen stets wieder dieselbe Funktionen. So z.B. Arbeitsgebäude, Maschinen etc., kurz alles was wir unter der Bezeichnung *Arbeitsmittel* zusammenfassen.»

¹ Underlined by author.

The reproduction of capital, of which Marx gives a thorough analysis in the second volume of «Das Kapital», has by *Tugan-Baranowsky* been compared with the process of digestion in the living organism.¹

Capital can only exist and be utilized when it constantly changes form and circulates. This circulation consists in the technical reproduction of each element in its material form or in the shifting out of these capital elements in exchange for others.

The characteristic circulation through which the fixed capital goes during its reproduction process has been thoroughly described by Marx. The idea of these peculiar «Umschlagszyklen» seems especially to have attracted his attention; he returns to the idea several times, and finds constantly new metaphores to throw light on the situation. We will shortly try to repeat the most important items in the reproduction process of fixed capital. P. 128:

«Dieser im Arbeitsmittel fixierte Teil des Kapitalwerts zirkuliert so gut wie jeder andere Aber die Zirkulation des hier betrachteten Kapitalteils ist eigentümlich. Erstens zirkuliert er nicht in seiner Gebrauchsform, sondern nur sein Wert zirkuliert, und zwar allmählig, bruchweis, im Mass, wie er von ihm auf das Produkt übergeht, das als Waare zirkuliert. Während seiner ganzen Funktionsdauer bleibt ein Teil seines Werts stets in ihm fixiert, selbstständig gegenüber den Waaren, die es produzieren hilft»

P. 133:

«Die eigentümliche Zirkulation des fixen Kapitals ergibt einen eigentümlichen Umschlag. Der Wertteil, den es in seiner Naturalform durch Abnutzung verliert, zirkuliert als Wertteil des Produktes. Das Produkt verwandelt sich aus Waare in Geld, also auch der vom Produkt zirkulierte Wertteil des Arbeitsmittels, und zwar hopft sein Wert aus dem Zirkulationsprozess als Geld nieder, in derselbe Proportion, worin dies Arbeitsmittel aufhört Wertträger im Produktionsprozess zu sein. Sein Wert erhält also jetzt Doppelexistenz Die Verwandlung seines Werts in Geld geht gleichen Schritts mit der Geldverpuppung der Ware, der sein Wertträger ist. Aber seine Rückverwandlung aus Geldform in Gebrauchsform trennt sich von der Rückverwandlung der Waare in ihre sonstigen Produktionselemente und ist vielmehr bestimmt durch seine eigene Reproduktionsperiode, d.h. durch die Zeit, während deren das Arbeitsmittel sich verlebt hat und durch ein andres Exemplar derselben Art ersetzt werden muss»

¹ Comp. *Tugan-Baranowsky*, «Studien zur Theorie und Geschichte der Handelskrisen in England», (Jena 1901) p. 199.

Bis zum Eintritt dieser Reproduktionszeit wird ihr Wert allmählig in der Form eines Geldreservefonds akkumuliert.»

P. 426:

«Sobald das fixe Element, Baulichkeiten, Maschinerie etc. ausgelebt hat, nicht länger im Produktionsprozess fungieren kann, existiert sein Wert neben ihm, vollständig ersetzt in Geld — Dies Geld dient dann dazu, das fixe Kapital in natura zu ersetzen und so diesen Bestandteil des produktiven Kapitals wirklich zu erneuern»

P. 427:

«Diese Schatzbildung ist also ein Element des kapitalistischen Reproduktionsprozesses, Reproduktion und Aufspeicherung.»

P. 138:

«Der im fixen Kapital ausgelegte Wertteil des produktiven Kapitals ist ganz, auf einmal vorgeschossen worden, für die ganze Funktionsdauer desjenigen Teils der Produktionsmittel, woraus das fixe Kapital besteht. Dieser Wert wird also auf einmal vom Kapitalisten in die Zirkulation geworfen; er wird aber der Zirkulation nur stückweis und allmählig wieder entzogen durch die Realisierung der Wertteile, die das fixe Kapital den Waaren zusetzt. Andererseits: Die Produktionsmittel selbst, worin ein Bestandteil des produktiven Kapital fixiert wird, werden auf einmal der Zirkulation entzogen, um dem Produktionsprozess für ihre ganze Funktionsdauer einverleibt zu werden, aber sie bedürfen für dieselbe Zeit nicht des Ersatzes durch neue Exemplare derselben Art, nicht der Reproduktion.»

The preceding statement will give an impression of the stress Marx laid upon the reproduction of fixed capital. It was therefore no mere accident that Marx was the first one to connect the reproduction of capital with the business cycle phenomenon.

Marx has also gone further into the conditions which determine the life-time of capital equipment. He distinguishes here between physical and moral wearing-out. Marx was of the opinion that the typical life-time of fixed capital was ten years. *Comp. II. 9. 4:*

«Man kann annehmen, dass für die entscheidendsten Zweige der grossen Industrie dieser Lebenszyklus jetzt im Durchschnitt ein zehnjähriger ist.»

It is easy to understand why Marx assumed ten years as the average life-time of capital instruments because at the time when Marx wrote «Das Kapital» the ten years wave was probably the only known business cycle wave. *D. H. Robertson* is therefore certainly right when

he says in «Some Material for a Study of Trade Fluctuations» (Journal of the Royal Statistical Society, vol. LXXVII, London 1914, p. 164):

«Karl Marx long ago suggested that the decennial character of crises was due to the fact that the fixed capital of the world needs replacement every ten years. This suggestion appears, indeed, to have been of the nature of a guess to explain the facts»

It is typical that Marx in his examples constantly chooses the duration of capital objects to be ten years. The only actual material which he mentions is the experience from railway companies; he quotes here several English sources.

Marx points out that those parts of a railway construction which particularly need renewal are the rails and sills and the wagons. According to English experience the wooden sills last 12—15 years, and the life-time of an engine was calculated to be 10—12 years.

In II. 9. 4 Marx points out: «Doch kommt es hier auf die bestimmte Zahl nicht an.» That Marx, nevertheless, lays particular stress on the fixation of a numerically determined average age of fixed capital, is to be seen from his correspondence with *Friedrich Engels*. In a letter of March 2nd 1858, he puts the following question to Engels («Der Briefwechsel zwischen Friedrich Engels und Karl Marx 1844 bis 1883» Herausgegeben von A. Bebel und Ed. Bernstein. Zweiter Band, Stuttgart 1913, p. 252):

«Apropos! Kannst du mir sagen, in wieviel Zeit, in Eurer Fabrik zum Beispiel, Ihr die Maschinerie erneuert? Babbage behauptet, im Durchschnitt werde in Manchester the bulk of machinery renovated every 5 years. Dies scheint mir etwas verblüffend und nicht quite trustworthy. Die Durchschnittszeit, worin die Maschinerie erneuert wird, ist ein wichtiges Moment in der Erklärung des mehrjährigen Zyklus, den die industrielle Bewegung durchläuft, seit die grosse Industrie sich konsolidiert hat.»

Engels replies in letter of March 4th 1858 (p. 252—254):

«Über die Maschinenfrage ist es schwer, etwas Positives zu sagen, jedenfalls ist Babbage sehr wrong. Das sicherste Kriterium ist die Percentage, die jeder Fabrikant jährlich auf seine Maschinerie für Verschleiss und Reparatur abschreibt, also in einer bestimmten Zeit seine Maschinen ganz herausverdient hat. Diese Percentage ist gewöhnlich 7½ Prozent, wonach die Maschinerie in 13⅓ Jahren durch das vom Nutzen jährliche Abgeschriebene gedeckt wird, also ohne Schaden ganz erneuert werden kann. . . .»

«Nun ist 13½ Jahre allerdings eine lange Zeit, in der viel Bankrotte und Veränderungen vorkommen, man wirft sich auf andere Branchen und verkauft alte Maschinerie, führt neue Verbesserungen ein; aber wenn diese Rechnung nicht im ganzen richtig wäre, so würde die Praxis sie längst geändert haben

«Zehn bis zwölf Jahre reichen hin, den Stamm der Maschinerie einen anderen Charakter zu geben, ihn also mehr oder weniger zu erneuern. Die Periode von 13½ Jahren wird natürlich durch Bankrotte, Zusammenbrechen wesentlicher Stücke, die eine Reparatur zu kostspielig machen usw., und dergleichen Zufälligkeiten so affiziert, dass man sie etwas kürzer nehmen kann. Aber unter zehn Jahre gewiss nicht».

Marx thanks him for the information in a letter of March 5th 1858 and continues:

«Die Zahl von dreizehn Jahren entspricht, soweit es nötig ist, der Theorie, da sie eine *Einheit* für one epoch of industrial reproduction setzt, die mehr oder weniger zusammenfällt mit der Periode, worin sich die grossen Krisen wiederholen, deren Verlauf natürlich noch durch ganz andere Momente, ihrer Reproduktionszeit nach, bestimmt wird. Das wichtige ist mir, in den unmittelbaren materiellen Voraussetzungen der grossen Industrien ein Moment der Bestimmung für die Zyklen zu finden.»

In II. 9. 4. Marx points out, as we have seen, that the replacement will take place in cycles due to the concentration of the capital investment and due to the typical life-time of the capital objects, comp: «... Zyklus von zusammenhängenden Umschlägen» «... bildet die Krise immer den Ausgangspunkt einer grossen Neuanlage».

This is, I think, the only place where Marx directly connects the replacement of fixed capital with business cycles. In other places he seems, quite contrary to this, to presume that the replacement will follow a steady line, with only casual, non-cyclical disturbances, comp. for instance p. 429:

«Jedes Jahr ist das Todesjahr für fixes Kapital, das in diesem oder jenem Einzelgeschäft oder auch diesem oder jenem Industriezweig zu ersetzen Die verschiedenen Kapitale sind also von verschiedenem Lebensalter, und wie jährlich in diesen Produktionszweigen Personen sterben, so erreichen jährlich Massen fixer Kapitale in diesem Jahre ihr Lebensende, und müssen aus akkumulierten Geldfonds in natura ersetzt werden.»

Thus, when Marx in the 20th chapter of «Das Kapital» writes about the effects of the fact that in one year more fixed capital is ready for reproduction than in another year, it is evident that he is only thinking of the more casual disturbances and not of cyclical fluctuations of the replacement activity (zusammenhängende Umschläge) as in II. 9. 4. Further Marx analyses here the effects of such disturbances under certain simplified conditions, compare p. 442:

«Wenn — alle anderen Umständen, also nicht nur die Stufenleiter der Produktion, sondern namentlich auch die Produktivität der Arbeit als gleichbleibend vorausgesetzt — ein grösserer Teil des fixen Elements von II c abstirbt als das Jahr vorher usw.»

In spite of the fact that Marx's investigation here only concerns casual disturbances in the relation between the production of fixed and circulating capital, and only under certain simplified conditions, it may be of interest to look further into his results. We will here try to give a statement of the results without going too much into the «scheme» Marx is working from (pp. 443—445):

«Wird bei einfacher Reproduktion und gleichbleibenden Umständen, also namentlich gleichbleibender Produktivkraft, Gesamtgrösse und Intensität der Arbeit — nicht eine konstante Proportion vorausgesetzt zwischen absterbendem (zu erneuerndem) und in alter Naturalform fortwirkendem (bloss für seines Verschleisses der Produktion Wert zusetzendem) fixem Kapital — so bliebe in einem Fall die Masse von zu reproduzierenden zirkulierenden Bestandteilen dieselbe, aber die Masse von zu reproduzierenden fixen Bestandteilen wäre gewachsen; es müsste also die Gesamtproduktion I wachsen oder es wäre, selbst abgesehen von den Geldverhältnissen, Defizit der Reproduktion da.

Im anderen Fall: Nähme die proportionelle Grösse des in natura zu reproduzierenden fixen Kapitals II ab, also im selben Verhältnis der nur noch in Geld zu ersetzende Bestandteil des fixen Kapitals II zu, so bleibe die Masse der von I reproduzierten zirkulierenden Bestandteile des konstanten Kapitals II unverändert, die des zu reproduzierenden fixen dagegen hätte abgenommen. Also entweder Abnahme der Gesamtproduktion I oder aber Überschuss (wie vorher Defizit) und nicht zu versilbernder Überschuss.

Dieselbe Arbeit kann zwar im ersten Fall mit zunehmender Produktivität, Ausdehnung oder Intensität, grösseres Produkt liefern, und so wäre das Defizit im ersten Fall zu decken; solchen Wechsel würde aber nicht ohne Deplazierung von Arbeit und Kapital aus einem Produktionszweig von I in den anderen stattgreifen und jede solche

Deplazierung würde momentane Störungen hervorrufen. Zweitens aber würde (soweit Ausdehnung und Intensivierung der Arbeit zunehmen) I mehr Wert gegen weniger Wert von II auszutauschen haben, also eine Depreziation des Produkts von I stattfinden.

Umgekehrt im zweiten Fall, wo I seine Produktion kontrahieren muss, was Krise für die darin beschäftigten Arbeiter und Kapitalisten bedeutet, oder Überschuss liefert, was wieder Krise. An und für sich sind solche Überschüsse kein Übel, sondern ein Vorteil; sind aber Übel in der kapitalistischen Produktion.»

.....

Ist die kapitalistische Form der Reproduktion einmal beseitigt, so kommt die Sache darauf hinaus, dass die Grössé des absterbenden und daher in natura zu ersetzenden Teils des fixen Kapitals (hier des in der Erzeugung von Konsumtionsmittel fungierenden) in verschiedenen Jahren wechselt. Ist er in einem Jahre sehr gross (über die Durchschnittsterblichkeit, wie bei den Menschen) so im folgenden sicher um so geringer. Die zur jährlichen Produktion der Konsumtionsmittel nötige Masse von Rohstoffen, Halbfabrikaten und Hülfsstoffen — sonst gleichbleibende Umstände voreingesetzt — nimmt deswegen nicht ab; die Gesamtproduktion der Produktionsmittel müsste also im einen Fall zunehmen im anderen abnehmen. Diesem kann nur abgeholfen werden durch fortwährende relative Überproduktion; einerseits ein gewisses Quantum fixes Kapital, das mehr produziert wird als direkt nötig ist; andererseits und namentlich Vorrat von Rohstoff etc., der über die unmittelbaren jährlichen Bedürfnissen hinausgeht (dies gilt besonders von Lebensmitteln). Solche Art Überproduktion ist gleich mit Kontrolle der Gesellschaft über die gegenständlichen Mittel ihrer eignen Reproduktion. Innerhalb der kapitalistischen Gesellschaft aber ist sie ein anarchisches Element.

Dies Beispiel vom fixen Kapital — bei gleichbleibender Stufenleiter der Reproduktion — ist schlagend. Missverhältnis in der Produktion von fixem und zirkulierendem Kapital ist einer der Lieblingsgründe der Ökonomen, um die Krise zu erklären. Dass solches Missverhältnis bei blosser *Erhaltung* des fixen Kapitals entspringen kann und muss ist ihnen etwas neues; dass sie entspringen kann und muss bei Voraussetzung einer idealen Normalproduktion, bei einfacher Reproduktion des bereits fungierenden gesellschaftlichen Kapitals.»

As we see, Marx has thoroughly analysed the effects of irregularities in the reproduction of fixed capital. It is almost tragical that Marx has not deepened this analysis in connection with real cycles in the reproduc-

tion, as hinted in II. 9. 4. No one else has probably possessed such excellent conditions for developing a complete reinvestment theory in explanation of the business cycles. The necessary material was ready: a thorough analysis of the reproduction and amortising process of fixed capital, analysis of the effects of uneven replacement, investigation concerning the wearing-out of the capital.

§ 3. Tugan-Baronowsky.

As we have seen, Marx — in spite of the pioneering work he performed in the analysis of the reproductive process of the capital — in his business cycle theory laid the main stress on relations concerning the distribution of the output of production in capitalistic society. It is — therefore — not Marx, but his pupil the Russian *Michael von Tugan-Baronowsky* who is considered the real founder of that school within the conjuncture theory which shifts the main stress to relations concerning the production of fixed capital.

Tugan-Baronowsky explains the business cycle phenomenon from a disproportionality in the relation between the production of capital goods and the production of consumption goods, maintaining that the capital production increases especially strongly under a rising business cycle and decreases strongly under a depression.

From two different starting-points Tugan-Baronowsky has arrived at his theory:

1. Firstly, Tugan started from Marx's analysis of the reproductive process in the second volume of «Das Kapital». Tugan reproaches Marx that he did not connect this analysis with the solution of the business cycle problem (M. v. Tugan-Baronowsky, «Studien zur Theorie und Geschichte der Handelskrisen in England, Jena 1901, p. 199):

«Im II. Bande des «Kapitals» befindet sich die glänzende Analyse der Reproduktion des gesellschaftlichen Kapitals, welche, unseres Erachtens, die Grundlage jeder wissenschaftlichen Theorie des sozialen Stoffwechsels in der kapitalistischen Wirtschaft werden muss. Dennoch ist diese Analyse bei Marx unvollendet geblieben; sie wurde vom Verfasser selbst zur Erklärung der Krisen und anderer Erscheinungen des heutigen Wirtschaftslebens nicht benutzt und, was noch wichtiger ist, sie steht in keiner Übereinstimmung mit anderen Ansichten von Marx.»

Tugan is obviously not aware that Marx in II. 9. 4 has indicated a business cycle theory, the reinvestment theory, which is founded on his analysis of the reproduction of the fixed capital. Tugan himself has, however, as we shall see, very sparingly made use of Marx's analysis in

his own conjuncture theory. For all that it is very probable that Marx's analysis has played a certain role to Tugan, giving him the impulse to seek the main cause of the business cycle fluctuations in relations concerning capital production.

Tugan is therefore not so far from the truth as *Jean Lescure* considers him to be (comp. Lescure, «Des crises générales et périodiques de sur-production», Paris 1907, pp. 496—497) when Tugan ascribes to Marx the fathership of his business cycle theory.

2. Secondly, Tugan-Baranowsky has come to his conclusion of the importance of the production of capital goods for business cycles in an inductive way, through the study of statistical material concerning crises in England.

But why, Tugan further asks, does the capital production occur at intervals. The explanation of this is in Tugan's opinion to be found in the conditions for the new formation of capital under the capitalistic system. Here he especially keeps his attention to that part of the newly saved capital which does not find application in the same trade or branch of production where it was produced, but appears in the loan-market as «free money capital». As a great part of the income under the capitalistic system is independent of the business cycle¹ a great part of that free loan capital will be offered in the market, not only during revival and prosperity, but during depressions as well.

A characteristic of business cycles is, Tugan points out, that the saved capital during a depression temporarily will be placed in public loans for unproductive purposes, or as deposits in banks which do not extend their loans correspondingly, and the like, while during a rising business cycle it will be invested in a real productive capital (capital equipment). Compare p. 241:

«Überhaupt, wie die günstigen Phasen des industriellen Zyklus sich durch eine verstärkte Anlegung von Kapitalien, durch eine Verwandlung des freien Kapitals in gebundenes charakterisieren, so wird die ungunstige Phase durch eine Akkumulation des freien, ungebundenen leihbaren Geldkapitals charakterisiert.»

The questions it would be of greatest importance to have answered are naturally, firstly, the reason why the saved capital during the depression is not invested at once, but is compiled as free loan capital, and secondly, what may be the cause that all the accumulated capital

¹ Comp. I. c. p. 240: «Die Einkommen dieser Art bilden insgesamt eine sehr bedeutende Quote des nationalen Einkommens . . . beinahe eine Hälfte des gesamten besteuerten nationalen Einkommens Englands.»

is invested simultaneously with a rising business cycle. To the first question Tugan gives no other answer than that the investment of the loan capital in industry during the depression meets with resistance. What sort of resistance this is he does not say. Compare l. c. p. 242:

«... die Anlegung des Leihkapitals in den Industrien begegnet aber einen Widerstand. Das Vorhandensein dieses Widerstandes kann keinen Zweifel unterliegen».

To the second question Tugan answers by referring to the fact that capital, which is not invested productively, does not bring its owner any income (public loans, bank deposits?) and consequently exercises a pressure in its attempt to be invested in industry. As by degrees more and more loan capital is accumulated in the market, this pressure ultimately becomes so strong that it overcomes the resistance. Compare l. c. p. 243:

«Von der einen Seite will also die Industrie kein neues Kapital mehr aufnehmen, auf der anderen aber strebt dies Kapital mit immer wachsender Macht in die Industrie einzudringen. Es muss ein Moment kommen, wenn der Widerstand der Industrie überwunden, das akkumulierte Leihkapital in der Industrie eine Anlage finden und sich in produktives Kapital verwandeln wird. Es tritt eine Epoche des Aufschwunges ein.»

Tugan explains the turning-point from prosperity into recession on the same basis, viz. that the funds of accumulated loan capital are exhausted, and that present saving is not sufficient to finance the extensive production of capital goods towards the end of the prosperity period.

Tugan-Baranowsky has compared this business cycle mechanism with a steam-engine, a metaphor which has become classical in the economic literature. Compare l. c. p. 251:

«Die Wirkung dieses ganzen Mechanismus kann man mit der Arbeit einer Dampfmaschine vergleichen. Die Rolle des Dampfes im Zylinder spielt die Akkumulation des freien Leihkapitals; wenn der Druck des Dampfes auf dem Pumpenstempel eine bestimmte Grösse erreicht, wird der Widerstand des Pumpenstempels überwunden, der Pumpenstempel bewegt sich, geht bis zu Ende des Zylinders, für den Dampf eröffnet sich ein freier Ausgang, und der Pumpenstempel tretet nach seinem alten Platz zurück. Ebenso dringt das sich akkumulierende freie Leihkapital, nachdem es eine gewisse Grösse erreicht hat, in die Industrie ein, setzt sie in Bewegung, es wird verausgabt und die Industrie kommt wieder in den früheren Zustand.»

Tugan-Baranowskys business cycle theory has been given high esteem. Thus *Spiethoff* has characterized his work as: «Die erste wissenschaftliche Krisenmonographie» (comp. Arthur Spiethoff, «Die Krisentheorien von Tugan-Baranowsky» und L. Pohle, «Schmollers Jahrbuch», 1903, p. 703), and it has formed the basis of a new tendency in the business cycle theory, in so far as a whole number of theorists have followed his example and have laid particular stress on the accumulation of free loan capital which during a rising business cycle is invested in productive capital.

For all this Tugan's theory to us seems to be rather primitive and not very satisfying, as he has not tried to explain a whole number of the problems arising in connection with his theory of the accumulation of free loan capital. We can only regret that Tugan-Baranowsky, who is a very keen Marx-critic and who reproaches Marx for not having utilized the analysis of the productivity of the capital in his business cycle theory has not personally utilized this analysis to a broader extent and further that he seems to have overlooked the only place where Marx himself has used this analysis as a basis for a business cycle theory, viz. II. 9. 4.

§ 4. Arthur Spiethoff.

Spiethoff had, already before Tugan-Baranowsky's work appeared in a German translation, been working on the same lines towards a solution of the business cycle problem.¹

Just as Tugan, Spiethoff points out the importance of the accumulation of supplies of free capital during a depression, which are absorbed during the rising conjuncture. With regard to the way in which these means temporarily are invested during the depression, Spiethoff gives a more detailed and somewhat more satisfying explanation than that of Tugan. Spiethoff points out that the newly saved capital temporarily assumes typical «Stockungsformen», whereby the capital from an individual point of view is invested because it brings output to the owner, but from a social point of view the situation is not the same, because it is not utilized in the production of capital equipment. Spiethoff mentions the following possible forms for such investments:

1. Müßiges Erwerbkapital.
2. Bankeinlagen.
3. Darlehen an Unternehmer zur Haltung von Überzeugungsvorräten.
4. Wertpapiere, die ins Ausland abgestossen werden können.

¹ Compare *Jean Lescure*, «Des crises générales et périodiques de Sur-production» p. 499.

In addition to this capital accumulation during the depression Spiethoff, however, brings in a factor which is not to be found in the theory of Tugan-Baranowsky. Spiethoff points out that towards the end of the depression a great many tasks will have been accumulated for that part of the production which serves «das reproduktive Konsum» (i. e. the production of means of production as contrary to that part of the production which works for the direct, immediate consumption). Comp. «Vorbemerkungen zu einer Theorie der Überproduktion, (Schmollers Jahrbuch 1902, pp. 730—731):

«Die Hausse und spätere Überproduktion kulminiert nicht in den Produkten des elementaren, unmittelbaren Verbrauchs, sondern in denen der grossen Industrien, die dem *reproduktiven Konsum* dienen. Für diese hatten sich eine Reihe von Aufgaben angesammelt, nach deren Erledigung die stürmische Nachfrage aufhören muss Das Wesentliche besteht darin, dass die Produktion bei Beginn jeder grösseren Hausse vor einem Vakuum steht, und zwar in doppelter Hinsicht. Neu sich öffnende Gebiete sind zunächst einmal bis zu einem gewissen Sättigungspunkt auszurüsten, in den alten Gebieten sind neue Erfindungen für eine grosse Anzahl von Wirtschaften erstmalig in grösserem Masstab zu liefern. Aber die Depression hat auch in Bezug auf alte Bedürfnisse vieles aus mangelndem Unternehmungsgeist unausgeführt gelassen, was nötig gewesen wäre. Es handelt sich hier nicht nur um Verkehrswege und neue Unternehmungen der verschiedensten Art, auch in tausend bestehenden Unternehmungen wären Kompletierungen nötig gewesen, alte ausgeleierte Dampf-, Werkzeug- und sonstige Maschinen hätten durch neue ersetzt werden müssen, aber bei den schlechten Zeiten behalf man sich mit Reparaturen. Es handelt sich bei dieser gesamten Nachfrage zum grossen Teil um einen Bedarf, der für lange Jahre gedeckt ist, wenn einmal ein gewisser Sättigungsprozess eingetreten ist. Dem jeweiligen Stande der Volkswirtschaft entspricht ein bestimmtes Mass von Gruben, Hüttenwerken, Verkehrsmitteln, Eisenbahnen, Fabrikanlagen etc., nach Kohlen, Lokomotiven, Dampf- und Dynamomaschinen ist eine in engeren Grenzen gehaltene Verwendung vorhanden als nach Fleischspeisen, Stiefeln, Kleidern etc., für die bei dem gegenwärtigen durchschnittlichen Standpunkt der Lebenshaltung eigentlich immer latente Bedürfnisse vorliegen, und deren Absatzbedingungen weit mehr einerseits in den Preisen andererseits in den Einkommensverhältnissen liegen. Für die Güter des reproduktiven Konsums ist nach Ablauf einiger Haussejahre für die aus der Depression her unbefriedigt gebliebenen und neu entstandenen Bedürfnisse ein Sättigungsprozess eingetreten, so dass es sich nicht

mehr darum handelt, ein leeres Gefäss zu füllen, sondern nur das Abfliessende zu ergänzen und nach Massgabe der fortschreitenden Ausdehnung der Wirtschaft eine Komplementierung eintreten zu lassen. Die bei Beginn der Hausse auftretenden besonderen Aufgaben können in längeren oder kürzeren Zeit erledigt werden; überstürzt man sich und schafft man Produktionsanlagen, die so gross sind, als handle es sich nicht um die Ausfüllung des Vakuums, sondern um einen dauernden Bedarf, so kann in der Folge der erheblich erhöhten Produktion keine gleiche Nachfrage gegenüberstehen....

Wie also einerseits für den reproduktiven Konsum ein grösserer, einmalig zu befriedigender Bedarf vorliegt, so steht auf der anderen ein grösserer, einmalig zu immobilisierender Kapitalvorrat zur Verfügung.»

Thus Spiethoff points out that the capital production at the beginning of the rising business cycle faces a «Vakuum» which is to be filled, «ein einmalig zu befriedigender Bedarf». One of the causes that call into existence such a vacuum is the fact that *the replacement* has been neglected during the depression, as the capital which was then worn out and ripe for replacement has not, or not to the full extent, been renewed. Thus we see that Spiethoff tries to find a cause of the business cycles in the reinvestment phenomenon, but only in that which we (in Part II, Constructive Theory) have called «secondary» or «generated» reinvestment cycles. Spiethoff does not consider the «pure» reinvestment cycles which Marx in II. 9. 4 connects with crises, the cycles which are due to the fact that the concentrated capital investment during an earlier period of prosperity simultaneously are worn out and ripe for replacement.

If the idea of this «einmalig zu befriedigender Bedarf» had occurred to Tugan-Baranowsky, it is probable that he, as a Marx-specialist, would have utilized the idea of Marx in II. 9. 4. Spiethoff, however, had already cut off direct connection with Marx's system.

§ 5. Albert Aftalion.

Another theorist who has connected the business cycle problem with the reinvestment phenomenon, is the Frenchman *Albert Aftalion*.

Aftalion finds the deepest cause of business cycles in the field of value theory, maintaining that the real cause of the fluctuations is the shifting valuation of *consumption goods*.

Owing to the fact that he takes his starting-point in the demand for consumption goods, Aftalion forms in a certain way an opposition to the «capital-production-theorists», Tugan-Baranowsky and Spiethoff, who

consider the fluctuations in the capital production to be the primary phenomenon, and the fluctuations in the consumption production to be a purely secondary phenomenon. Compare Albert Aftalion, «La réalité des surproductions générales, Essai d'une théorie des crises générales et périodiques», (in «Revue d'économie politique», 1908, p. 701):

«Tout doit se ramener à une question de valeur, dépendre en définitive du jeu changeant de nos désirs, de nos besoins.»

On the other side, Aftalion also lays stress on some technical circumstances in connection with the production of capital goods. We will here confine ourselves to a statement of his work in this field without a detailed record of the other parts of his business cycle system.

It will be advantageous to divide the contributions of Aftalion to capital-production-theory in two main parts according to his two terms «Période de construction» and «Période de gestation».

1. *Période de Construction.*

In the opinion of Aftalion, the rising business cycle, as we have seen, will take its starting-point in a growing demand for and rising prices of consumption goods. As, however, the production in the capitalistic society is a typical «round-about-production» (Böhm-Bawerk), it is first necessary to produce more capital goods. Now it will take some *time* from the starting of the production of capital goods and until the consumption goods, produced by the new equipment, has been finished. In this interval the demand for consumption goods will remain unsatisfied, the demand will even have a tendency to rise because of the employment of several additional workers in capital production. Consequently, the construction of more and more capital goods will be started. When some time has passed, however, a number of the new machines will be finished and taken into use, so that the demand for consumption goods soon will be satisfied. In spite of the sinking prices additional new machines will still for a long time be utilized, leading to a general overproduction. Prosperity will then turn into recession.

The interval from rising business cycle to the beginning of depression will then, according to Aftalion, be closely connected with the period of time that on an average will elapse from the starting of the production of new machines to the time when the first goods, produced by the new machines, appear on the market. He thinks that in a modern society this will correspond to a period of about two years, pointing out, however, that he dares not fix any «*corrélacion numérique rigoureuse*» between these relations.

2. Période de Gestation.

Further, Aftalion tries to explain the duration of the depression from the technical conditions of the «round-about-production», connecting it with the time when capitalistic productive instruments are in function.

Like Böhm-Bawerk Aftalion is reckoning in «production periods». The production period of a consumption article means the time which passes between the starting of the construction of a machine for producing the article and the manufacture of the final consumption article. If, for example, it requires two years to construct a machine for shoe-production, and this machine can be kept in operation for five years, Aftalion is reckoning the production period for the first pair of shoes produced by the machine, to be a little more than two years, and for the last pair of shoes to be seven years. (Comp. Aftalion l. c. 1909, p. 204).

For our purpose it is of course much more advantageous to regard the life-time of machines, and in the example above reckon the construction period to be two years and the function period to be five years.

When prosperity has passed, there is (as seen in 1. «Période de Construction») produced a disproportionate number of machines and other durable production means, which must be kept in work, it being too expensive to let them stand idle. For rather a long time, therefore, there will be over-production of consumption goods, and, consequently, low prices. Only when a considerable part of these capital instruments has been worn out, will consumption goods again be scarce so that prices may rise.

In the same way, therefore, as in the period of prosperity the satisfaction of the demand for capital goods will not manifest itself till the construction of too many machines has already begun, in the depression the necessity of renewing the capital will not obviously come into view until a condition of under-capitalization has already become a fact.

The replacement of capital goods in the depression period, therefore, in the opinion of Aftalion, is not sufficient to compensate for the depreciation of capital. Compare l. c. 1908, p. 705:

«On hésite à remplacer totalement les métiers hors d'usage. On ne renouvelle pas régulièrement le matériel des usines. On est dans une période où la société ayant trop fabriqué de capitaux dans les années précédentes, les utilise sans y substituer d'autres en quantité égale.»

Compare l. c. 1909, p. 213:

«Il existe un taux normal de la capitalisation annuelle afin, à la fois de remplacer le capital qui s'use et d'accroître en vue de l'avenir

la masse des capitaux existants. Mais ce taux normal et moyen n'est qu'une entité abstraite. En fait la civilisation procède en cette matière par bonds irréguliers. Le taux normal est dépassé durant la prospérité. Il n'est pas entièrement atteint dans la dépression.»

As we see, Aftalion considers the business cycle problem as in the first instance a *problem of regulation*. Compare l. c. 1909, p. 214:

«Tout régulateur manque L'intensité du besoin social actuel, par le moyen des prix et des profits, ne révèle que l'excès des objets de consommation et des capitaux en activité. Rien ne renseigne sur les capitaux qui seront bientôt hors d'usage et déterminant une pénurie prochaine. Quand on constate la saturation *présente* du besoin, on ne peut croire en même temps à son insatisfaction *virtuelle*. Quand on souffre encore de la *surproduction* de biens de consommation on ne peut admettre qu'il ait en même temps *sous-capitalisation*.»

We see that Aftalion like Spiethoff connects the business cycle problem with what we have called the *secondary* (generated) cycles in the capital replacement activity of the community. One should have expected that it would have been most natural for Aftalion, when explaining the duration of the depression on the basis of the functional time of capital goods and from the replacement activity, to connect the business cycle phenomenon with the *pure* (generating) reinvestment cycles, with those cycles that come into existence when a great number of capital goods which have been constructed at the same time, simultaneously are worn out and have to be replaced. The idea that in succeeding years different quantities of capital instruments become ripe for replacement, seems, however, not to have occurred to Aftalion, who on the contrary seems to presuppose that the masses of capital goods worn out in different years on the whole will be of the same magnitude.

It is therefore logical that Aftalion for this «période de gestation» as for his «période de construction» dares not fix any definite duration. He only says that several years must pass before sufficient capital is worn out. Compare l. c. 1909, p. 213:

«Plusieurs années en effet doivent passer avant que soit hors d'usage une bonne partie de l'énorme matériel antérieurement fabriqué»

Compare p. 205:

«Je me hâte d'ajouter, pour éviter toute méprise, que je ne prétends fixer aucune corrélation numérique rigoureuse entre la durée des deux stades du procès de production et la durée des deux périodes du cycle

économique, de la prospérité ni de la dépression. Déjà la durée de la production est assez malaisé à préciser pour chaque catégorie de marchandises À plus forte raison, la période de production pour l'ensemble des marchandises, la durée du procès de production collectif, résultante des mille procès de production particuliers à chaque industrie, constitue-t-elle une conception difficilement dilimitable, aux contours nécessairement flottants.»

§ 6. D. H. Robertson.

At the same time that the theory of the *secondary* (generated) reinvestment cycles — as advanced by Spiethoff and Aftalion — won general appreciation and by several investigators was included in their business cycle theories, the idea of Marx of the *pure* (generating) reinvestment cycles remained ignored.¹

The first theorist who seriously examined the idea of Marx about pure reinvestment cycles seems to have been *D. H. Robertson*, who in an address before The Royal Statistical Society in London, December 1913 refers to the observation of Marx in «Das Kapital» II. 9. 4. and remarks that «it has not, perhaps, received adequate attention at the hands of subsequent writers».²

In his address Robertson tried to demonstrate that in several cases it would be possible to explain sudden increases in the activity of the capital producing industries on the basis of pure (generating) reinvestment cycles, as great quantities of capital goods constructed in previous periods of prosperity simultaneously would reach the average age of replacement for this sort of capital goods. Robertson refers among others to material from railway construction, the ship building industry, and the house building industry. We will later on comment on some of his observations. In the above cited address Robertson has not, however, tried to deliver a more detailed theoretical analysis of the reinvestment phenomenon.

In his book «A Study of Industrial Fluctuation» (London 1915, pp. 13—25) Robertson has again returned to the idea of pure (generated) reinvestment cycles. The present author has not been able to obtain this

¹ Jean Lescure has in his work: «Des crises générales et périodiques de surproduction» (Paris 1907, pp. 497—498) commented the observation of Marx in «Das Kapital» II. 9. 4. He has, however, completely misunderstood the meaning of it.

² Compare «Some Material for a Study of Trade Fluctuations» by D. H. Robertson (in «Journal of the Royal Statistical Society», Vol. LXXVII, year 1913—14, pp. 159 sq).

work, and must therefore be content to cite the following remark of *Wesley C. Mitchell* in his «*Business Cycles*» (1930, p. 30):

«Mr. D. H. Robertson suggests that the recurrence of business cycles may be due in large part to the more or less simultaneous wearing-out and re-ordering of large masses of equipment made in an earlier period of prosperity.»

It is possible that Robertson in this book has examined the theoretical side of the problem in more detail.

In his later works, on the other hand, Robertson obviously does not lay much stress on the reinvestment theory. In his book «*Banking Policy and the Price Level*» (London 1926) he thus only incidentally mentions the reinvestment phenomenon.

§ 7. A. C. Pigou.

A. C. Pigou includes the pure (generated) reinvestment cycles among the impulses that may produce a «*Rhythm of Periodicity*» in the business cycle movement. We will here confine ourselves to a quotation from his «*Industrial Fluctuations*» (London 1927, pp. 207—208):

«First there is the tendency of human construction to wear out after a certain interval — their limited length of life. A boom, .. is always characterized by an abnormal mass of constructional work and of work upon the manufacture of machines and other instrumental goods. When the boom is over, the mere fact that it has occurred and has led to an extensive provision of instruments makes a further provision unnecessary The result is that the group engaged in making these things for a time works less hard. The period of quiescence passes away when the life of the things made in the first boom draws to an end. Of course, different things have lives of different lengths. Houses, for example, last much longer than delicate tools. But there is reason to believe that many different sorts of machinery enjoy the same sort of length of life. Ten years seems to be, not merely the average, but also the markedly predominant length. This, at all events, is the view of the Director of the British Census of Production (Report, pp. 35—36). At some such interval as this, therefore, we should look for a secondary boom: to be repeated again after equal intervals. In this process it would seem there is a true cause making for rhythmic movement. In view, however, of the large obstructive influence exercised by friction it can hardly be a very important cause.»

§ 8. K. Schönheyder.

We have seen that several authors from the time of Marx and later have tried to connect the business cycle phenomenon with the reinvestment cycles. Some have thought of the pure (generating) reinvestment cycles, but most of them of the secondary (generated) reinvestment cycles.

Nevertheless we may hold that it was the Norwegian economist, Professor Dr. *Kristian Schönheyder*, who at first developed a complete business cycle theory on this basis alone.

Schönheyder had already been occupied with the reinvestment problem for a considerable time when in 1927 in the «Statsøkonomisk Tidsskrift» (pp. 57—116) he published his paper on «Produksjonssyklene og krisene».¹

The idea of connecting the business cycle problem with the reinvestment cycles had occurred to Dr. Schönheyder, as he personally has informed the present author, without his knowing about the previous work of Marx and Robertson along the same lines.

In the above mentioned paper Schönheyder has developed a business cycle theory based on both the pure and the secondary reinvestment cycles. As our own statement of the reinvestment theory (in Part II: Constructive Theory) in the main follows the same lines, we do not find it necessary here to give a complete report of his theory in detail.

In spite of the fact that we mean that all necessary elements for constructing a satisfactory conjuncture theory on the basis of the reinvestment phenomenon are included in Schönheyder's paper, we still found that it was necessary before we started the statistical investigation in order to verify the theory at first as Part II to develop our own statement of the reinvestment theory. The first reason for this is that the paper of Schönheyder, in our opinion, is very little satisfying from a systematic view point, because he does not distinguish clearly enough between the pure and the secondary reinvestment cycles. In the second place our statistical investigation has in some particulars required a more complete development of the theory than Schönheyder has delivered.

An important side of the problem, which we cannot see that Schönheyder mentions in his paper, is the question about how great a per cent of capital equipment is replaced. This per cent of maintenance (or of falling off) is of course of great importance when one wishes to determine the amplitude of the reinvestment cycles. Some points of detail, where the opinion of Schönheyder differs somewhat from our

¹ Dr. Schönheyder states that he is working on an extended edition of the paper, that will most probably be published in a German journal of economics.

own, will be commented on in their due place in Part II. When the statement of Schönheyder and that of the present author in some respects show some difference, it is perhaps partly due to the fact that Schönheyder is absolutely convinced that by advancing the reinvestment theory he has delivered the definite solution of the business cycle problem. Such a subjective conviction may of course be very successful when developing a new business cycle theory, but it will easily result in an over-evaluation of the importance of the new factor, and a corresponding underestimation of other theories. In accordance with our own view of the business cycle problem as stated in the introduction, we will here only regard the reinvestment theory as one possible working hypothesis among many others.

The business cycle theory of Schönheyder at first met with some opposition among theorists. Thus *L. V. Birck* in a paper in «Statsøkonomisk Tidsskrift» (1924, p. 208) declares that the business cycle theory of Schönheyder in his opinion to a great extent is «scholastic web» and that «its results will increase the abundant stock of the science of «exploded fallacies». This utterance may, however, partly be due to the fact that Schönheyder at that point of time had not yet delivered any complete statement of his theory.

Later on the interest for the reinvestment theory has obviously increased. We may for example mention that *Professor Frisch*, who already in «Statsøkonomisk Tidsskrift» 1927 made a mathematical statement of some parts of Schönheyder's theory, in his mimeographed lectures has developed a reinvestment theory.¹

Further *Dr. Johan Akerman* in his treatise «Om det ekonomiska livets rytmik» (Stockholm 1928), delivered a critical estimation of the theory. Some of the objections that Akerman makes against the theory of Schönheyder are, however, as also Professor Frisch points out (in a paper in «Statsvetenskaplig Tidsskrift», Lund 1931, pp. 281 sq.) due to a mis-understanding of the article of Schönheyder.

¹ Compare *Makrodynamikk for økonomiske systemer*, p. 85. 26. Oslo 1933.

PART II. CONSTRUCTIVE THEORY

CHAPTER 1. PURE REINVESTMENT CYCLES

§ 1. Consumption Cycles. Mainly Concerning Reinvestment Cycles.

Nearly all consumption is cyclical, as demand reappears shortly after having been satisfied. The period between every time the demand needs to be satisfied is, however, entirely different for various demands. It is a characteristic of general articles of *consumption* that the demand for them returns with relatively short intervals. Thus the demand for food has to be satisfied several times a day. And the demand for new clothes returns with somewhat regular intervals because the old clothes are worn out or the seasons pass by. As to the major number of consumption goods, we may perhaps presume that the consumption period does not exceed one year.

The demand for *capital goods* — production instruments and long-lasting consumption goods — is also a cyclical one. A person who buys a machine to-day for his business will regularly some time in the future, when the machine is worn out or outmoded, be in need of a new machine to *replace* the old one. Investment of to-day will come back as *reinvestment* some time in the future. But the period will last much longer with regard to capital goods than with regard to consumption goods, in most cases it will last for several years.

A sensible business man foresees the fact that a machine some day has to be replaced by a new one, and manages his business affairs in such a way that he is economically prepared for this eventuality. In his book-keeping the reinvestment demand is expressed through the reduction of the value of the machines as they become older, and in many cases through the foundation of special funds for replacements.

But not all investment of to-day is followed by reinvestment some time in the future. Firstly, the investment in many cases will soon prove to be a failure, as the income of the machine is not sufficient for yielding any interests or even for amortization — so-called «Kapitalfehlleit-

ungen» —. Further, during the long period of time in which a machine can be in function changes may take place in the conditions of profitability with the result that a replacement of the machine will not be advantageous.

§ 2. Will the Reinvestment be Cyclical for Society as a Whole?

Also for society as a whole the fact holds good that the investment of to-day comes back as reinvestment some time in the future. In capitalistic society the reinvestment — as well as the new investment — is made mainly by private business concerns which — when we do not take into consideration an eventual psychic infection — make their resolutions independent of each other.

The question is then; will this reinvestment on the part of the individual concerns, when taking place at a normal time — i. e. when it is not disturbed by psychic infection or anything else — for the community as a whole be distributed evenly over the years to come, with mere accidental deviations, or will it have a *cyclical* tendency, and be inclined to concentrate in certain years or periods.

Most of the authors who have expressed themselves regarding this subject, seem to consider it a matter of course — without further reflections — that the reinvestment for society as a whole, provided that it elapsed normally without any disturbances of the business cycles, would be spread evenly during the years to come. There seems to be a prevailing opinion that if only the individual concerns would replace their machines when they are worn out or when they are amortized, no cycles could manifest themselves in the reinvestment for the society as a whole.

We have already mentioned (in Part II, Dogmatic History) that both *Spiethoff* and *Aftalion* are of the opinion that the reinvestment for a great part is neglected during the time of depression, as the machines which are then worn out are not replaced at that time, the replacement being postponed and concentrated in the periods of revival and prosperity. But the idea that the reinvestment in itself, when occurring at a normal time, should have an immanent tendency to appear cyclically, obviously does not occur to any of them.

Also *J. M. Clark* is of the opinion that when the reinvestment actually is concentrated in certain years, it is entirely due to the fact that the concerns consider the expenses for the replacement of machinery as «postponable costs» and, therefore, economize on this account during hard times. Clark is therefor of the opinion that it is unconditionally in the interest of the society that reinvestment from the part of individual concerns takes place at normal time, at the time indicated by the book-

keeping. The interest of society with regard to a regularization of the replacement activity will then, to his opinion, be satisfied. Compare John Maurice Clark, «Studies in the Economics of Overhead Costs» (Chicago 1923, p. 56):

«To be sure, stabilizing the account in the books removes the strongest motive for irregularity in the actual doing of the work, and this is one of the greatest benefits derived from a depreciation account. However, there is still no adequate positive motive for keeping this work regular; no motive; that is, corresponding in force to the interest the community has in regularization.»

The opinion that the replacement activity in society would be evenly distributed over time, if the machines were only replaced when they were worn out, also manifest itself in the following observation by *F. Schmidt*:

«— Indessen ist vollkommen sicher, das die Entwicklung der Wirtschaft ebenso in normal aufsteigender Linie erfolgen könnte, wie in der uns geläufigen Wellenbewegung. Warum soll . . . eine Erneuerung in dem Masse, in dem die Anlagen durch die Produktion verbraucht werden, der Volkswirtschaft nachteilig sein?»¹

Erich Schiff writes:

«Für den einzelnen Investor wird sich die tatsächliche Auswechslung soweit es sich um grosse feste Anlagen handelt, überwiegend auf einzelne Termine zusammendrängen; für die Volkswirtschaft, deren Produktion synchronisiert ist, muss die Kapitalreproduktion unter Dem bilde sukzessiver, gleichmässig über die Zeit verteilter Ersatzinvestitionen gedacht werden.»²

These authors mean, as we have seen, that if the replacement had its normal way, that is if the machines were replaced when they were worn out or when they were amortized, the reinvestment would for society as a whole be spread evenly throughout time. We have seen that both Spiethoff, Aftalion and J. M. Clark have maintained that replacement will have a tendency to take place in cycles, because it is *not* made at the normal time. They maintain that reinvestment will be unevenly spread throughout time because reinvestment will be neglected during periods of depression, the replacement of those capital instruments

¹ F. Schmidt, «Die Industriekonjunktur — ein Rechenfehler! » *Zeitschrift für Betriebswirtschaft*, Jahrg. 1927, Heft 3, p. 81.

² Erich Schiff, «Kapitalbildung und Kapitalaufzehrung im Konjunkturverlauf», Wien 1933, «Beiträge zur Konjunkturforschung», herausgegeben vom Österreichischen Institut für Konjunkturforschung, No. 4, p. 87.

which are ripe for replacement will be postponed. In the periods of recovery and prosperity, on the other hand, in the opinion of these authors, both that capital will be replaced which normally should have been replaced at that time, and in addition a part of that capital which should have been replaced previously. These cycles appear because the replacement demand is *elastic* up to a certain degree, due to the fact that the expenses for replacement are «postponable costs». No doubt it is also true that such a concentration of replacement to a certain degree takes place during the course of the business cycles. Later on, (in Ch. 3, § 1) we shall return to this sort of cycles in the reinvestment which we call *secondary (or generated) reinvestment cycles*.

That which is of special interest to us here, however, is that type of cycles in the reinvestment activity which Marx, Robertson and Schönheyder (comp. Part I) have pointed out, namely those cycles which may manifest themselves in the reinvestment because the number of capital instruments produced in different years varies in magnitude and because the capital goods produced in the same year will need replacement rather simultaneously. The characteristic feature of these cycles is just the fact that they arise because the reinvestment demand is *not elastic*. These cycles arise when the reinvestment takes place at the time when the capital instruments have reached their typical, normal age for replacement. That the reinvestment activity is so small in certain periods is, according to this theory, not mainly due to the fact that only a small part of the capital goods, which then reaches the typical replacement age, is replaced, but is due to the fact that an unproportionally small part of the capital goods of the community in these periods reaches the typical replacement age. That part of the capital goods which reaches the typical age for replacement during the period of depression is not proportionate to the depreciation of all capital in the community. When further the reinvestment activity in other business cycle periods grows above the normal level, it is due to the fact that an unproportionally great part of the capital goods becomes ripe for replacement in these years. We call these cycles *pure (or generating) reinvestment cycles*.

The theory of these pure reinvestment cycles forms a parallel to the well known *Eilert Sundt's Law* in the theory of population. This maintains that if an abnormally large number of births has taken place in a population within a short period, a number of births above the normal level will reappear after about 27 years (the typical age of marrying), the same will happen after another 27 years and so on. A considerable variation in the number of births for the different years will reflect itself into the future.

The pure reinvestment cycles are a similar regeneration phenomenon, in accordance with the generation cycles of Eilert Sundt. In capital production just as in populations large generations will be followed by echos. The pure reinvestment cycles are, therefore, due to the uneven age distribution within the stock of capital instruments in society.¹

Before proceeding to speak more in detail about the conditions for the arising of pure reinvestment cycles, it may be useful to decide some terminological questions.

§ 3. Definition of some Terms.

1. We will first try to define the two nearly related terms *replacement* and *reinvestment*.

Replacement is to be understood as the purchase of a new machine (or other type of capital goods) in stead of an old one of the same sort, that is scrapped or sold.

Reinvestment is to be understood as the purchase of a new machine, when and because an old machine of the same sort is fully amortized, or when and because the amortization of the old machine has reached a certain point.

Replacement will then ordinarily also be reinvestment, when the old machine is fully or partly amortized. In the same way reinvestment will most frequently be accompanied by replacement, but not always. One may keep the old machine in function for some time in addition to the new one.

Reinvestment is especially concerned with capital in abstract form

¹ *Jean Lescure* has wholly misunderstood this. Comp. «Des crises générales et périodiques de surproduction» (Paris 1907, pp. 508—509):

«Karl Marx avait déjà parlé de l'usure plus ou moins décennale du capital fixe et de la nécessité d'en reprendre la production tous le dix ans Ce qu'il y a de sûr, c'est qu'en elle-même elle (cette idée de Marx) est inexacte, car le capital fixe s'userait-il décennalement, rien n'impliquerait la nécessité de la réfection de tout le capital fixe employé à la production la même année; une répartition égale sur chaque année serait parfaitement concevable: de capital fixe A créé en 1880 serait usé et remplacé en 1890, — le capital fixe B créé en 1881 serait usé et remplacé en 1891 etc. etc., Théoriquement, l'usure décennale du capital fixe n'implique nullement sa production par saccade.»

The question here is not primarily that of replacing both capital A and capital B in 1890, but concerns the variations which can arise in the replacement activity, even if capital A is replaced at normal time in 1890, and capital B is replaced at normal time in 1891, as a result of the fact that capital A is, for example, twice as great as capital B.

or in the form of money. Replacement on the other hand is concerned with individual real capital instruments.

What is of most interest to us are the cycles that may arise in the reinvestment activity; whether or not the reinvestment is accompanied by replacement. On the other side it is clear that it will be very difficult through a statistical investigation to measure the reinvestment activity directly. In order to attain this it would be necessary to investigate in detail the accounts of many concerns. In an examination of the shifting out of capital instruments, as made in Parts III and IV of the present work for the Norwegian shipping industry in the years 1883—1932, only the replacement can be expressed. One has to be content with the replacement as an approximate statistical expression for the reinvestment.

2. Our next task is to draw up the border line between *reinvestment* (and replacement) and *new investment*.

Here we must first point out that in this work we are only concerned with reinvestment and new investment *within the single concern*, not for the community as a whole. When a concern purchases a machine by means provided in some other way than by amortization of an old machine of the same sort (and without shifting out an old one), we consider it as a new investment and not as a replacement, even if another concern simultaneously scraps a machine of the same sort without buying a new one. We do not take an interest in whether the number of (and capacity of) the machines in the community as a whole remains constant or is increasing.¹

In determining the border line between reinvestment and new investment within the same concern it would be possible to use various methods.

¹ Our distinction between reinvestment and new investment, therefore, does not correspond to the distinction of *George H. Hull* between «replacements» and «optional construction». (Compare «Industrial Depressions» (New York 1911, p. 103):

«Of the huge total of construction . . . about two-thirds, even in the busiest of years, consists of repairs, replacements, and such extensions as are required by the growth of population. This portion of construction is necessary and must be executed every year. But the remaining portion is «optional construction», and is undertaken or not according as investors see a liberal or a meagre profit in providing new building and equipment.»

In the same way *J. L. Snider* is thinking of the community as a whole when in his «Business Statistics» (New York 1929) he divides the sales in the motor car market in «New Owner Sales» and «Replacement Sales». By «replacement sales» is meant the number of motorcars which have to be sold every year in order to compensate for the number which are scrapped in the same year, no matter whether or not the same persons or concerns who scrapped the old cars, buy the new ones.

One might for instance, as Prof. *Frisch* does in his mimeographed lectures («Makrodynamikk for økonomiske systemer», autumn term 1933, p. 8526.2.) base the division on the *technical capacity* of the machine. Frisch regards a case as reinvestment when the new machines are of the same (or of less) capacity as the old ones. If the capacity of the new machines is greater, that part of the capacity which exceeds the capacity of the old ones is considered as new investment.

We must, however, be aware first of all that this definition only takes into consideration what we have called replacement. Those cases where the old machines are still kept in function for some time along with the new ones (which are purchased from the amortization funds) will according to this definition always have to be regarded as new investment. Secondly, we must keep in mind that constant technological progress has brought with it the condition that machines are regularly replaced with machines of greater producing capacity and of more perfect construction than the old ones. A firm that wants to keep its position in the market cannot be content to keep the capacity of its producing instruments unchanged; it must constantly expand. In distinguishing between reinvestment and new investment, therefore, in our opinion one ought not to lay too much stress on the condition of unchanged capacity.

Further one might, in distinguishing between reinvestment and new investment, take into consideration the originally invested *money capital*, and consider as reinvestment only that part of the price of the new machine that corresponds to the amortized capital. Even when we here do not take into consideration those difficulties for calculating the values of the machines, which result from the changes in the purchasing power of money, we also here meet with the objection that technical and economic progress has the effect that the machines regularly will be replaced by greater, more perfect, and consequently in most cases also more expensive machines. Consequently it is also an object of much disagreement whether the per cent of amortization is to be calculated so low that it is just sufficient to compensate for the originally invested sum of money capital, or if one shall allow for so liberal a per cent of amortization that it will be possible for the firm on this basis to follow technical development.¹

¹ On this question compare for example *Erich Schiff*, («Technischer Fortschritt als Kostenfaktor» (Zeitschrift für Nationalökonomie, Wien 1930—31,2)). Schiff quotes from the report of a German governmental commission of 1928 «Gutachten über die gegenwärtige Lage des rheinisch-westfälischen Steinkohlenbergbaues»:

«Die Kommissionmehrheit vertrat den Standpunkt, dass eine ordnungs-

In the statistical part of the present work we have chosen a method of calculation according to which we consider a newly constructed ship as a replacement structure when it is purchased on the basis of, or in connection with, the shifting out by the same shipowner of older ships, even if the new construction is greater.

3. A term which we must keep distinct from new investment is *primary investment*. Primary investment is to be understood as that previous investment which is the object of a reinvestment. This primary investment itself may of course as well have been the reinvestment of a still prior new investment or reinvestment, as a new investment.

4. As for the definition of the terms «pure reinvestment cycles» and «secondary reinvestment cycles» comp. § 2.

§ 4. A Survey of the Conditions for the Coming Into Existence of Pure Reinvestment Cycles.

Whether or not reinvestment activity in the community will produce cyclical oscillations may depend on the following factors:

1. *The time distribution of the primary investment.* It will be of significance whether the primary investment is evenly distributed over time or whether it is concentrated in certain periods. Some concentration of the primary investment will regularly be a necessary condition for the coming into existence of pure reinvestment cycles. In the purely theoretical analysis it will often be advantageous to presume that primary investment is concentrated in one moment. One will, however, come nearer to reality by presuming another form of distribution, for instance by presuming that it approaches the so called «normal» form of distribution (the function of distribution of Gauss).

The theory of pure reinvestment cycles in the same way as the Eilert Sundt's law in the first instance bears on the question of how a skewness in the age distribution that has already come into existence, will result in cyclical oscillations in the future, or what is called the «echo phenomenon». On the other side it is clear that it also may be of some interest to look at the question of how this first skewness in the age

gemässe Abschreibung die Anlagewerte so ersetzen müsse, dass eine normale Rationalisierung, die lediglich eine Kapitalerhaltung und nicht eine Kapitalvermehrung oder -verminderung einschliessen soll, möglich ist.»

Further Schiff observes:

«Die Praxis hat zwar zu unserer Frage bereits insofern Stellung genommen, als sie wohl schon seit längerer Zeit die Abschreibungssätze wegen der Überholungsgefahr höher annimmt, als es die blosse physische Abnutzung verlangen würde.»

distribution may arise. It is then not difficult to point out factors which will lead to a concentration of capital investment. We will first mention different shocks that disturb the even course of economic development in a community. A war, for instance, will often result in a disproportionately strong expansion of those industries which produce army or navy supplies or those industries which produce goods previously imported from foreign countries. Further, wars often bring with them the destruction of capital goods to a great extent. This will then in many cases result in a concentration of the capital production for rebuilding purposes shortly after the end of the war. In a similar way we may think that a new revolutionary invention, a sudden change in the trade policy, the opening up of new trade routes etc., will influence the course of capital production. In this connection we may refer to the well known «Führertheorie» of *Schumpeter*. According to this theory business men will always hesitate to take up new, unknown ways, but if *one* has only taken the lead and shown the way, all the others will follow.

It is, however, not necessary to presume that the first unevenness appeared suddenly due to a strong shock. If we assume the pure reinvestment waves to be followed by *secondary* waves in the investment (to which we return later on) even quite insignificant unevenness in the investment activity may lead to cycles.

Another factor of importance with regard to the appearance of pure reinvestment cycles may be:

2. *The age distribution of the reinvestment.* The question is here whether the capital goods will show any tendency towards concentration around a typical, normal age of reinvestment, or whether the reinvestment will be evenly distributed throughout all ages. The distribution around the typical reinvestment age may have various forms.

We must here distinguish between two questions:

a) will the reinvestment curve for *the individual types of capital goods*, for example for automobiles, spinning-machines or steamships shows a tendency towards concentration round a typical reinvestment age, and

b) how far will the age distribution curves for the reinvestment of *various types of capital goods* show conformity.

3. *The periodical length* (the distance between the tops in the primary investment and the reinvestment). It is obvious that the more «flattened» the form of the reinvestment, the greater will be the tendency of the reinvestment cycles to overlap, and the longer will be the periodical length which is necessary in order to prevent a rapid disappearance of the

cycles. On the other hand we may say that the shorter the periodical length, the more «hochpflichtig» the cycles will have to be, if they shall not disappear quickly.¹

4. *The per cent of maintenance or of falling off*, that is how many capital instruments are actually reinvestment and how many of them are «lost in the course of time». It is clear that with a very small maintenance per cent the reinvestment cycles will very soon disappear even if the reinvestment curve shows a very strong concentration around the typical reinvestment age.

§ 5. Factors Determining the Reinvestment Time.

We have (in § 4. 2) seen that one of the main conditions for the coming into existence of pure reinvestment cycles is that the age distribution of the reinvestment shows a concentration around a typical age of reinvestment. Naturally the reinvestment curve may also show concentration around two or more points, so that there are several typical ages of reinvestment. We will return to this later on.

We will here consider more in detail the factors that determine the age at which the capital instruments are replaced. We will then distinguish between (A) replacement at an extraordinary time because of accidents and (B) replacement at the normal time.

A. Replacement because of accidents.

Some capital instruments may be destroyed by accidents, for instance by fire or shipwreck, before the time of their normal replacement. For some types of capital goods, as is the case with ships and motor cars, this is of great importance, for other types it is of less importance. Partly due to the development of insurance activities, the owners will in most cases be able to replace the destroyed or lost capital instruments at once, the reinvestment being financed by the insurance companies.

One might perhaps have expected that accidents are a factor that would influence the capital instruments with the same force during all their life-time.²

¹ *Griffin* at once takes it for granted that the dampening which may be present, will be so strong that variations in the production in single years will play no important role. Compare C. E. Griffin, «The Life History of Automobiles, Michigan Business Studies, Vol. 1, No. 1. February 1926, p. 25:

«The normal replacement demand for any one year is influenced by the production of several past years. Being composed of different portions of the production of each of some fifteen years it is itself relatively unaffected by the variation from normal of any one year's production. Hence the replacement demand moves in a comparatively steady course.»

There seems, however, to be reasons for assuming that many accidents are of such a nature that they will influence capital instruments with different force at different ages. Marx thus points out that most accidents that may happen to a machine naturally are casual, but he continues («Das Kapital», II, p. 145):

«Dennoch scheiden sich aus dieser Masse zwei Sorten von Reparaturarbeiten ab, die einen mehr oder minder festen Charakter haben und in verschiedene Perioden der Lebenszeit des fixen Kapitals fallen — Gebresten des Kindesalters und die viel zahlreicheren Gebresten des über die mittlere Lebenszeit hinausgerückten Alters.»

Even if, therefor, the accidents in themselves are casual, the power of resistance of capital instruments diminishes regularly as they grow older. Thus old ships will more often be wrecked in storms than will newer ones. A motor-car-accident is often due to the fact that the brakes are worn out. In these cases we see that there is some connection between the accident and the physical wearing-out of the machine. We may perhaps also assume that there often may be a similar connection between accidents and the fact that the machines become antiquated. Even if we do not take into account the cases of direct insurance-fraud, it is obvious that machines will receive less care and inspection as they grow old and antiquated.

B. The normal replacement.

The most important factors that will influence normal replacement, are the following:

1. Physical wearing-out,
2. Moral wearing-out (antiquation),
3. The period of amortization.

1. *Physical wearing-out.* This depends, as Marx points out («Das Kapital», II, p. 140) on two factors:

a) Firstly, the wearing-out is due to the use itself. Example: «Im allgemeinen verschleissen die Schienen im Verhältniss zur Anzahl der Züge.»

b) Secondly, the wearing-out may be due to the influence of the power of the elements. «So leiden die Schwellen nicht nur durch wirklichen Verschleiss, sondern auch durch Fäulniss.»

Of course the physical wearing-out may lead to replacement even if the machine is not completely worn out. As a machine grows older, its

* This is the opinion of Griffin, who observes (l.c. p. 20):

«The accident factor would seem to be fairly constant throughout the life of a car.»

producing capacity will show a tendency to diminish because it is more exposed to accidents, and therefore it will be more expensive to keep it in use. Comp. Marx II, p. 145: «... je mehr über ihre mittlere Lebenszeit hinausgetreten, je mehr sich also der normale Verschleiss gehäuft hat, das Material, aus dem sie besteht, vernutzt und altersschwach geworden, desto zahlreicher und bedeutender werden die Reparaturen, nötig, um die Maschine bis zur Ende ihrer durchschnittlichen Lebensperiode in Athem zu erhalten; ganz wie ein alter Mann um nicht vorzeitig zu sterben, mehr medicinische Ausgaben hat als ein jugendkräftiger.»

As the machine grows older it will consequently cost more to produce the same quantity of goods than when new. *Rye Clausen* calls this difference between the present costs of production and the costs of production that would manifest themselves when using a new machine the *costs of age* (Alterskosten) of the machine.¹ Due to this increasing cost of age there will come a time when it is more profitable to purchase a new machine than to go on keeping the old machine in use.

The point of view is the following: The partly worn machine will be replaced when it is more lucrative to purchase a new machine than to keep the old one in function, *even if the new machine is of precisely the same construction as the old one.*

2. *Moral wearing-out.* This term was created by Marx, comp. II, p. 156: «... Wenn einerseits die Entwicklung des fixen Kapitals dieses Leben ausdehnt, so wird es andererseits abgekürzt durch die beständige Umwälzung der Produktionsmittel, die ebenfalls mit der Entwicklung der kapitalistischen Produktionsweise beständig zunimmt. Mit ihr daher auch der Wechsel der Produktionsmittel und die Notwendigkeit ihres beständigen Ersatzes in Folge des moralischen Verschleisses, lange bevor sie physisch ausgelebt sind.»

As a consequence of technical progress there will regularly appear, during the lifetime of a machine, machines on the market which are technically more advanced. A machine is therefore seldom replaced by a new one of just the same construction, but rather by a machine which is more advanced. The technical improvements will partly be of such a nature that they may fit in with the old machines, but for a great part this fitting in will not be possible.

Therefore, even if a machine is not sufficiently physically worn so that it would not be more profitable to buy a new machine of the same construction, it may be that it is unable to *compete with new machines of improved design.*

¹ Comp. A. *Rye Clausen*, *Fornylsen eller Ændringen af et producerende Anlæg*, Ingeniørvidenskabelige Skrifter, B. Nr. 7, København 1932.

We are so accustomed to the constant improvement in machines that we take it into consideration when fixing their amortization periods.

3. *The amortization period.* This will be determined from experience on the basis of the two preceding factors, the physical and moral wearing out. It is, however, not inconceivable that the amortization period itself, though fixed on the basis of experience, on the other hand may be of independent importance. As mentioned above (compare p. 37) *J. M. Clark* has particularly emphasized the importance of fixed customs in amortization, because they lead to uniformity in the replacement activity in the community as a whole. We may therefore suppose that machines in many cases will be replaced at the end of the amortization period (or when the amortization is advanced to that point when the machines customarily are replaced) even if neither physical nor moral wearing out as yet makes the replacement necessary.

When the owner in such a case replaces machines at the time indicated by the amortization account it may be due to a certain amount of conservatism or because the owner out of regard for competition or in view of prestige wants to keep the machines up to date. This factor will be of special importance in branches where the prices are fixed by agreement or in other way, so that competition will take place in the form of «service».

Further, it may happen that the management of a concern prefers the strengthening of the financial position by purchases of new material to a distribution of larger dividends to the shareholders. Consideration for the laws of taxation may also be involved. The concern may want new amortization objects. In this connection we may mention taxes on funds and the recently repealed imposition in the Norwegian laws of taxation which stated that only three quarters of the value of a ship might be written off.

We have previously (p. 41) mentioned the disagreement on the question whether amortization percentages should be fixed so low that they only suffice to replace the originally invested money capital, or whether they should be fixed so liberally that they may form the financial basis for keeping pace with technical progress, that is, so that they will enable the concern to purchase the larger, more perfect and therefore more expensive machines which in the meantime have appeared on the market. *Prion* formulates the question in this way: is the purpose of the amortization process to attain only «nominelle Kapitalerhaltung» or to attain «materielle Kapitalerhaltung»?¹

¹ Comp. Willi *Prion*, *Die Selbstfinanzierung der Unternehmungen, in Kapital und Kapitalismus*, Erster Band, Hgg. von Bernhard Harms, Berlin 1931, p. 232.

This is, however, a somewhat different question from the question whether the amortization should only be fixed according to the physical wearing out or whether it should also consider antiquation. It is clear indeed that a writing off which would only pay attention to the physical wearing of the machine would not even be sufficient to cover «*nomielle Kapitalerhaltung*». In order to keep the originally invested money capital intact it is not enough that the machine be fully amortized when it is physically worn out, but the machine must be fully amortised when it loses its economic value, that is, when it is so antiquated that it is preferable to purchase a new machine with improved construction. It is another question whether the amortization should provide sufficient means for the purchase of a new, more expensive machine.

There can hardly be any doubt that the amortization percentages in real life are often calculated so liberally that the amortization partly finances the purchase of larger and technically more perfect machines.

It is obvious, however, that one in calculating the percentages of amortization can in no case consider more than the regular technological development. Only minor improvements and changes in technique can be foreseen and provided for. Great revolutionary inventions will always be scarce and casual. These great inventions may suddenly make all calculation of the profitability of existing machinery worthless and make it necessary to replace machines a long time before they are amortized. We will later on return to this and point out what results such a sudden change may have in the replacement activity in the community.

We may presume that the three above mentioned factors, namely physical wearing out, moral wearing out, and the period of amortization, in most cases will *cooperate* in determining the time at which replacement takes place. Thus the period of physical wearing out in many cases will nearly coincide with that of the moral wearing out. No doubt past experience with obsolescence will often determine how solidly machines should be constructed. It would not be profitable, even if it were possible, to construct machines for a longer duration. In some cases, however, as for example in the shipping industry, special circumstances make it necessary to construct capital instruments for a longer duration than indicated by the period of obsolescence. In the same way the period of amortization will, as we have seen, in the long run be determined in accordance with the other two factors. In most cases therefore we may assume that physical wearing out, moral wearing out, and the period of amortization together will determine a typical replacement age for the capital instrument i question.

On the other hand we must be aware of the possibility of each of

these factors producing its *separate replacement cycles*. Every one of them may create concentration around different points of the replacement age distribution curve. This is particularly to be expected with regard to such capital instruments as for example ships where the period of physical duration is not determined by the period of obsolescence as found by experience, but by factors outside of the calculation of profitableness (the regard for security etc.) with the result that they become obsolete long before they are physically worn out.¹

Besides the factors mentioned here several others will also be involved in determining the time when it is profitable to replace a capital instrument. The *interest rate* will for example be involved in so far as it will be more expensive to purchase a new machine when the interest rate is high than when it is low. We may also mention the value of the old machine, its *cessation value*, as *Rye Clausen* (l. c.) calls it.

In many cases, especially with regard to capital goods which possess a short utility age, it will be the scrap value which is concerned here, as the machines regularly will pass directly from the first owner to the scrap heap. When capital equipment with a longer life span is concerned, as for instance with ships, this will, however, only very rarely be the case. A ship will regularly change owners several times before being ultimately broken up.

This circumstance, that the machines do not pass directly from the first owner to the scrap heap, is not characteristic of the shipping industry alone. *Engels* has pointed out this fact with regard to spinning machines (Briefwechsel p. 253): «Die alte verkaufte Maschinerie wird auch nicht gleich altes Eisen, sie findet an kleinen Spinnern usw. Abnehmer, die sie noch verwenden. Wir haben Maschinerie laufen, die gewiss zwanzig Jahre alt ist; und wenn man hier manchmal einen Blick in alte rapplige Konzerns tun kann, so sieht man altfränkisches Zeug, das mindestens dreissig Jahre alt ist.»

Rather far-reaching consequences arise from the circumstance that the capital instruments in many cases do not pass directly from the first owner to the scrap heap, because there will be no direct connection

¹ In the statistical part of the present work, we will point out that three different typical replacement ages are to be found for ships, namely at the ages of about 9, 15, and 20 years. A plausible explanation of this is that the 9 years replacement is due mainly to obsolescence, the 15 years replacement is due to amortization, and the 20 years replacement is due to physical wearing. This explanation is further confirmed by the fact that in the period 1902—1913, a period during which no decisive change in the marine technics took place, the 15 and 20 years replacement was relatively much more dominant than in the periods before and afterwards, when great technical changes took place.

between the breaking up of old ships and the construction of new ones. It is those shipowners who are selling ships of ages from 9 to 20 years, who regularly replace them by new constructions, not those owners who break up old (25—30 years old) ships. Consequently, we cannot measure the replacement activity by comparing the magnitude of new constructions with that of those broken up, concluding that the difference is replacement. The breaking up does not cause any direct demand for new constructions, and the constructions do not automatically lead to breaking up of old ships. In the long run there will, no doubt, be some connection between these factors,¹ but there will be room for considerable difference in time.

This lack of relationship between shipbuilding and breaking up is of great importance in the business cycle theory. It is evident that abundance of tonnage will easily manifest itself when not only larger and more perfect ships are built to replace the ships sold, but when in addition these old ships are not at once broken up, but for many years still may be present in the freight market.²

§ 6. How Far May it be Presumed that the Conditions Necessary for the Creation of Pure Reinvestment Cycles are Present in Actual Life?

1) *The time distribution of the original investment.* There is no doubt that the investment of capital in the production of capital instruments and of consumption goods of long duration shows a distinct tendency towards concentration in certain periods. We need only to quote B. Ohlin (Ett konjunkturuppsving's förutsättningar och möjligheter, Stockholm 1933, p. 6): «In short, *the real investment* which is great during prosperity and decrease much during the period of depression»

This is perhaps one of the few characteristics of the business cycle about which practically all economists agree, that the production of capital goods is a dominating factor in the course of the business cycle»

¹ Jfr. Tinbergen, Ein Schiffbauzyklus?, Weltwirtschaftliches Archiv 34. Band 1932 II, p. 152 sq.

² Compare Snider, J. L., Business Statistics, New York 1929. In calculating the replacement sales he presumes that in every case where an automobile is broken up there will be demand for another old automobile to replace it, and that the owner of this last one in his turn will purchase a new one. However, even in the motor car trade of an individual country this effect will only be an indirect one.

2) *The time distribution of the reinvestment.*

a) *For individual types of capital goods.* During recent years there are, especially in U. S., calculated «mortality tables» for a whole series of various capital goods. The mortality tables for motor cars have perhaps been prepared most carefully.

We may refer to *Gardner, George, Life Tables for Automobiles, in The Quarterly Journal of Economics, February 1933.*

Griffin, C. E., The life History of Automobiles, Michigan Business Studies Vol. 1, No. 1, February 1926.

Kurtz, E. B. Life Expectancy of Physical Property, 1930.

Winfrey, R. and Kurtz, E. B., Life Characteristics of Physical Property, Bulletin 103 of the Iowa Engineering Experiment Station, Iowa State College 1931.

The tables published in these works show with regard to most types of capital goods a distinct concentration around some typical «death age».

As we have pointed out before it is, however, not always the death age of the capital instruments which determines the replacement age. Several capital instruments will not pass directly from the first owner to the scrap heap. With regard to these capital instruments the time of replacement will consequently not be determined chiefly by physical wearing out. The first owners will replace at a much earlier date. We have worked out such a replacement curve in our statistical investigation of the replacements within the Norwegian mercantile marine.

b) *For all types of capital goods.* The thing of interest here is to see how far the total replacement curve, which includes all various types of capital goods, is typical.

Mortality tables for the capital goods seem to indicate that the typical mortality age for a great part of capital goods is to be found between 8 and 10 years. This is also indicated in the amortization rules of the taxation laws.¹ According to these rules, it appears that capital with a duration of less than 5 years may be practically left out of consideration. It is likely that the uniformity which is caused by the formulation of fixed rules for amortization will help to make the replacement more concentrated around some typical ages than the wearing out alone would indicate.

It is possible that a certain conformity in the age of wearing out for various sorts of capital goods may be due to the fact that a few materials will be dominating at the building of nearly all types of capital instru-

¹ Compare *Schenheyder* in *Statsøkonomisk Tidsskrift* 1927, p. 111.

ments. With regard to machines there will also be a certain similarity in the construction of various types.

We may here also mention the circumstance named above that the experienced obsolescent age of machines often will be decisive to the solidity in their construction. It will therefore be possible that if for example a 9 year business cycle has been experienced, capital goods will be built in view of a 9 years duration. The very fact that the total replacement curve is concentrated around a typical age, leads consequently to a tendency of further concentration round the same age. This will throw some light upon the way in which these fluctuations originally may have come into existence.

3. *The maintenance per cent.* This factor has usually been somewhat neglected. Schönheyder for instance seems to presume that nearly all capital will be replaced.

Our investigation of the Norwegian shipping industry shows, however, that the maintenance per cent plays a rather important role. It seems to be this factor in the first plan which explains why the replacement is not so dominating in business cycles as Schönheyder is inclined to believe. Our investigation in Part IV gives the result that 84,6 per cent of the ships acquired as new constructions left the first owners before they reached the age of 30 years, but only 39,8 per cent of the ships were replaced. In other words: the total per cent of maintenance was 47,0.

The corresponding percentages for sold ships alone were 72,0, 32,9, and 45,7, and for wrecked ships alone 12,6, 6,9, and 54,8.

The circumstance which in the first place causes this per cent of falling off is that the average lifespan of the ships is very long in relation to that of the shipping companies. The life-time of concerns will, firstly, depend on the life-time of man. Secondly, it will depend on structural changes in the industry. It appears that very few shipping companies have understood during a long period of time to adapt themselves to the new conditions which constantly arise. For example, only a small number of sailing-ship-owners in Norway survived the transition to steam ships.

In most other industries we may, however, expect that the maintenance per cent will be much greater than in the shipping industry, firstly because the capital instruments regularly will have a shorter life-time and secondly, because the living age of the concerns probably will be longer.

CHAPTER 2. AMORTIZATION AND SAVING.

§ 1. The Amortization Saving.

As we have seen above the reinvestment process has two different aspects: on one side we have the capital instruments which by degrees are more and more worn out (physically and morally) until they must be replaced. On the other side we have amortization, that is the economical preparation for the replacement of capital instruments.

The double existence of value in the reproduction of fixed capital was, as we have mentioned (p. 16), one of *Marx'* favorite ideas. In the second volume of «Das Kapital» he describes over and over again how the capital goods gradually yield value, which is circulated in the form of produced and sold wares and then in the shape of money returns to the owner of the capital goods where this «Geldniederschlag» temporarily is accumulated as «Schatz». Ultimately all value will have left the capital instrument, leaving only a lifeless body. But at the same time the «Geldverpuppung» of its value will be accomplished; the change from money form to utilizing form may again take place.

This amortization process within the single concern finds its expression in the book-keeping in the writing off the value of the capital goods with a simultaneous accumulation of funds, if the capital instrument has been originally purchased from resources of the owners, and repayment of loans, if it has been acquired by means of credit. In both cases there will take place a liquidation in the account.

In a modern community with an advanced credit system the released resources will in most cases temporarily be placed as deposits in banks or the like, either directly from the owner of the capital instrument or by the lender.

This deposition of means in view of future reinvestment will naturally represent a large accumulation of funds within the community. In a modern community with its huge capital resources we may presume that these amortization funds to a great extent regularly will surpass the saving of profit.

In the paper «Kapitalbildung und Investitionen in der deutschen Volkswirtschaft 1924 bis 1928»¹ a calculation is made for the amortiza-

tion sums within the most important branches of business in Germany for the years 1924—1928. This calculation shows for the included branches² a total sum of «Abschreibungen (Ersatzanlagen)» of 26206 millions of RM and of «Neuanlagen» 21993 millions RM. The amortization sums surpass then the new investments by 4213 millions RM. For the group industry taken alone the sum of amortizations amounts to 7590 mill. RM and for new investments 3663 mill. RM. The sum of the amortizations in the industry was, therefore, twice the sum of new investments. The authors point out that this is due to the fact that the capital goods in the industry have a relatively short life time, and therefore require a high amortization rate.

In spite of its great extent the importance of the amortization process has been neglected by most theorists up to the present time. New saving has attracted nearly all the attention. Saving has been identified with new saving; only that is considered as saving which surpasses the necessary expense to maintain the machinery.

During the last years, however, a reaction has taken place. In recently published economic works it is frequently pointed out that the capital market, the «capital disposition» of the community, does not only consist of the new capital recently saved, but also of the amortization capital released by the amortization process.³

The essential difference between the new saving and this «amortization saving» as we will call it, is that whereas the new saving is «free»

¹ Vierteljahrshefte zur Konjunkturforschung, Herausgegeben vom Institut für Konjunkturforschung, Sonderheft 22, Berlin 1931, von Dr. Günther Keiser und Dr. Bernhard Benning.

² Die Wirtschaftsgruppen: Industrie, Elektrizitäts-, Gas-, und Wasserversorgung, Verkehr, Landwirtschaft, Wohnungswirtschaft und Oeffentliche Verwaltungswirtschaft.

³ Compare Fritz Machlup, Börsenkredit, Industriekredit und Kapitalbildung, Wien 1931, (Beiträge zur Konjunkturforschung, Hgg. vom Oesterreichischen Institut für Konjunkturforschung, Nr. 2) p. 15: «Der Begriff der Kapitaldisposition umfasst mehr als die verfügbaren Sparmittel, er umfasst auch die zur Reinvestition verfügbaren Erneuerungsrücklagen der Wirtschaft, das Amortisationskapital.... Die Erneuerungsrücklagen stehen ebenso wie die Sparrücklagen als freie Kapitaldisposition zur Bildung von Realkapital zur Verfügung.»

Comp. *Kapitalbildung* und Investitionen in der deutschen Volkswirtschaft 1924 bis 1928, p. 35: «Der Kapital- und Geldmarkt hat nicht nur die Funktion, das *neugebildete* Kapital den kapitalbedürftigen Stellen zuzuleiten, sondern er hat daneben auch die Funktion, die *vorhandenen* Kapitalien, soweit nötig, neu zu verteilen....».

Comp. Erick Schiff, Kapitalbildung und Kapitalaufzehrung im Konjunktur-

in so far as the saver may place it where greatest profit may be expected, the amortization saving is from the first booked for a certain use, that is for investment in a new capital instrument when the old one is to be replaced. This saving corresponds to a certain requirement and is, on the basis of experience, adjusted to this requirement, it grows as the requirement ripens. We must, however, be aware that this difference is entirely a formal one. There is no necessity for using the amortization saving to replace the worn out machines, even if it is booked for this purpose. Often this saving finds another application in so far as not all machines are replaced even if they are amortized.

§ 2. Amortization and Reinvestment Cycles.

Perhaps the fact that the amortization saving is connected and adapted to a certain requirement has caused most theorists to presume that this amortization saving and its reinvestment will elapse smoothly and quietly without producing any disturbances of importance in production and price conditions. This conclusion was especially natural when it was assumed that the demand itself would be a constant force. It was then more plausible to expect disturbances from the new saving, which may be compared to troops who are used to conquer new lands for industry and trade.

We have seen, however, that if this amortization- and reinvestment process does not cause any disturbances in the economic life, then this process must be evenly distributed throughout time, so that not any years are preferably used for amortization and others for reinvestment for the community as a whole. An unevenness here will have the same effects as an unevenness in the relation between new saving and new investment; the effects might indeed be still more fatal because the amortization saving is greater.

In the individual concern the amortization and the reinvestment will elapse discontinuously if the concern is not a very large one. If no

verlauf, Wien 1933, (Beiträge zur Konjunkturforschung Hgg. vom Oesterreichischen Institut für Konjunkturforschung, Nr. 4) p. 30: «Nicht nur wirkliche Rücklagen der Wirtschaft strömen bei den Banken zusammen, auch das Erneuerungskapital, das den Unternehmungen in den Betriebserlösen zufließt, aber erst nach einer gewissen Zeit reinvestiert wird, schlägt sich für diese Zwischenzeit als Bankguthaben nieder.»

Comp. Bertil *Ohlin*, Ungelöste Probleme der gegenwärtigen Krisis, Weltwirtschaftliches Archiv, 36. Band, Juli 1932, p. 15: «Das laufende Angebot liquider Mittel auf dem Kapitalmarkt stammt aus zwei Quellen: 1. echten Ersparnissen, 2. Kapital, das während des Produktionsprozesses z. B. durch Abnutzung liquide wird.»

disturbances shall appear for the community as a whole, it is necessary that in every year the reinvestment corresponds to the saving of amortization funds. When some concerns reinvest their amortization funds and purchase new machines, there must be other concerns which are amortizing in order to replace their machines in some future year. For the community as a whole the depreciation of the capital must be the same as the replacement, if no disturbances shall be produced.

It is obvious, however, that smaller disturbances always might occur. It is not to be expected that exactly the same quantity of capital shall die every year. *Marx* has, as we have seen, (p. 20 sq.) pointed out how these more casual irregularities might cause disturbances in the production conditions.

More serious disturbances will naturally be produced if the amortization saving and the reinvestment have tendency to elapse cyclically. It is evident that we will have a serious factor of disturbances if the laying up of funds or repayment of loans takes place simultaneously for a whole series of concerns, there being no other concerns which reinvest corresponding sums at the same time, and if, at a later period, the same concerns need larger sums for reinvestment than is simultaneously saved by others.

During the last years several theorists seem to have become aware of the importance for the business cycle phenomenon of such disturbances in the equilibrium between amortization and reinvestment. But the attention has mainly been drawn to the disturbances due to what we have called *secondary* reinvestment cycles.

Compare *Kapitalbildung* und Investitionen in der deutschen Volkswirtschaft 1924 bis 1928, p. 26: «In der Industrie und in der Verkehrswirtschaft ist vielfach zu beobachten, dass die Abschreibungsbeträge einige Jahre hindurch angesammelt werden, bis sie dann insgesamt wieder zu tatsächlichen Ersatzinvestitionen verwendet werden; in der Zwischenzeit dienen sie der Erhöhung der Liquidität o. a. m. (Die Aufschiebung von Investitionen ist besonders häufig in der Depressionsphase zu beobachten; die Belebung der Wirtschaftstätigkeit findet in mancher Hinsicht dann im ersten Stadium der ansteigenden Konjunktur eine bedeutungsvolle Anregung gerade durch die Inangasetzung von derartigen Ersatzinvestitionen.) Wenn sich also in der Zuführung der Abschreibungen zu Ersatzinvestitionen gewisse—konjunkturell sehr wichtige—zeitliche Verschiebungen ergeben, so ist doch — auf längere Sicht gesehen, — ihre Verwendung zur Instandhaltung des Produktionsapparats im allgemeinen unvermeidlich.»

Compare Erich, *Schiff*, Kapitalbildung und Kapitalaufzehrung im

Konjunkturverlauf, Wien 1933, p. 83: «Manche Ersatzinvestitionen lassen sich aufschieben. In schweren Depressionszeiten werden häufig Erneuerungsinvestitionen aufgeschoben — Ansammlung von Bankguthaben, denen der «aufgestaute Erneuerungsbedarf» in der Industrie entspricht —, die später, wenn die Rentabilitätsverhältnisse sich bessern oder ihre Besserung für die nächste Zeit erwartet wird, nachgeholt werden.»

It is obvious, however, that similar disturbances of the equilibrium between depreciation and replacement will arise due to what we have called *pure* reinvestment cycles. The situation is here that a series of concerns simultaneously have purchased machines which possess approximately the same amortization dates. Disturbances due to pure reinvestment cycles may possibly be of greater importance for the business cycle phenomenon than those due to secondary reinvestment cycles, because as secondary reinvestment cycles may only influence the business cycle when revival has already begun, the pure reinvestment cycles may be one of those factors which give the impulse to the turnover from depression to revival.

To be able to realize the importance of this lacking equilibrium between amortization saving and reinvestment, we must first investigate what forms the amortization funds may have before they are invested in capital goods. For this purpose we must be aware of the difference that may exist between individual saving and saving from the viewpoint of the community as a whole.

§ 3. Individual and Social Saving.

Many theorists emphasize the difference between the activity of saving in a primitive community, where the money is hoarded, and the saving in a modern community, where the money is placed as deposits in banks.

Saving on the part of some members in a primitive community will cause prices to fall, so that other members of the community may increase their consumption. If, then, the savers resolve to spend the saved money, prices will rise, and the non-saving persons will have to decrease their consumption. But if all the members of the community save at the same time, for example in order to buy grain in bad years, there will not be caused any restriction of the consumption, but on the other hand the saving will have no effect in bad years, provided, of course, that grain cannot be purchased from other countries.

Under modern conditions, according to economic theory, the effect of saving will be of an entirely different nature. The saving is here

invested, it leads to a prolongation of the period of the «roundabout production» in the community, in other words the saving becomes capital.¹

The ideal situation would arise if the saving of individuals in the modern community was always followed by social saving, that is, by an increase of capital goods. The saving on the part of one individual does not, however, always lead to an increased production of capital instruments.²

As we have seen *Tugan-Baranowsky* and his school based their business cycle theory on the fact that the saving takes place rather evenly at all times, while the investment, the production of capital goods is especially concentrated at the periods of revival and prosperity. We have seen similar conditions with regard to amortization saving.

When now during the depression saving takes place which during the depression is not applied to the production of capital instruments, the question is how this saving is placed and the effects of it on production in the community.

One possible explanation was that the saving would lead to an increase of the production of consumption goods and raw materials which would be stored. In this way the saving during the depression might lead to a preparation of the increased capital production during the revival. Many theorists presume that this is what actually takes place in the business cycle.

Compare Knut *Wicksell*, *Krisernas gåta*, *Statsøkonomisk Tidsskrift* 1907, p. 262: «As far as I understand, there is no alternative: liquid capital which is not at once invested and transformed into capital instruments, *cannot* be incorporated in any other form than that of — stocks of wares.»

This presumption is, however, scarcely a correct one. Firstly, the available statistical dates do not indicate that any such accumulation of wares takes place during a depression. Secondly, it is not very probable that such an accumulation would take place during the depression. Since this question has been investigated in detail by some of the most prominent economists of modern time, we will here confine ourselves to quote:

D. H. *Robertson*, *Banking Policy and the Price Level*, London 1926, p. 82: «... Stocks of materials and finished goods. ... The statistics of their actual behaviour are sparse and inconclusive. There is,

¹ Compare Knut *Wicksell*, *Vorlesungen über Nationalökonomie*, Zweiter Band, Geld und Kredit, Jena 1928, pp. 7 sq.

² *Wicksell* makes also a little reservation, compare l. c. p. 12: «... wenn sich alles durchaus zweckmässig ordnet....»

however, some evidence that in the recent cycle in this country stocks diminished during the last few months of the boom, increased during the first year of the depression, and during the remainder of the depression suffered a continuous decline.»

Compare *Special Memoranda* of the London and Cambridge Economic Service on «Stocks of Staple Commodities» published in April 1923, June 1924, July 1925, February 1926, March and September 1927, and August 1929.

J. M. Keynes, *A Treatise on Money*, Volume II, London 1930 p. 145: «The conclusion . . . may be summarised by saying that our present economic system abhors a stock of liquid goods. If such a stock comes into existence, strong forces are immediately brought into play to dissipate it.»

When the money, saved during a depression, is neither invested in capital instruments, nor used in financing the accumulation of stocks of wares, it is clear that the savings from some individual members of the community must have the effect of increasing the consumption of other people. Saving in a moderne community may consequently have just the same effect as saving in primitive communities. However, since a modern community is a much more delicate organism than a primitive one, it is possible that saving which is not at once invested in capital goods, may have a destructive effect. Saving may by diminishing the demand of consumption goods lead to a decrease of the production of such goods.

Compare Ragnar Frisch, *Sparing og sirkulasjonsregulering*, Oslo 1933, pp. 11, 12: «The third case arises when some reduce their consumption without others increasing their consumption correspondingly and without a change in the production. In the first place the effect will be that consumption goods accumulate in shops and in warehouses as unemployed dead capital. And in the second place this will in turn lead to the stopping of the production machinery in the community, which delivers the continuous stream of goods. The laborers are forced into unemployment, and the machines are not used, both of which mean destruction of the productive values in the community.»

§ 4. Amortization Saving During the Depression is Merely Individual Saving.

From the preceding analysis it will be evident that amortization saving during the depression to a great extent is saving only from the individual point of view and not from that of the community as a whole. This saving is not at once invested in capital instruments nor in goods. What is saved is merely latent purchasing power; when the time for replacing the machines occurs, the amortization funds will give the con-

cerns the power to force others to cut down their consumption in order that the productive means in the community to a greater extent may be used for the reproduction of capital goods.

The inner contradiction within the capitalistic community, (which was specially emphasized by Tugan-Baranowsky¹) between the organization of the production in the individual concerns and the anarchy of the production in the community as a whole, manifests itself clearly in this field.

We see that the replacement in the individual concerns is an occurrence which is foreseen and prepared as carefully as is the birth of any prince. This preparation from the side of the individual concerns has not, however, the effect that community as a whole will be better prepared when an increase in the replacement activity appears.

Compare D. H. Robertson, *Banking Policy and the Price Level*, p. 96: «It is one of the paradoxes of «private enterprise» with its adjunct of a modern banking-system, that the utmost exercise of thrift and foresight on the part of individuals may be perfectly ineffective in protecting the community from the adverse effects of a «shortage of capital». Individuals may hoard bank-balances and use them later for purposes of investment, but their action cannot result in the community as a whole putting the activity Lacking into cold storage and taking it out again as required.»

The only way in which the community could be prepared for the increase of the production of capital instruments during a revival would be by accumulating stocks of finished consumption goods during the depression. As we have mentioned before, such stocks would under an economic system based on profitableness rather be a hindrance to an improvement of the situation.

Compare J. M. Keynes, *A Treatise on Money*, II, London 1930, p. 145: «Recovery — broadly speaking — cannot begin until stocks have been absorbed, with the result that the process of recovery cannot be much facilitated by the existence of stocks.»

J. M. Keynes has further pointed out that when such an accumulation of stocks during the depression for speculative purpose does not take place, the main reason is that the costs would be too great. Of special importance in this connection is the great remuneration that must be calculated to outweigh the possible changes in the purchasing power of money the time the wares are lying in the store-houses.

When the amortization period is ended the individual concerns have by accumulating amortization funds acquired the power to force the

¹ Compare Tugan-Baranowsky, *Studien zur Theorie usw.*, Jena 1901, p. 28.

members of the community to reduce their consumption. The activity of saving, from the part of the community, which is necessary for the replacement, comes consequently into existence in the form of *enforced saving*.

This point Åkerman does not consider in his criticism of the reinvestment theory of Schönheyder where he raises the objection that the time of reinvestment will depend on the offer of saving (i. e. voluntary saving).¹

If we regard industry as a group distinct from other groups of the community our point of view is that industry during the period of depression by accumulating amortization funds in the form of latent purchasing power and by turning them into effective purchasing power when the actual replacement takes place, enforces the other groups to reduce their consumption, thereby making parts of the productive powers in the community free to be disposed to reproduction of capital instruments. From this viewpoint we see that amortization saving has a great resemblance to saving by some members in primitive communities.

We may, however, also regard industry as buyer of machines as distinct from the machine industry as machine purveyor. (The machine industry will then belong both to the first group as machine purchaser and to the second group as machine producent.) From this point of view we see that the effect on the parallel amortization saving within the industry has much resemblance with the saving by all the members of a primitive community in order to meet an extraordinary bad harvest.

Simultaneous investment of the amortization saving from a whole series of concerns would not only lead to a rise in prices of consumption goods, whereby it would enforce real saving from the part of other members of the community, but it would also lead to a still stronger rise in the prices of machines. This rise of machine-prices has the effect that the amortization saving of the concerns partly will be in vain. This also explains why industry preferably purchases machines when they are most expensive. The machines become expensive because all concerns have resolved to purchase them simultaneously, it is not because they are expensive that everyone buys machines.²

¹ Compare J. Åkerman, *Om det ekonomiska livets rytmik*, Stockholm 1928, p. 162: «With regard both to reinvestment and to new investment the offer of saving will at all events be the dominating factor.»

² Compare J. M. Clark, *Overhead Costs* p. 396: «The undue concentration of capital expenditures ought to be relieved by the effect of high prices at the peak and low prices during a depression, which would make it worth while to buy equipment during depressions for the boom that is coming, and deter people from buying at the peak. But while fluctuating prices ought to work this way, they do not.»

CHAPTER 3. THE MAINTENANCE PROBLEM.

We have seen that the pure reinvestment cycles — those cycles that come into existence as an echo after a previous top in the investment curve — will show a distinct tendency of *dampening*. This is due, first, to the time distribution of the reinvestment and, secondly, to the percentage of falling off. Those cycles in the investment activity that we know from actual statistical data show, however, no tendency of dampening.

In order therefore to explain the maintenance of the cycles we must look for other tendencies which may compensate for the tendency of dampening. The same question, the *maintenance problem*, will manifest itself in all cases where theorists advance systems that lead to damped cycles.

We will in the following explain the maintenance of the cycles in two ways

- 1) By secondary cycles of investment. (Automaintenance.)
- 2) By forces outside the system.

§ 1. Automaintenance.

1) *Secondary Reinvestment Cycles.* Secondary reinvestment cycles come into existence because the reinvestment during the business cycle will be concentrated during revival and prosperity. The secondary waves are due to the elasticity of the reinvestment demand, to the fact that the actual doing of the replacement may be moved forward or backward in relation to the normal reinvestment time.

We have assumed, at the formulation of the theory of pure reinvestment cycles, that the reinvestment time was determined independently by causes outside the business cycle. This assumption, however, will only partly agree with reality. The date, when it is profitable to replace a capital instrument, will to a large extent be influenced by the various prospects of rentability during the various phases of the business cycle. Compare Ragnar *Frisch*, Mimeographed lectures p. 8521, 2 «It would then be more appropriate to say that the life time of capital instruments

is dependent on the phase of the business cycle so that life time itself is an unknown variable in our macrodynamic system.»

Further we have assumed that the concerns come to their resolutions concerning replacement independent of each other. In reality, however, we have to consider the general optimistic state of mind of the concern managements during revival and prosperity and the pessimistic state of mind prevailing during depressions. We must also consider the possibility of mass psychology.

2) *Postponement of the Reinvestment.* The most important change in the reinvestment time will be to the effect that the reinvestment period during depression is *prolonged* beyond the normal reinvestment date. The replacement of machines; which during a depression reach their normal replacement age, is to a large extent neglected, as the machines either are kept in use longer than usually or they go out of use without being replaced.

When machines may be kept in use beyond the normal replacement age, it is naturally due to the circumstance that the normal reinvestment age of machines regularly is not determined by the limit of their maximum age. Even if the replacement age was determined solely with regard to physical wearing, the age when the machine is totally worn out would not be decisive. The replacement age depends whether it is profitable any longer to keep the machine in use owing to the rising age expenses. There will then always be a physical possibility to keep machines in work some time beyond their normal replacement age.

Economically this possibility for postponement is expressed in the fact that the replacement expenses are «postponable costs».¹ In bad years the concerns will reduce the replacement budget. The postponing of the replacement may be motivated by lack of capital; the concerns need all resources to cover their current expenses. But even if capital may be provided, it may happen that concerns prefer to postpone replacement because the market is glutted with goods, so that there is not full employment for the machine. Besides, postponing of the replacement may naturally be motivated by the general pessimism during a depression. One is inclined to view the future prospects of the branch so pessimistically that one does not only omit to start new enterprises, but even neglects the maintenance of the old machinery.

There will, however, be certain limits to how long reinvestment may be postponed beyond the normal reinvestment date. For those concerns, which hope to continue in the branch, a time will ultimately arrive when

¹ Compare J. M. Clark, *Overhead Costs*, p. 55.

reinvestment becomes an urgent demand. It is likely to presume that the beginning revival will be reinforced from this dammed up reinvestment demand. Compare *Schonheyder*, 1927, p. 89: «... a constantly increasing demand for reinvestment, a demand which during long years of depression has been checked unnaturally, but which now presses forward in consequence of a law of gravitation which is stronger than any other static or dynamic force known within economic life.»

Many theorists have laid great stress upon the role which this postponement of reinvestment is playing in the business cycle. Nor can there be any doubt that such a postponement of the replacement regularly will take place during a depression. It is, however, a question to which extent this neglect of the reinvestment from the side of several concerns is counteracted by the tendency of rationalising. While during revival and prosperity the efforts are, above all, to increase the producing capacity, depression is characterized by rationalisation. Compare *Cassel*, *Theoretische Sozialökonomie*, 1927, pp. 517—518: «... die Depressionsperiode veraltete Produktionsmittel ausmustert, sie durch neue und bessere ersetzt und damit die durchschnittliche Produktivität steigert.»

A key to the understanding of how these two contrary tendencies work during a depression is given by Sven *Helander* in his work *Die internationale Schifffahrtskrise und ihre weltwirtschaftliche Bedeutung*, Jena 1928, p. 29: «... wie die Schifffahrtskrise selbst geeignet ist, die Qualitätsunterschiede vielfach zu vergrößern. Die notleidenden Reeder können ihre Tonnage nicht mehr auf derselben qualitativen Höhe erhalten. Die kapitalreichen Reeder werden durch die niedrigen Frachten gezwungen, sich durch besondere technische Verbesserungen günstiger zu stellen, um bei dem niedrigen Frachtniveau doch gewinnbringend arbeiten zu können.» Compare also p. 31: «Heute ist es die Schifffahrtskrise selbst, die vor allem dazu gezwungen hat, schlechte Schiffe abzuwracken um durch Umbauten und Neubauten neue Schiffe zu gewinnen, die so rationell arbeiten, dass sie trotz des niedrigen Frachtniveaus etwas besser rentieren.»

3) *Shortening of the Reinvestment Period.* During prosperity we may further expect that a tendency of shortening the reinvestment period beyond the normal will manifest itself. Some capital instruments will be replaced before they normally should be ripe for replacement.

A factor which is involved here is the technical and economic progress. Usually new machinery will be larger and technically more perfect than the replaced one. It will have greater capacity and work cheaper. When, therefore, during a revival a whole series of concerns within one branch of industry is replacing their machinery by larger and better machinery,

other concerns within the same branche will have to replace as well, even if the normal replacement age of their machines is not still reached. The still inamortized part of the value of their old machines must then be written off as loss.

4) *Pure and Secondary Reinvestment Cycles. The Elasticity of the Replacement Demand.* We have seen that the reinvestment shows two opposite tendencies: on one hand a certain inelasticity which in connection with concentration in the distribution of age may lead to pure reinvestment cycles, on the other hand a certain elasticity which may lead to secondary reinvestment waves during the business cycle. While, therefore, the inelasticity may create independent cycles (generating cycles) the waves, due to the elasticity in the reinvestment will be dependent on other waves.

Akerman seems to be of the opinion that a reference to this elasticity is sufficient to disown the reinvestment any «generating» influence upon the business cycle. Compare Johan Akerman, *Om det ekonomiska livets rytmik*, Stockholm 1928, p. 161: «When the elasticity of the reinvestment demand is taken into account, the importance of the theory is much reduced, as the present business cycle will then dominate over the influence that previous cycles may have on the development of the reinvestment group.»

Of course it is correct because of this elasticity the reinvestment cycles might adjust themselves to a sufficiently strong fluctuation produced by other causes. But when there are limits for this elasticity, in other words when the reinvestment shows some inertness, there is also a possibility that the other factors in the business cycle might adjust themselves to the pure reinvestment waves. A certain elasticity will also be present for the other factors. What factors will be dominating is naturally dependent on their relative force, so that the question may only be answered on the basis of quantitative measurements of the factors involved.

That which is of special interest to us is the relation between pure and secondary reinvestment cycles. We see that the elasticity of the reinvestment just as well as it may lead to a disturbance of the pure reinvestment cycles, it may lead to a strenghtening of the cycles. For of course the secondary reinvestment cycles may as well adjust themselves to pure reinvestment cycles as to waves due to other causes. The pure and the secondary reinvestment may cooperate. The inertness of the reinvestment leads to a rise of the reinvestment curve in the years when great masses of capital instruments are ripe for replacement, and the elasticity of the reinvestment leads to a concentration of the

replacement of the capital produced during the adjacent years about the same time. Then this will lead to a further rise of the curve. This concentration of the reinvestment during the revival and prosperity will naturally have the effect of counteracting the tendency of dampening the pure reinvestment cycles.

5) *New Investment, Amortization, Saving of the Concerns and Free Saving.* To explain the maintenance problem we can say that the pure reinvestment cycles do not only release secondary reinvestment cycles, but also secondary *new* investment cycles. New investment as well as reinvestment will be concentrated during revival and prosperity and new investment in one business cycle will reappear as reinvestment later on.

It will be advantageous here to consider more closely the various categories of saving and investment. In accordance with the recent German-Austrian theory we may distinguish between the following three groups.

a) *Amortization saving and reinvestment.* This group we may call *bound* saving because it is bound to a definite purpose, that is replacement. (This group we have dealt with above in chapter 2.)

b) *Saving of the concerns and «Selbstfinanzierung».* Concerns will regularly, beside and beyond their amortization saving, lay aside resources for the purpose of investment within the concern for extensions. This saving is not to be considered as a wholly voluntary saving on the part of the concerns. In a period of constant expansion it is not sufficient for the concerns to replace their out-worn machinery. A concern, which will hold its position in competition with others will have to extend the production capacity corresponding to the growth of the market, or else it runs the risk of being pushed aside by more expansive competitors.

Already *Tugan-Baranowsky* was aware of that. Compare *Studien etc.* p. 28. «... das bis zu einem gewissen Grade auch der Kapitalist selbst ein einfaches Mittel der Akkumulation des Kapitals wird. Die Gesetze der kapitalistischen Konkurrenz verlangen gebieterisch vom Kapitalisten eine Erweiterung der Produktion und die Kapitalisierung eines bedeutenden Teiles seines Profites.» Compare also *Emil Lederer, Kapitalbildung aus Einkommen.* (Kapital und Kapitalismus, Band I, Berlin 1931), p. 216. «... für den Unternehmer bzw. für das Unternehmen, wenn es einmal einen gewissen Umfang erreicht hat, ist das Erfordernis des Wachstums, das Erfordernis der Ausdehnung so selbsterständlich aus dem Lebensgesetz der Produktion heraus dargeboten, dass der Unternehmer das Einkommen, das er in unserem Sinne aus der Volkswirtschaft heraus bezieht, gar nicht als ein ihm gänzlich und restlos zur freien Verwendung zustehendes privates Einkommen anzusehen geneigt ist, sondern im

voraus bereits gedanklich mit einem gewissen Wachstumstendenz der Unternehmung rechnet und daher die Abspaltung eines Teiles dieses Einkommens zur Investition als «normal» ansieht. In der Tat unterscheidet auch der englische Sprachgebrauch schärfer, als wir es tun, zwischen dem Prozess des *saving*, also des Sparens, und des *investment* aus dem Betriebe hinaus.»

This type of saving is therefore to be considered mainly as *bound saving*. It is not, however, as the amortization saving, bound to the replacement of a definite capital instrument, but is bound to be invested preferably in some particular concern or branch.

c) *Free saving and new investment*. Free saving will partly consist of the saved wages of individual persons, partly of profit which does not find any application within the branch where it has been produced. This saving is not bound to any definite application but appears on the capital market and will be invested where the changes for profit are best.

Earlier, we have dealt with the numerical relation between the amortization saving and the new saving (comp. p. 54). Regarding the numerical relation between the saving of the concerns and free saving it is difficult to form any opinion all the time no definite data are available. *W. Prion* calculates the self-financing in Germany in the period 1925 to 1928 being about 6 milliards RM. (Compare Kapitalbildung und Investitionen p. 30). The total sum of new saving in Germany in the same period was calculated to about 22 milliards RM. *Erich Schiff* (Kapitalbildung und Kapitalaufzehrung im Konjunkturverlauf, Wien 1933, p. 24) has also made a survey of the different groups of saving in this same period. Of a total sum for new investments of 21,4 milliards RM he calculates that 2,3 milliards were financed by public enforced saving (taxes, social insurance etc.) and 6,4 milliards through creation of formal money capital. Of the remaining 12,7 milliards, 9,7 are regarded as «Spar-kapitalbildung» (free saving) and 3,0 milliard as «Unternehmungskapitalbildung» (saving of concerns). According to this the saving of concerns should amount to one third of the free saving. We must, however, be aware that this calculation includes all investments in Germany in the period considered. It is to be expected that for the group of industry alone the saving of the concerns will amount to a considerable greater per cent of the invested sum.

6) *The connection between the amortization and the saving of concerns*. The problem of the saving and self-financing of concerns is discussed with special interest in the recent German and Austrian economic literature. It has been pointed out that a disproportionate expansion of some branches of industry may be a consequence of the

self-financing by the concerns, because these capitals do not pass the capital market and therefore will not necessarily be led in that direction where the demand for capital is greatest. The importance for the business cycle of such a partial self-financing has been explained by R. *Liefmann*.¹

What we here especially will draw attention to is the close connection that necessarily exists between amortization and saving by the concerns and therefore also between reinvestment and self-financing. As we have already pointed out above it will in many cases be difficult to draw the line of distinction between reinvestment and new investment because machines are regularly replaced by new ones that technically are better developed and of greater producing capacity, and therefore cost more than the old ones. Amortization saving alone will therefore not be sufficient to finance the purchases, it will be necessary to add from the new saving. Shipping industry gives here an excellent example. The average size of oceangoing ships has had such a growth that an ordinary ship-owning company in most cases when it wants to extend its tonnage must do this by shifting out smaller ships with larger ones. Self-financing has necessarily to go hand in hand with reinvestment. In other cases the transition to an improved technique will lead to expansion and rebuilding of the whole concern. Nor in this case will it be possible to finance the replacement by the amortization funds alone.

Concern saving will therefore partly be invested in connection with reinvestment of amortization saving, but partly will its investment also depend on the same motives as in the case of the investment of the free saving.

7) *Secondary cycles in new investment.* While amortization and concern saving have the purpose of financing replacement and rationalisation within existing concerns, free saving has the special purpose to finance the foundation of new concerns and new branches within industry.

Revival, once commenced, will always release secondary cycles in new investment. Most new enterprises are started during revival and prosperity. The same factors which we mentioned when dealing with secondary reinvestment cycles will be involved here. Starting of new enterprises will partly be due to real improvement in rentability, and partly it will be based on the more optimistic state of mind prevailing during revival and prosperity. Waves of pure speculation will appear and multitudes of new, purely speculative enterprises come to the fore.

¹ Compare R. Liefmann, *Inlandskapital, Auslandskapital, Kriegstribute in Weltwirtschaftliche Vorträge und Abhandlungen*. Heft 8, Leipzig 1930.

Previously (chapter 2) we have considered how pure reinvestment cycles have their monetary background in the parallel saving of funds and investment of these funds from the part of a whole series of concerns. We have seen that this amortization saving on the part of concerns is to be regarded as mainly individual saving, saving of latent purchasing power. The real, social saving needed for the replacement process will be produced through a forced restriction of the consumption on the part of other members of the community. The same is to a great extent the case both with the concern saving and the free saving.

We see that great disagreements between saving and real investment will exist during the business cycle. During depression saving will surpass the investment volume, so that a part of the saving is led back to consumption, but during prosperity investment will be so great that the simultaneous voluntary saving will not suffice, so that an essential part of the real, social saving is to be procured through forced saving.

8) *Progressivity as a maintenance factor.* The large extent of both concern saving and free saving in modern societies is a consequence of the progressivity. During a period of more than a hundred years the population in most civilized countries has been constantly growing, and the increase of the capital quantity has been still stronger. We have got so used to this constant technical and economic expansion that we usually will take it into account. Most calculations are based on its continuity.

Quite naturally this constant development has characterized economic theory too. Not seldom theorists claim general validity for laws, which only would be correct when a tacit assumption of constant expansion is made. This is perhaps especially the case considering business cycle theory. No doubt many business cycle theories are based on a tacit assumption of constant expansion. Some theorists mention, however, expressly progressivity as one of the powers which maintains the business cycle. This is for example the case with *Cassel* and *Schumpeter*. The side of progressivity which these theorists especially have attended to is, however, the constant changes, «Neuerungen», which will characterize development. We shall deal with the importance of this factor later on. That which is of interest to us here is the effect of the *rising trend* itself in the capital investment in maintaining the reinvestment cycles.

A rising trend in the volume of investment will have the effect that new investment will play a great role beside reinvestment. That the new investment, however, will be dominating is not granted through the rising trend alone. While the size of new investment will depend on the increase of the consumption of goods, the size of reinvestment will depend

on the quantity of capital which is present within the society and on its age and life time.¹

At a rising trend reinvestment will be of smaller importance in relation to new investment than at a constant level of investment. At a descending trend one may perhaps presume that the reinvestment will be dominating. It would then seem to be logical to conclude that reinvestment cycles would play a more important part at a descending trend than else would be the case. One might expect that they would manifest themselves most evidently when the reinvestment was of greatest importance in relation to the new investment.

Here, however, several circumstances must be taken into consideration. Firstly we must be aware that at a rising trend the absolute size of the capital that has to be replaced will grow from period to period, as not only reinvestment but also new investment from previous periods must be replaced. Secondly, at a rising trend the secondary cycles of re- and new investment will show a continuous growth. At a constant or decreasing trend in reinvestment all the tendencies to dampening of the pure reinvestment cycles will exert their influence to a full extent. As mentioned before this dampening is due to the time distribution of the reinvestment and to the per cent of falling off. At a rising trend it is probable that these tendencies to dampening will be counteracted. The per cent of falling off will probably be outweighed by the increasing new investment. And the tendency of spreading which the pure reinvestment cycles show may be compensated by the cumulation of the pure reinvestment cycles and the secondary cycles. A rising trend in the investment may therefore act as a source of maintenance for the reinvestment cycles.

§ 2. Maintenance of Reinvestment Cycles² by Outside Forces.

1. *The impulse phenomenon.* In the preceding section we have seen that the tendency of dampening of pure reinvestment cycles might be counteracted by their calling into existence secondary cycles in reinvestment and in new investment. We presumed that the cycles might be maintained by forces included in the swinging mechanism. (Auto-maintenance.)

We shall now see how the cycles may be maintained by forces outside the mechanism, by external impulses.

¹ Compare the discussion Frisch-Clark, especially Ragnar *Frisch*, The Interrelation between Capital Production and Consumer-taking, *Journal of Political Economy*, October 1931, p. 653.

Compare also Erich *Schiff*, *Kapitalbildung* etc. p. 69.

We must here be aware that even when a cyclical movement is auto-maintained it is not impossible that outside impulses may play a role. We may thus think that at some critical point in the business cycle (for instance at the turn-over from depression to revival) there may be a friction that must be overcome if the movement shall run its course. (As example we may mention that the theory of Tugan-Baranowsky presumes that at the end of depression a resistance manifests itself against the productive investment of the accumulated funds of free saving.) It is then possible that this friction regularly will be overcome by an impulse outside the business cycle system. The task of the impulse in such a case is then only to *release* powers that already are present in the mechanism, and which in either case would have been released later on, either because the pressure they exerted would at last grow strong enough to overcome friction or because of the influence of another outside impulse. In economic life there will always be several factors present which, when conditions are ripe, may act as releasers.¹

The sort of impulses, however, which we at present are thinking of, are those which are not only releasing powers already present in the mechanism, but which themselves *deliver* the power that maintains the cyclical movement. We shall call this sort of impulses *shocks* to distinguish them from the previously mentioned releasing impulses.

Impulses influencing a cyclical movement may occur:

1) Regularly with intervals corresponding to the period of the cyclical movement.

2) Secondly, impulses may occur regularly at intervals which, though being different from the period of the cycles, still stand in a certain relation to this period. Impulses may, for instance, return at intervals twice as long as the period of the cycle. Shocks returning regularly with such an interval would then only influence the cycle at every second period. The effect might then be that the cycle would alternatively have a great and a small amplitude.

Further the interval between the impulses might be, for instance, $\frac{1}{2}$ or $\frac{1}{3}$ the period of the cycles. Such impulses might then influence the cycles every time when releasers are needed, but at other times not. Of special interest in this connection is that cycles of different periodical length may influence each other as impulses. The business

¹ Compare *Pigou*, *Industrial Fluctuations*, p. 212: «Thus, Professor Jevons while he claims that bumper crops occur at intervals of from three to four years and give *some* impulse to industry each time they occur, admits that they only give an *effective* impulse at intervals of seven or ten and a half years, when other conditions are ripe.»

cycle theory of J. *Akerman* is just based on the idea that shorter cycles may act as impulses for the longer ones, he presumes then that the period of the major cycle will always be a multiple of the periods of the minor ones.

3) Thirdly, impulses might return at intervals that in themselves are regular, but which do not correspond to or stand in any simple numerical relation to the period of the cycles.

The effect of such impulses will then probably not be very different from the effect of

4) Impulses occurring at intervals not regular, sporadic.

Some theorists have held the opinion that if impulses should be able to call into existence or maintain a cyclical movement they must necessarily themselves occur regularly at intervals corresponding to the period of the cycles and that in consequence irregular impulses would be of no interest because they would only have the effect of disturbing the cyclical movement.

Compare Irving *Fisher*, *Our unstable dollar* etc. p. 193: «To keep the business cycle up there must be applied some outside force. But, unless the outside force happens also to be cyclical and unless in addition the rhythm of said force happens to be exactly synchronous with the business pendulum itself, these outside forces will not perpetuate, but obfuscate the cycle, like the wind blowing on the reeds.»

Compare Joseph *Schumpeter*, *Die Wellenbewegung des Wirtschaftslebens*, *Archiv für Sozialwissenschaft und Sozialpolitik*, 39 Band 1915 p. 3: «Wenn immer aus politischen oder anderen Ursachen eine erwartungswidrige Veränderung der Daten erfolgt, mit denen der Kaufmann rechnet — ein Krieg, eine Revolution, ein plötzlicher Wechsel der Handelspolitik, eine plötzliche erwartungswidrige Gestaltung der Ernte, ein plötzlicher Modewechsel u. ä. können solche Ursachen sein — so wird es zu «Krisenerscheinungen» kommen es kann höchstens eine Aufgabe der Analyse konkreter Verumstände vorliegen nicht aber eine Aufgabe für den Theoretiker. Das gilt besonders dann, wenn es sich um ausserwirtschaftliche oder um Zufallsstörungen handelt.»

This point of view is, however, very superficial. One must not ignore the possibility that even impulses occurring quite sporadically may call into existence regular cycles when they act on a mechanism that has a tendency to move cyclically.

Compare *Pigou*, *Industrial Fluctuations*, p. 206: «. . . . the recorded rhythmic movements might result from the operation of causes which are sporadic in their nature, and do not recur rhythmically, but which,

once they have come into play, instead of exhausting themselves in a single effect, start wave movements...»

How such irregular impulses can produce cyclical movements, is recently explained in mathematical form by Ragnar *Frisch*, who has developed a theory of the cycle-producing and maintaining influence exerted by the *cumulation* of a series of erratic shocks, of which every single shock may be insignificant. (Compare Propagation Problems etc. pp. 28—29 and Mimeographed lectures 8528, 2 sq.)

In the following we will especially be concerned with the influence on the business cycle of singular strong shocks. One of the first theorists who has pointed out the importance of such shocks for the business cycle phenomenon was Knut *Wicksell*, who illustrates their influence through following metaphor. (Ekonomisk Tidskrift 1918, p. 71, note). «If one beats a rocking-horse with a club, the movements of the rocking-horse will be very different from those of the club. The blow is the cause of the movements, but the conditions of equilibrium of the thing itself will determine the form of the movements.»

2. *Inventions*. We have pointed out how the even technical progress has the effect that machines are regularly replaced by new machines, which are more technically developed and which cost more than the old ones, and further how this will have the effect that machines regularly become oldfashioned before they are physically worn out. We have also mentioned that concerns foresee this regular technical progress and take it into account by calculating greater amortization percentages than indicated by the physical wearing-out alone and by laying up extra funds in addition to the amortization funds.

Great, epoch-making, inventions, which suddenly revolutionize the whole process of production will, however, naturally occur more seldom and sporadically. Concerns cannot therefore foresee them and prepare themselves economically to the rebuilding of the factories that often is necessary to utilize such great inventions.

We then come to the question what influence these revolutionizing inventions may have on the reinvestment cycles. Will they, because of their irregular occurrence, disturb the rhythm of the cycles, or is it conceivable that they may adjust themselves to the cycles, thereby reinforcing them?

Knut *Wicksell* presumed that the influence of the great inventions on the business cycle was as follows (Krisernas Gåta, Statsøkonomisk Tidskrift 1907, p. 265): «New, great discoveries and inventions must, owing to the order of nature, occur only sporadically, they cannot, therefore, form a stream growing as evenly as the growth of population

and the increasing demand for consumption goods. As soon as the first mentioned stream shows a decreasing tendency, there will, however, be a breach in the progress, and this in my opinion, is the proper cause of the business cycles and the crises I do not mean, of course, that prosperity will come as soon as we have learned new methodes of production. . . . The new inventions must at first *ripen*, technically and economically, and gain the confidence of the business world, which of course will require a shorter time when an optimistic state of mind is prevailing on the market.»

Wicksell was of the opinion that accumulation of liquid capital in the form of stocks of wares was the most important part in this economic process of ripening, which must be fulfilled before the inventions could be utilized. We have mentioned above (pp. 58—59) that investigations recently made do not sustain the assumption that such a laying up of stocks regularly takes place before revival begins. Then, of the idea of the economic and technical ripening, on which Wicksell lays so much stress, practically nothing more is left than that a general confident state of mind must be prevailing if the inventions shall be utilized, or in other words: inventions must wait until recovery has begun before they are taken into use.

That inventions often must wait until the prospects of profitableness have become better before they are utilized, has also been pointed out by *Pigou*. We will quote from his *Industrial Fluctuations*, p. 44: «It is not the making of an invention that sets up the reactions .. in the industry. . . . it is the *adoption and actual working* of the invention or discovery that does this. . . . there is evidence that in slack periods technical devices and improvements accumulate in the sphere of knowledge, but are not exploited till times improve.»

Consequently both Wicksel and Pigou in reality regard great inventions as a quite passive factor, that adjusts itself to the periodicity in economic conditions which is produced by other factors. In their opinion, therefore, inventions cannot generate cycles, but only reinforce the amplitude of cycles already present.

In opposition to these two authors *Schumpeter* regards inventions or more generally expressed all «innovations» (*Neuerungen*)¹ as the active factor in the business cycle. Schumpeter assumes that the plans for such innovations accumulate during depressions and that it is their actual

¹ In his paper «The Explanation of the Business Cycle» in *Economica* 1927, p. 295, Schumpeter defines Innovations in the following way: «By innovations I understand such changes of the combinations of the factors of production as cannot be effected by infinitesimal steps or variations on the

adoption from the side of one courageous business that leads to the turnover from depression to revival, because other concerns can and must follow collectively when one gives the example.

All these authors seem however to ignore a factor that will be of much importance with regard to the question of the point of time at which an invention should be utilized, namely the amortization and replacement of the machinery already in function. We shall try to explain what factors will influence the utilizing of new inventions in several cases.

1) Firstly we will presume that the invention concerns the production of a commodity that is not previously in use. We presume further that the utilizing of the invention requires the construction of new factories. It is evident that it would be much easier both to procure the necessary capital and to introduce the new commodity on the market during a period of revival or prosperity than during a depression. It is, therefore, very probable that such inventions in most cases will have to wait for better business conditions before they are utilized.

2) Secondly, we presume that the invention concerns the utilizing of a new source of producing power, for instance electricity. As *Schönheyder* has pointed out (l. c. 1927, pp. 69—70) is characteristic of such inventions that they do not lead directly to a growing demand for producing power in industry. (Indirectly they may of course do so if the new power can be delivered at a much lower price than the previously used.) If the new powerproducing machines shall make their way into industry, they must therefore in most cases replace old works. But here they meet with an obstacle: the amortization of the old works. The new works shall not only replace the old ones, but preferably also be acquired on the basis of reinvestment. The process of amortization ought at least to have been partly fulfilled before the replacement takes place. Therefore the presence of old, obsolete works in most cases forms a hindrance for the immediate utilizing of new machines. This has been pointed out by several authors.¹

margin. They consist primarily in changes in methods of production and transportation, or in changes in industrial organisation, or in the production of a new article, or in the opening up of new markets or of new sources of material.»

¹ Compare *Marx* II, p. 141: «Einerseits bildet die Masse des fixen Kapitals, die in einer bestimmten Naturalform angelegt ist und innerhalb derselben eine bestimmte Durchschnittslebenszeit anzudauern hat, einen Grund der nur allmähigen Einführung neuer Maschinen etc., und daher ein Hinderniss gegen die rasche allgemeine Einführung der verbesserten Arbeitsmittel.»

Compare also H. v. *Beckerath*, *Technischer Fortschritt und Kapitalver-*

Of course it will not be necessary to wait until the old works are wholly amortized before the new works are taken into use. When the new works are more technically developed and cheaper in use, there will, already before the amortization process of the old ones is fulfilled, come a stage when it is profitable to purchase the new machines even if some loss must be written off the old ones. The condition for the profitableness of the utilizing of the new machines before the old are fully amortized, is consequently that the new machines work so much cheaper that they in addition to the amortization of their own value can amortize the loss incurred on the old machinery. The problem of determining the point of time at which it will be profitable to purchase a new, technically more perfect machinery is developed in mathematical form by *Rye-Clausen*.¹

We see that an invention in the present case may lead to a shortening of the period of replacement of the old machinery. The utilizing of the new machinery will to a great extent have a tendency to adjust itself to the periodicity of the existing reinvestment cycles, but partly it will disturb the rhythm.

On the other hand the detection of a new producing power no doubt will have the effect that the cycles will have a greater amplitude, it will in other words act as a maintaining factor. We may here quote Schönheyder (l. c. 1927, p. 70): «On the other hand the new producing power (electricity) and the prospects that it opens up will to a great extent influence the force of the demand for reinvestment. Several concerns, which perhaps in other case would have thought it advantageous to continue with their steam works for a considerable time, now will take up the new method of producing and scrap their old machines.»

3) Thirdly we presume that the invention concerns a new method of producing a commodity already on the market. We presume further that

schleiss usw. in Kapital und Kapitalismus, Band II, p. 336: «Kapitalverschleiss als Bremse In der Tat wirkt der Umstand, dass der technische Fortschritt mit Kapitalverschleiss verbunden ist, hemmend auf den ersteren zurück.»

Compare Erich Schiff, Kapitalbildung und Kapitalaufzehrung usw. Wien 1933, p. 75, Note: «Der Einfluss, den die «Determinante Vergangenheit» auf die Struktur der Wirtschaft dadurch ausübt, dass ein beträchtlicher Teil der Produktion stets mit Mitteln und Apparaten weitergeführt wird, die im gegebenen Moment vom rein technischen Standpunkt nicht die rationellsten sind, deren Ersetzung durch technisch vollkommeneren jedoch wirtschaftlich verfehlt wäre»

¹ Compare: Bidrag til en rationel Bestemmelse af Tidspunktet for Fornyelsen eller Ændringen af et producerende Anlæg. København 1932.

the new method requires quite new factories, so that an adjustment of the old ones is not possible.

It is evident that the existing concerns in the branch will have many advantages to the utilizing of the new producing method in relation to new starting firms. The older firms will have experience in the methods of producing the commodity in question, they will be able to purchase raw materials at the lowest price, and they will know the purchasers. This last factor will be of special importance with regard to commodities that have an inelastic demand, so that a lower price will not lead to a considerable increase in the sale.

On the other hand, however, the old firms will in many cases have an important drawback in their old machinery. By a premature use of the new method of production the existing firms may incur a loss on the old machinery that surpasses the gains by the cheapening of production. New starting firms, therefore, will have the great advantage that they have no old machinery that must be taken into account. In many cases this advantage will no doubt be so great that it outweighs all other advantages that existing firms possess in relations to new ones.

Already in 1912 this fact has been pointed out by Robert *Liefmann*, (*Theorie des Sparens und der Kapitalbildung in Jahrbuch für Gesetzgebung, Verwaltung und Volkswirtschaft im Deutschen Reich 1912*) who especially lays stress on the risk of overcapitalization that will result from the fact that new firms do not need to take into account the losses which already existing firms may suffer by the premature utilization of new methods of production. Liefmann regards this as an important defect of construction in the capitalistic system.

When at first a firm has taken up a new way of production, other firms in the same branch of industry will be compelled to do the same. They are then faced by a «fait accompli» and cannot wait for the point of time when theoretically it would be most profitable to replace their machines. When a new and better method is adopted in rivalling firms, the old machinery has already lost much of its value.

We may conclude that whether it will be new starting concerns or old ones that at first will utilize a new invention will depend on the relative advantages of the two groups. If already established firms introduce the new methods of production, one may expect that they as much as possible will adjust the introduction of the new machinery to the reinvestment cycles.

3. *Of the Losses in the Value of Old Machinery which is a Consequence of Technical Progress.* We have seen that the appearance of new, technically more perfect machinery will lead to a decrease in the value

of elder machinery, a decrease that the firms will have to write off as loss.

Even the steady technical progress will be accompanied by such a loss. That part of the amortization percentages which surpasses what is necessarily due to physical depreciation, is the price that must be paid for progress. With regard to the steady technical progress it is, however, probable that the advantages of the new machinery regularly will be so great that they more than compensate for the loss suffered by the premature replacement of old machinery. Even if concerns must introduce new machinery before the amortization of the old one is ended, this will be advantageous for the concerns if the new machinery has so low operating costs that the saving on account of this is sufficient to cover the remaining amortization. If, however, the concerns through competition are forced to purchase new machinery before this moment, they may suffer a real loss. It is then a doubtful question whether these losses, which individual firms sustain, also are losses felt by the society as a whole or if the losses on the part of individual firms are always compensated for by proportionate or greater advantages on the part of other firms.

Robert Liefmann tried to demonstrate that the premature introduction of new methods of production may lead to a loss for the community as a whole. This question has been very much under discussion in the recent German and Austrian literature.¹

I think that Liefmann answers this question on too narrow a basis when only taking into consideration the capital accounts of the firms which are directly involved. A lowering of the cost of production in one branch of industry will of course influence also other branches indirectly and may lead to increase or decrease in the capital values in these other branches. Further, other factors than the capital accounts of the industry might be taken into consideration, such as for instance the advantages of lower prices for the consumers.

At any rate it cannot be denied that a too rapid introduction of an invention often leads to a greater loss than advantage for the concerns directly involved, and it is possible that a less rapid introduction of the invention in many cases would be an advantage for the society as a whole.

The losses sustained in this way by individual concerns or by the community as a whole is a typical consequence of the waste of productive powers that accompanies free competition. In the opinion of Liefmann

¹ Compare for example Fritz *Machlup*, *Industriekredit und Kapitalbildung*, Wien 1931, p. 58.

Compare also Erich *Schiff*, *Kapitalbildung usw.* Wien 1933, pp. 52 sq.

this is the only case where the struggle of the individuals for the greatest possible profits, even supposing that they had a perfect knowledge of the economic conditions (especially supposing that they were in no error regarding the demand for capital in community) might come in opposition to the interest of the community of producing the greatest benefit for all its members.

It is evident, as also *Beckerath*¹ points out, that this loss might be evaded in an economic system where the state were the only «Unternehmer» or where the different branches of industry and trade were united by strong organisations. In such a system it would be possible, when a new machine should be introduced, to take into consideration the effect it would have on the already existing capital. The management would then be able to postpone the introduction of the machinery until the amortization of the old machinery was sufficiently advanced. This is the well known policy of many economic combinations (trusts and cartells). We may here quote *Liefmann*: «Nichts anderes als eine Anpassung an diese theoretischen Grundsätze ist auch die bekannte Vereinbarung des internationalen Kartells der Flaschenfabrikanten, die einen Fonds von 12 Mill. MK. zum Ankauf der Owenschen Patente einer Flaschenblasmaschine aufbrachten, in der Absicht, die allmähliche Ersetzung der alten Einrichtungen durch die neuen sich nicht zu schnell, vielmehr nach einem einheitlichen Plane vollziehen zu lassen.» (l. c. p. 1623).

Many theorists have emphasized the hostile attitude that monopolies often show towards new inventions. It is, however, evident that a monopoly regularly will have the same interests as individual competing firms in the utilizing of new inventions, provided that the old machinery is amortized up to the point where the advantages of the new machinery outweighs the loss on the old machinery. The hostility of the trusts therefore should in reality only bear upon the *premature* introduction of inventions, not on the inventions themselves.

Edwin G. Eckel seems to disregard that all machinery must be replaced sooner or later, when he observes (*Coal, Iron and War*, London, p. 223): «In the absence of competition there would be no incentive to work out a new process, and every incentive not to apply it if it happened to be invented. For in every case a new process means writing off a part of your fixed capital and scrapping existing plant. If you have no competition there is no reason why you should accept this

¹ Compare H. v. *Beckerath*, *Technischer Fortschritt und Kapitalverschleiss in freier Konkurrenzwirtschaft und gebundener Wirtschaft. Kapital- und Kapitalismus II*, pp. 329 sq.

certain loss.» The right point of view is emphasized by *Bouniatian* (*Les Crises Économiques*, p. 388, Note 2): «Les pertes causées par les progrès de la technique aux capitalistes a provoqué depuis longtemps l'hostilité de ces derniers. Celle-ci s'est manifestée dans ces derniers temps par la tendance des grandes entreprises à acquérir les brevets de perfectionnement pour retarder leur emploi jusqu'au moment qu'elles jugent favorable, lorsque ces perfectionnements ne peuvent plus déprécier les dépenses antérieures.»

4) *Other Types of Shocks.* Besides inventions many other sorts of sudden changes in economic dates may influence reinvestment cycles. We shall here confine ourselves to mention some of the most important cases.

a) Physical destruction of great masses of capital. Such destruction may be due to wars, accidents, such as fires, earthquakes, inundations etc. A sudden destruction will then regularly be followed by a concentrated restoration. Whether such a catastrophe shall have a reinforcing or a destructive influence on the reinvestment cycles will obviously depend on which stage of the cyclical movement the catastrophe sets in. Beside their influence on already existing reinvestment cycles, such accidents may of course also start new ones.

As an example of such destruction of physical capital on large scale we shall mention the sinking of mercantile ships during the great war. In the statistical part of this book we have among other things analysed the effect of this destruction on the Norwegian mercantile fleet. Of all nations was Norway the one which suffered the relatively greatest loss of tonnage. A considerable part of the lost tonnage was rebuilt in the years of 1920 and 1921. In consequence, the age distribution of the Norwegian fleet in the succeeding years shows a very strong concentration about the ships constructed in the said years. This concentration was so strong that it no doubt would have started a distinct reinvestment cycle even if it had not fitted in with already existing reinvestment waves. This top of construction of ships in the years of 1920 and 1921 coincided, however, with an already existing cyclical movement in the reinvestment and reinforced it considerably.

b) An imperialistic war or a civil war will not only influence the reinvestment by concentrated capital production after the war to compensate for the losses. Also during the war several branches of capital producing industries both in the belligerent and in the neutral countries may be subject to considerable expansion. Especially if the war is of long duration, it will have the effect to call into existence new industries in countries which previously were supplied with industrial commodities

from one of the belligerent countries. This was, as is well known, the effect of the Napoleonic wars on the countries on the European continent, and it was the effect of the world war on the oversea countries. We may in this connection mention the many new shipbuilding yards which during the great war were established around the world.¹

It is obvious that also regarding this increase of the capital production during the war it will be of significance whether it coincides with a top in the existing cyclical movement in the reinvestment or not.

5) *Structural Changes.* We have previously dealt with changes in the economic dates which have relatively short duration. Other changes will, however, have a more permanent character, and have the effect that whole branches of industry or trade in a country lose their importance, and others are called into existence.

Such structural changes may be due to technical progress which may change the relative importance of a branch of industry. Further, they may be due to the opening up of new countries and the discovery of new sources of raw materials. We may here for instance mention the influence of the cultivation of the American prairies on the European grain production, and how the technical development and the detection of new and richer strata of ore in other countries have had the effect of reducing the significance of the Scandinavian iron works. Structural changes may also be due to the adoption of new trade routes and to changes in trade policy. We may in this connection mention the repeal of the British Act of Navigation and its significance on the Norwegian shipping industry, and how the present tendency of protection in most countries changes the relative importance of the exporting industries contra the industries working for the home market.

Especially in a country that in itself has not the necessary qualifications for self-supply, and which therefore is dependent on the world market for selling its wares or services, the population will for short intervals have to face structural changes in industry and trade. The population will then have to choose between two alternatives: either to adapt themselves to the new conditions, i. e. prepare themselves to a chronic poverty or open up new ways of employment. It will depend on the character of the population which of these two alternatives will be chosen.

Structural changes of this sort will of course be accompanied by a

¹ It is not impossible that this factor, that the non-belligerent states had their greatest investment period during the war and the belligerent countries after the war, to a great extent explains the different phases of the business cycle in different countries after the war.

very great per cent of falling off in the reinvestment in those branches of industry that lose their importance. If, however, new branches of industry are developed in stead of them, investment in these new branches will often be relatively concentrated because of their rapid expansion. Because this concentration in the investment in the new branches, such as we have pointed out above, will have a tendency to adjust itself to already existing reinvestment cycles, we obviously have a factor here that may maintain the reinvestment cycles.

It is no doubt such structural changes *Schumpeter* is thinking of when he emphasizes that it is characteristic of the business cycle phenomenon that every cycle indicates a breach with the previous development.¹ *Schumpeter* has here pointed out a very significant factor. These structural changes may be an important source of maintenance for the business cycles. In opposition to *Schumpeter* we shall however in the following try to show that it is not very probable that the periodicity of the cycles is produced by these structural changes.

¹ Compare *Theorie der wirtschaftlichen Entwicklung*, 1926, p. 324: «Jene «Gegenbewegungen» hemmen die Entwicklung nicht bloss, sie machen *dieser* Entwicklung eine Ende. . . . die Entwicklung, die dann wieder einsetzt, ist eine neue, nicht einfach die Fortsetzung, der alten.» P. 332: «. . . Andere Vorgänge haben das Besondere, dass sie die industrielle Entwicklung aus ihrer Bahn ablenken. . . Damit endlich sind wir bei der Sache. Die Krisen sind Wendepunkte der wirtschaftlichen Entwicklung.»

CHAPTER 4. TO WHAT EXTENT CAN THE BUSINESS CYCLES BE EXPLAINED BY THE REINVESTMENT CYCLES?

§ 1. Introduction.

In chapters 1 and 2 we have shown how cycles in the reinvestment may be generated as an «echo phenomenon». As these pure reinvestment cycles would have a strong tendency of being damped, we pointed out in chapter 3 some factors which might explain the maintenance of the cycles. In doing so, we confined ourselves to factors directly influencing the production of capital goods. It is, however, evident that also many other factors, as for instance monetary and psychological factors will influence the business cycles. As, however, the purpose of the present work is not to describe the business cycle phenomenon in its totality, but only to analyse one possible theory among many others, it would lead too far to discuss all factors that may cooperate in generating and maintaining the cycles.

In this chapter we shall therefore try to show that the reinvestment theory delivers a *plausible* solution of the three main points in the business cycle theory, namely:

- 1) the turn-over from depression to recovery
- 2) the turn-over from prosperity to recession
- 3) the periodicity of the cycles.

§ 2. The Turnover from Depression to Recovery.

a) *The explanation of the reinvestment theory.* The turnover from depression to recovery is one of the things that it has been most difficult for the various business cycle theories to explain in a satisfactory way. We see also that it is on this point that the theorists preferably attack the theories of others.

The theory of the pure reinvestment cycles will here, in our opinion, deliver a satisfactory explanation, as it is able to explain not only *why*, but also *when* and *how* the turnover takes place.

1. *Why the turnover takes place.* We have pointed out above how, after a concentrated primary investment — in casu during a previous period of prosperity — and provided that the time form of the replacement shows a normal distribution (or another concentration) about a typical age of reinvestment, the reinvestment activity in the community after some years will show an even and steady tendency to increase. This increase in capital production because of pure reinvestment cycles will then be followed by a further increase in the investment, as secondary cycles both in reinvestment and in new investment will be released and will form the basis of a general prosperity.

2. *When the turnover will come.* The turnover will take place when the normal (typical) time of replacement for the great number of capital instruments is near. At that time the process of amortization will also be completed.

3. *How the turnover takes place.* If the turnover from depression to recovery shall be called into existence because of an increase in the reinvestment activity in the community, it is necessary that a great number of concerns simultaneously determine to replace their machinery.

The theory of pure reinvestment cycles explains how such a determination can take place simultaneously from a great number of concerns which are acting *independently of each other*. In order to produce an increase in the capital production nothing more is required than that every individual management resolves to effect the replacement of its machinery at the normal age of reinvestment. The concerns may act without being in touch with each other.¹ Consequently we do not need special impulses to explain why the concerns simultaneously decide to reinvest.

In order to explain recovery we need not refer to the psychic infection. The turnover would take place even if the concerns were acting entirely independent of each other. But of course the mob psychology plays a great role in increasing the rate of growth during the boom when it has once commenced.

We may further notice that the resolution of reinvestment does not demand any determined, firm resolution on the part of the management of

¹ Of the opposite opinion is *Schumpeter*, compare *Theorie* etc. p. 335: «Würden die neuen Unternehmungen in unserem Sinne voneinander unabhängig auftreten, so gäbe es keinen Aufschwung und keine Depression als besondere, unterschiedbare, auffallende, regelmässig wiederkehrende Erscheinungen.»

the concerns (or eventually on the part of the banks) as is the case regarding resolutions of the starting of new concerns. On the contrary, the replacement of the capital instruments at the normal time is generally a current, every-day business, that does not require much attention on the part of the management. Even regarding great, precious, capital instruments it will often be determined beforehand through an old established practice *when* replacement shall take place.

It will not here make much difference whether the firm works mainly by its own capital or by borrowed capital. If the replacement requires the raising of loans, instead of loans repaid through the amortization, in most cases a renewal or prolongation of an existing credit relation will be the result. Lender and borrower are acquainted and trust each other. The firm applying for loan has then regularly existed so long that it has proved its ability to yield interest on and to amortize the invested capital. Even if the replacement is accompanied by an extension of the producing capacity, the raising of the loan will not meet with such difficulties as the raising of loans for the purpose of starting new concerns.

Neither is it necessary to presume an especially *optimistic state of mind* among the managers if the increase in the reinvestment shall take place. Replacement must to a great extent take place even if the future prospects of profitableness for the branch are not at all promising. If a concern wants to continue its existence, it will be necessary for it to replace its capital instruments when they are physically worn out. And if a firm shall not be driven out of the market by its competitors, it is necessary that it keeps the standard of its machinery intact. It must in other words replace the machines before they become obsolete. A general optimistic state of mind in a branch of industry will in most cases be due to the fact that the prospects of rentability have improved. The reinvestment theory does not presume that any improvement in the prospects have already taken place when the turnover sets in. On the contrary the theory explains why the prospects improves.

b) *Comparison with several other theories.* We will here consider the explanation of the turnover from depression to revival given by other theories as compared to the explanation given by the reinvestment theory. We will confine the comparison to theories which, like the reinvestment theory, search for the cause of the business cycles in factors concerning the capital production, but which, contrary to the reinvestment theory, put the main stress on new investment.

Fully realizing that it would be most satisfactory to prove how the turnover to recovery sets in automatically when depression has lasted for some time *Tugan-Baranowsky* tried to explain how the newly saved

means during the depression are accumulated in funds, because there will be some hindrances of their investment during the depression. Tugan argued that these funds of newly saved resources would ultimately, through their own weight, overcome the resistance, and press forward to investment in industry. His comparison with the condensation of steam in the cylinders of a steam engine, which, when the pressure is sufficiently strong, makes the stamps rotate, has become a classical illustration of an automatic recovery releaser.

In Tugan's statement it does not appear clearly whether this accumulation of funds during the depression shall be real, social saving, (which then only could take the form of stores of raw materials and finished consumption goods) or whether it only represents individual saving, an accumulation of purchasing power. The adherents of the theory have maintained both forms for saving.

Whether the saving may assume this form or the other, it is not easy to realize how the accumulation automatically may lead to a turnover in the business cycle. Concerning real saving during the depression in the form of stores of raw materials and consumption goods, we may refer to the quotations above (pp. 59—60) from J. M. Keynes «A Treatise on Money» Vol. II, London 1930. The results may be considered under three heads:

- 1) Due to the great expenses it is not very likely that such a laying up of stores will take place.
- 2) The available statistical material does not indicate that such a laying up of stores is taking place towards the end of depression.
- 3) Even if such stores were accumulated, it is not very likely that they would forward the turnover; a condition to this is, on the contrary, that the stores first are cleared away.

Concerning purely individual saving, an accumulation of purchasing power, it is not easy to see how this accumulation should produce any recovery. Tugan seems to be of the opinion that the cause of the new saving ultimately forcing itself into industry, is that it is deposited in such a way during the meantime, that it gives no interest.¹

This is, however, not correct. The individual saver may always be able to deposit the means so as to give him some income. Or, as *Spiethoff*

¹ Compare Studien etc. p. 243: «Das nicht angelegte Kapital bringt keinen Zins — es fungiert als Kapital gar nicht, hat keinen Gebrauchswert für seinen Besitzer. Je mehr solche nicht fungierenden Kapitalen vorhanden sind, desto energischer muss der Drang sein zur produktiven Anlegung des freien Kapitals.»

express it, the newly saved resources will during depression assume typical «Stockungsformen», whereby they are productive «sonderwirtschaftlich» as they bring interest to the owner, but from a social point of view they are not taking part in the production. These saved resources will then mostly be led back to consumption, either directly as state and communities make loans for consumptive purposes, or indirectly, as they are used to cover losses within existing concerns. In this case it is not easy to see how these resources may exert pressure to invade the industry.

We may of course realize that some of the saved resources, which are placed as deposits in banks during the depression may not be lent out again.¹ Here we must be aware that the banks during the depression consider their liquidity somewhat differently than during the prosperity, they need greater reserves to feel safe. It is, however, possible that in this way there may be an accumulation of funds in the banks, which they would like to lend. Furthermore, this might lead to a lowering of the interest rates. In this way the accumulation of funds may to some extent lead to an improvement in the rentability prospects and thus facilitate the transition to recovery. The question is, however, if this facilitation will be sufficient to produce the turnover. The turnover would have to take a starting-point within the banks. In order that the turnover should come, the leaders of the credit establishments, due to the difficulties in lending the deposits, would have to be more friendly towards the idea of financing new enterprises. It is clear, however, that the resistance which is to be overcome, is so great that far stronger means are needed to cause a change of the situation than an insignificant improvement in the rentability prospects. During depression the banks will distrust very much all new enterprises, and in lending out the question of safety will stand above all others.¹

Another theorist who also seems to think that the turnover from

¹ Compare Erich Schiff, *Kapitalbildung* etc. p. 31: «Das «Hängenbleiben» von bereitgestelltem Geldkapital in der Sphäre der Geldakkumulation.»

¹ Compare Spiethoff, Article «Krisen» in *Handwörterbuch der Staatswissenschaften*, Jena, 1925 p. 70: «In der Stockung staut sich das Kapital, und der Leihzins sinkt fortgesetzt, während die fest verzinslichen Papiere ebenso im Kurse steigen. Aber diese Ertragsverschlechterung des Leihkapitals führt nicht zu steigender feste Anlage. Steht diese doch nicht nur ebenfalls unter sinkendem Gewinn, sondern sogar unter Verlustgefahr, die durch Uebererzeugung und allgemeinere Neigung zur Preissenkung bewirkt werden. Daher die jedem Unternehmer und Erfinder bekannte Tatsache, dass in der Stockung das Kapital sich besonders misstrauisch und für neue Unternehmungen und Gedanken doppelt schwer zugänglich zeigt.»

depression to recovery may occur automatically is *Aftalion*. In opposition to Tugan who meant that the turnover was enforced by a surplus of free, saved resources, Aftalion explains the turnover in an appearing lack of consumption goods towards the end of the depression, because the machinery is not replaced to any sufficient extent during the depression. This theory is logically much more satisfactory, as it is based on a deeper knowledge of the problem of value and of rentability in a modern society. That the theory delivers a logically satisfactory explanation does not mean, however, that this explanation is the right one. As we have pointed out above (pp. 36—39) it is correct that the renewal of the capital instruments during the period of depression does not take place to the full extent; firstly because less capital instruments are ripe for replacement during the period of depression than what corresponds to the total depreciation of the capital of the society; and secondly because then the per cent of falling off will be greater than during prosperity. Another question rises however, if this leads to lack of consumption goods. Here we must firstly take into account that the great per cent of falling off in some disproportionately developed branches of industry and in some firms partly at least will be compensated for by forced rationalizing in other branches and firms. *Cassel* holds the opinion that the producing capacity regularly increases during the period of depression because of rationalizing.¹ Secondly, if the turning point should be generated by a lack of consumption goods, one must expect that especially the consumption industries would suffer from want of capital. It is, however, a matter of fact that the business cycle influences the «konsumferne» industries most seriously. Thirdly, if there should be want of consumption goods, capital destruction in consumption industries must be so great that it more than outweighed the decrease in consumption regularly taking place during the depression. The quantitative relation between these factors would then ultimately be decisive.

It is, however, a matter of fact that during a depression there is much unemployed producing capacity in most branches of industry. A considerable increase of production might therefore take place without making an expansion of the machinery necessary.¹

¹ Compare. *Theoretische Sozialökonomie*, Leipzig 1927, pp. 517 sq.

¹ Compare Bertil *Ohlin*, *Ungelöste Probleme der gegenwärtigen Krisis*, *Weltwirtschaftliches Archiv*, 36 Band, Juli 1932, p. 11: «... die Tatsache ..., dass die Depression durch starke Ueberkapazität in den meisten Industriezweigen charakterisiert wird. Diese Ueberkapazität wiederum macht es unsicher, bis zu welchem Grade eine Kosten- und Zinssenkung zur Anlage in neuem Sachkapital anreizen wird.»

It is therefore not likely that the explanation of the turnover from depression to revival is to be found in this point.¹

The difficulties in giving a satisfactory explanation of how the turnover to recovery takes place automatically as a consequence of the accumulation of saved resources or as a consequence of lack of goods, has had the result that later theorists preferably have tried to explain the turnover as influenced by more active forces outside the fluctuation mechanism itself (in a more restricted sense).

Typical is here the development which *Spiethoff's* business cycle theory has undergone. In his articles in *Schmoller's Jahrbücher* 1902, 1903 and 1909 Spiethoff pursues mainly the same lines as *Tugan-Baranovsky*, laying the main stress on the accumulation of free, saved resources during the depression and on the increasing need of capital goods, because the replacement is neglected during the depression. But while Tugan thought these forces to work quite mechanically, Spiethoff meant that certain «releasing factors», — such as for instance the utilization of new inventions, the opening up of new markets etc. —, were needed in order that the turnover should occur.

Later on Spiethoff puts the main stress on these releasing factors and the state of mind they produce at the managers, while the accumulation of free, saved resources is only considered to be of secondary importance. In his article «Krisen» in «Handwörterbuch der Staatswissenschaften» vierte Auflage, Jena 1925, he for instance says as follows (pp. 70—71): «Die letzte Ursache der Aufschwungsbewegung ist etwas *Seelisches* und nichts *Wirtschaftliches* . . . In der Stockung staut sich das Kapital, und der Leihzins sinkt fortgesetzt, während die fest verzinslichen Papiere ebenso im Kurse steigen. Aber diese Ertragserleichterung des Leihkapitals führt nicht zu steigender feste Anlage . . . Um Leitsterne für feste Kapitalanlagen zu schaffen, bedarf es kühner, wagender Männer, die grosse Teile ihres Vermögens und oft ihr Schicksal für die Durchführung einer Idee aufs Spiel setzen.»

¹ The idea that the capital destruction during the depression in a necessary «Bereinigungsfunktion» which in itself leads to conditions causing the recovery, has lately been attacked from several quarters.

Compare for example: Erich *Schiff*, *Kapitalbildung und Kapitalaufzehrung im Konjunkturverlauf*, Wien 1933, p. 138: «Wohl hat man darauf hingewiesen, dass unter bestimmten Umständen eine Selbstverschärfung der Depression eintreten kann, die zu sekundären Schumpfungerscheinungen führt, welche nicht mehr zum Prozess der Anpassung gehören.»

Compare *Ohlin*, *Ungelöst Probleme* usw. p. 19: «Anderseits liegt auf der Hand, dass es innerhalb des Liquidationsprozesses selbst nichts gibt, dass ihn beendet, wenn er «ausreichend» ist.»

Spiethoff has thereby in reality joined Schumpeter's «Führertheorie» in this point. Schumpeter bases his theory on the circumstance, that the difficulties which during the depression prevent investments in new enterprises (Neuerungen), to a large extent will be of such a nature that if only one «Unternehmer» would lead the way, the problem would be much more simple to others. Schumpeter then presumes that revival will come, because one single or some few daring Unternehmer manage to break the «statisch-Hedonische Bann», which during the depression has been lying over the economic life of society, and causes «eine energisch-dynamische Bewegung» as other managers then follow «in hellen Haufen».

In order to explain how the turnover to a recovery comes into existence Schumpeter has then, as we see, found it necessary to bring in the heroic manager, who is acting out of pure idealism, and to equip him with an immense surplus of power that he shall act as a «deus ex machina» according to the old classical example. It is obvious that Schumpeter in pointing out these non-economical (non-hedonistic) motives¹ has included factors far beyond the usual border lines drawn up for social economics. Schumpeter admits this when writing in *The Explanation of the Business Cycle*, *Economica*, 1927, p. 292: «The second kind of reactions is not gripped by our analytic machine — although of course their consequences are — unless we «put a new arm» to it, which is precisely what I have been trying to do since 1912» The only argument for seeking the explanation of one of the main points in the business cycle theory in such non-economic factors, must be that no better explanation is to be found in purely economic factors. The great attention which Schumpeter's theory has won may therefore be explained as an admission of failure as to the former attempts to give an automatic (mechanic) explanation of the turnover.

As previously mentioned, in our opinion the reinvestment theory will give a satisfactory explanation of how the turnover to revival may occur wholly automatically. The reinvestment will not have to overcome those difficulties which the new investment has met with; no heroic behaviour on the part of the managers is needed to make the reinvestment wave rise. Even the problem to obtain bank credit during the depression will not be the same obstacle to old concerns replacing their machinery as to new concerns. Bank loans for replacement of the ma-

¹ Compare *Entwicklung* p. 135: «Wägen sie (die kühnen Unternehmer) bei jedem Schritte die Intensität bestimmter Bedürfnisse gegen einen negativen Wert ab, der einer Unlust des betreffenden Aufwandes an wirtschaftlicher Tätigkeit entspricht?».

chinery instead of repayment of loans will, as pointed out, usually be a current affair.¹

Schumpeter seeks then the explanation of the turnover in the behaviour of new men and in the appearance of new concerns, while older concerns in his opinion by their actions only cause secondary cycles.² The reinvestment theory, on the other hand, explains the revival out from the resolutions of already existing concerns acting in accordance with established principles, and reduces the new men to play a more secondary rôle, because they, to a great extent, will rise with a rising business cycle, and not start it.

In our opinion, therefore, the reinvestment theory gives a more satisfactory and general solution of the problem of how the turnover from depression to recovery takes place than does the innovation theory of Schumpeter.

That the reinvestment theory here gives the correct solution is also indicated by the results of our statistical investigation of the reinvestment in the Norwegian mercantile marine.

That the general solution of the problem is to be found in the reinvestment does not involve, however, that Schumpeter's innovations may not occasionally start the recovery. We have previously mentioned that *Liefmann* has pointed out the advantages which new concerns possess in the utilization of a new invention because they do not need to pay attention to the amortization of capital which is already invested. New concerns, therefore, need not wait until normal reinvestment time has elapsed for the old machinery, before they introduce new machines.

¹ Compare Oskar *Morgenstern*, *Qualitative und Quantitative Konjunkturforschung*, Zeitschrift für die gesamte Staatswissenschaft, 85. Band 1928 Heft 1, p. 72: «... dass *Pigous* Problem ähnlich liegt, wie das *Schumpeters*, das aber beide, charakteristisch genug, nicht ganz durchgreifend behandeln. *Pigous* Geschäftsmann geht ebenso wie *Schumpeters* Unternehmer zur Bank um Kredit, der eine mit besonderen Erwartungen, der andere mit dem Plan einer neuartigen Kombination von Produktionsmitteln. Beide müssen den Bankier überzeugen, und in dem Sinne kommt es nicht auf sie an, sondern auf den Entschluss der Bank, ihnen Kaufkraft zur Verfügung, zu stellen. Der Bankier macht also auch eine Prognose und seine Entscheidung ist der eigentliche kausale Faktor.»

² Compare *Schumpeter*, *Explanation etc.*, p. 307: «They (the banks), not only finance innovators' or entrepreneurs' demand, but also the demand of other people who simply want more credit because they see prices rise. They are even specially willing to give it to those people, for they are their old customers. Hence, they help the coming up of a secondary wave of the boom to which, although it also increases forced saving, it is impossible to attribute the function of the «primary wave».

There may therefore be a possibility that occasionally recovery may be started by new men when new, and especially epoch-making production methods appear in the market.

§ 3. The Turnover from Prosperity to Recession.

Under this head we will see how the reinvestment theory may help to the understanding of the turnover from prosperity to recession.

We may take our starting point in the discussion between the professors *Clark* og *Frisch* in *Journal of Political Economy* 1931—32. In «*Studies in the Economics of Overhead Costs*», 1923, p. 390, Clark had shown the connection between capital production and the rate of increase in consumption. Clark makes the observation that in spite of the fact that maximum in capital production regularly occurs before maximum in consumption during the business cycle, the consumption is leading all the same, because capital production is depending on the rate of increase of consumption, and not on its absolute size, and because this rate of increase of consumption will be greatest about one-quarter of a period before the maximum point is reached in consumption, and simultaneously with the maximum in the capital production. Professor Clark and several other theorists were of the opinion that this connection between capital production and consumption is sufficient to explain the turningpoint from prosperity to recession. The objections of professor Frisch we may resume in two points:

1) It is not correct that capital production depends on the rate of increase of the consumption alone. This is only correct regarding one part of the total investment, viz. new investment. The other part of the total investment, the reinvestment, will depend on other factors.

2) The connection between capital production and the rate of growth of consumption is in no case sufficient to explain the turningpoint from prosperity to recession, because this is only one equation to determine two unknowns, namely capital production and consumption. The system therefore is indeterminate.

In the system, consequently, there is needed one additional condition which explains why the rate of increase of consumption ultimately will decrease. In his paper «*Propagation Problems and Impulse Problems in Dynamic Economics*», 1933, professor Frisch makes the system determinate by introducing a new condition determining the growth of consumption, namely, the idea, originally advanced by *Walras*, of an «*encaisse désirée*», i. e. the need of the public for cash. The idea is that as production is growing a point will be reached where, due to the stiffness of the monetary system and due to psychological factors etc., a certain tight-

ning in the money supply will occur. It is likely that this will tend to diminish the rate of increase in consumption.

This is of course a possible solution of the problem. Another and perhaps better solution would be to seek the lacking condition in relations concerning *the reinvestment*. Professor Frisch has not put up this solution, though one might have expected him to do so, as he points out that total capital production consists of two parts, viz. new investment and reinvestment, of which only the first one may be said to depend on the rate of increase in consumption. Concerning reinvestment Frisch states in this connection only its dependence on the depreciation and on the total size of consumption. This simple supposition makes, however, the whole case more intricate. If consumption is increasing, but at a constant rate, reinvestment will increase evenly, and new investment will decrease. In order that the total capital production shall decrease it is no longer a sufficient condition that the rate of increase in consumption is decreasing. In order that a turnover shall come, it is necessary that new investment is decreasing so strongly that it outweighs the increasing reinvestment. And, as Clark points out, this supposition that reinvestment depends on the depreciation is not in accordance with reality.¹

If we now presume that reinvestment (or part of it) will be independently determined in relation to consumption, viz. by the investment during preceding business cycles, we have to consider the following factors in our system:

1. Total capital production, consisting of two parts.
 - a) Replacement, determined by the pure reinvestment cycles.
 - b) New investment determined by the rate of increase of consumption.
2. Consumption, which is again dependent on total capital production.

We might then presume that a revival will take place in the following succession: Recovery starts in capital production by pure reinvestment waves. This causes an increase of consumption. The increase of

¹ Compare J. M. Clark, *Capital Production and Consumer-Taking: A Further word*. Journ. of Pol. Ec. 1932, p. 692: «One further qualification should be made. As already noted, instead of «depreciation» it would be really more accurate to speak of the need for replacements; and it is not strictly accurate to assume that this is necessarily increasing because the volume of equipment is at present growing. The need for replacements depends on the volume of equipment constructed twenty years ago — if its life is exactly twenty years — and this may have been increasing, decreasing, or standing still. The effect of this fact is further blurred by the fact that different units will wear out after different periods of service.»

consumption is followed by an increase of new investment, the last one increasing in relation to the rate of increase in the first one. The increase in new investment then causes a further increase of the consumption etc. etc.

The turnover to recession might be explained in the following way: the reinvestment, which will be independently determined by the pure reinvestment cycles, will be the first one to fall off. We have then two factors left: new investment and consumption, which are mutually dependent on each other, in so far as new investment is dependent on the rate of increase in consumption. When one of the factors, which determined consumption, namely reinvestment, falls off, it is likely that this will tend to diminish the rate of increase in consumption. Those two factors — new investment and consumption — are not able to keep *perpetuum mobile* in work, and the whole system collapses.

A very usual explanation of the turnover from prosperity to recession is that it is due to a *deficiency of capital*. This explanation is pointed out especially by the theorists who presume that the turnover to recovery is due to accumulated funds of free capital. It may in that case be logical to presume that the turnover to depression is due to exhaustion of these funds, and that the running (voluntary and/or forced) saving is not sufficient to cover the strongly growing demand.

A whole series of authors agree that the turnover is due to a deficiency of capital, but they disagree very much as to what this deficiency, which manifests itself in «Geldklemme», really and properly implies.

As usual Tugan-Baranowsky does not give any explanation. He is only stating (Studien etc. p. 246): «Die Eisenbahnbauten könnten aber nicht fortwährend in demselben Umfange, wie zu Zeiten des Aufschwungs, fortgesetzt werden — dazu fehlt einfach das Kapital.»

Compare Spiethoff (Die äussere Ordnung des Kapital- und Geldmarktes, Schmollers Jahrbuch, 1909, p. 949): «... gipfelt die Ueberzeugung in den technischen Produktionsmitteln und gewissen langdauernden Gebräuchsgütern (Wohnhäusern, Eisenbahnen usw.). Diese sind unverkäuflich, weil es an Erwerbskapital fehlt, womit sie allein gekauft werden können. Diesem fehlenden Kapital entspricht in der konkreten Güterwelt ein Fehlen der Komplementärgüter der Produktionsmittel, das sind die zu ihrer Verwendung nötigen Arbeitskräfte und die zu deren Gewinnung nötigen Genussgüter.»

Compare Robertson (Banking Policy etc. p. 90): «... the actual «crisis» may be correctly described as due to a «deficiency of capital» in the sense of a deficiency of the activity lacking». Comp. p. 93: «.. it

is an error to identify the «shortage of capital» which precipitates a crisis of the constructional type with a shortage of stocks of consumable goods (as Spiethoff appears to do).»

It is, however, possible that we in the conditions investigated here may find a better — or in any case supplementary — explanation of this «Geldklemme». Our statistical investigation regarding reinvestment cycles in the Norwegian mercantile marine shows that reinvestment regularly is dominating in the first part of a rising business cycle, and that new investment is predominant later on.

According to this we may assume that capital production will change character in course of the business cycle: In the beginning the capital production will take place preferably at the expence of older, solid concerns, and financially it will be very well funded by amortisation — and new-construction funds. The rentability of the investments may seem certain, as a continuation of an existing concern is involved. Even if loans are made, these will not, as mentioned before, meet with any difficulties, as the question mostly is about renewal and prolongation of existing credit conditions for the benefit of older clients. As the boom is progressing the banks, on the other hand, yield credit to purposes which economically are not so well funded. They yield loans to capital production, the rentability of which, to a great extent, is dependent on a chronic prosperity. Ultimately even solid banks may be misled to the financing of mere swindle enterprises.

It is then very explicable that, at the first signs that the climax is reached, panic sets in within the banking world; and that further credit extension, to accomplish commenced capital constructions often are refused, because the banks now realize the bad quality of these newly established concerns.

§ 4. The Periodicity of the Business Cycles.

1) *What is meant by periodicity?* The term periodicity is used in business cycle theory in several meanings. Firstly, there are some theorists who thereby indicate that the business cycles return with a definite, strictly unchangeable periodical length. Thus *Jevons* theory is well known, which tried point out a connection between the crises and the appearance of solar spots, and thereby explain the cycles as «bound» fluctuations, which must reappear with the same regularity as the astro-nomic phenomenon to which they are connected.

W. C. Mitchell points out (*Business Cycles* pp. 377—378) that it does not conform with usual scientific terminology to use the term «periodicity» about other fluctuations than those which reappear with such a mathema-

tical precision, with «a definite time interval». As, however, the distance between the actually existing business fluctuations (measured from top to top) is far from regular, we ought not, in the opinion of Mitchell, to use the term periodicity about them.

Most of the theorists have, however, stuck to the term periodicity even after they realize the futility of all attempts to show that the cycles reappear with strict regularity. The theorists have then usually passed over to the other extreme and will by the term periodicity express nothing but the tendency to elapse in waves, viz. that depression follows after prosperity, and prosperity follows after depression.

Periodicity does not then indicate more than what is indicated by «fluctuations» or «waves». Compare *Tugan-Baranowsky*, Studien etc. p. 233:

«Die kapitalistische Entwicklung ist periodisch in dem Sinne, dass sie sich aus aufeinanderfolgenden Epochen des Aufschwunges und des Niederganges, der Blüte und der Depression zusammensetzt, dass ihre Laufbahn einen Zyklus bildet»

Compare Joseph *Schumpeter*, Theorie der wirtschaftlichen Entwicklung, 1926, pp. 319—320: «Mit «Periodizität» kann man zwei Dinge meinen. Einmal die blosse Tatsache, dass jedem «Aufschwung» eine «Depression» folgt, jeder «Depression» ein «Aufschwung». . . . Sodann die konkrete Länge des Zyklus: Das aber kann keine Theorie ziffermässig erklären, weil das natürlich immer von den konkreten Daten des Einzelfalls abhängt.»

The distance between those tops of the business cycle which directly may be observed in actual material, will however not be decisive as to the correctness in using the term periodicity in connection with business cycles. Firstly we must be aware that those waves which can be observed directly in the curves for raw data mostly are the result of a cumulation of several cycles of different periodical length. Every attempt to calculate the distance between all the tops observed in the material, without paying any attention to their belonging to longer or shorter fluctuations, must necessarily be quite meaningless. (This is, however, just the method *Mitchell* is using in his *Business Cycles*.) But even if we try to discern between fluctuations of different length, we will get an incorrect impression of the regularity, if we only observe the tops or the bottom points, such as they may be regarded directly in the actual material. Owing to the cumulation of several fluctuations of a different periodical length, these top- and bottom-points will be displaced in relation to each other. Only after a decomposition of the various cycles it

is possible to determine the distance between the top- and bottom-points. If this is done it will appear that the regularity of the fluctuations is much greater than what the original data indicated.¹

Secondly we must be aware that even if the periodical length in the decomposed series shows some irregularity, we may still in the swinging mechanism find a definite tendency towards a repetition of the cycles with a mathematically precise periodical length, a tendency which, for various reasons, is not always realised in the economic life. We have mentioned above how different shocks, which constantly will influence the swinging mechanism, on one hand may lead to a maintenance of a damped, cyclical movement, and, on the other hand, may produce some irregularity in the swinging period, because several of the factors here involved will have a certain elasticity.

2) *Explanation of the periodicity.* As we have pointed out in the preceding passage, it may be justifiable to use the term «periodicity» about the business cycles, when we understand the term as a *tendency* to return with precise, definite periodical length.

This periodicity may then be understood as a consequence of a certain inertia in the system, with the result that, when put into motion, it needs some time to complete a swinging motion. The periodicity is a consequence of the structure of the swinging mechanism. As a metaphor we may mention that every swinging of a pendulum put into motion will always take the same time. If we kick the pendulum, the only consequence is that the amplitude becomes greater; the swinging time will remain unchanged.

It is obvious that the business cycle theories which put the main stress on psychological factors — as for instance most monetary theories do — hardly can explain how such regular «lags» come into existence. (Nothing is more certain than the fact that people react more rapid and slow according to the strength of the motivating factors.) It is therefore plausible that the explanation of the periodicity preferably is to be found among the technical, and not among the psychological factors.

This periodicity, this rhythm in the business cycle will then have a satisfactory explanation in the reinvestment theory. As already pointed out, the pure reinvestment cycles are due to the fact that a large quantity of capital goods is to be replaced at regular intervals. Decisive to the periodical length is then the normal reinvestment period for the capital goods. We have shown that the normal reinvestment period, above all, will depend on the technological factor, the wearing out. Capital goods will

¹ Compare several papers of Ragnar *Frisch* on the decomposing of time series.

be replaced when they are so much worn, that it is profitable to purchase new ones. Also economic factors are involved here.

As pointed out before, definite customs will be established as to the time for replacement of the capital goods. And these experiences will on the other hand be decisive as to how solid and for how long function time the capital instruments are built. These factors will have the effect that the reinvestment in the community will show a certain inertia. The reinvestment waves will have a certain stability in the midst of all the other unstable factors which are involved in the business cycle phenomenon. The other factors therefore may be presumed to subordinate themselves to the reinvestment waves.

The reinvestment demand will, on the other hand, show a certain elasticity. Various shocks may lead to a certain displacement in the time for the reinvestment. The most important thing here is that the reinvestment time will be somewhat shortened when especially revolutionizing, new inventions appear in the market. But there will always be certain limits to this displacement, so that it may well explain a certain irregularity in the periodical length, but it will not lead to a total disturbance of the rhythm.

3) *Cycles with different periodical length.*

Even when the business cycle theory had left the old problem conception which conceived the «crises» as the examination object, and had turned to treat the business cycle as a whole, the theorists were for a long time only talking about the business cycle in general. If any of these older theorists mentioned any definite periodical length, the period was almost always 7 to 10 years. (Comp. Tugan-Baranowsky, Aftalion, Lescure etc.) Generally they were only aware of this one cycle — the so-called ten-years cycle — which was especially prominent in those data which illustrate the economic development in Europe in the last half of the 19th century.

Now the economic science, however, has realized that many cycles of different periodical length are present in economic life. The movement we may observe in time series for economic data is consequently composed of several cycles of different duration.¹

4) *Which business cycles may be put in connection with the reinvestment cycles?*

Which cycles may be put in connection with the reinvestment waves, will naturally depend on the periodical length of the reinvestment waves, which further depends on which replacement age (or which replacement

¹ Compare Ragnar Frisch lecture «Konjunkturrene» in «Verdensøkonomien i efterkrigstiden». Universitetets Radioforedrag 1932.

ages) is typical for the various sorts of capital goods. This is naturally a question which cannot be answered satisfactorily till sufficient statistical material is found.

The available data, especially Kurz's mortality tables for physical property, indicate however, that many various sorts of capital goods have a typical replacement age about 8—9 years. It is therefore logical to presume that the replacement is one of the causes determining the so-called 10 years cycle (whose periodical length regularly will be about 8—9 years).

From the assumption of the ten years' life time of the capital instruments the reinvestment is put in connection with these 10 years cycles for example by Marx, Pigou and Schönheyder.¹

As pointed out during the investigation of an analogous relation concerning impulses (comp. p. 72) it is, however, not necessary for the conception of a connection between the reinvestment cycles and the business cycle in general that they have precisely the same periodical length. Thus reinvestment waves, with a periodical length twice the length of the business cycle, may very well generate the latter, as the primary investment from one period skips over the next cycle and influences the second next. As an example we may mention that Kurtz' data indicate that several types of capital instruments show a concentration of the reinvestment time about 18—20 years age. These may very well be presumed to influence waves of a periodical length of about 9 years. Our investigation of the reinvestment in the Norwegian shipping industry indicates a concentration of the replacement ages of ships about 9 and about 18—20 years. These reinvestment ages may be presumed to lead to the appearance of the five-years cycle observed in curves concerning the ship building.

¹ Comp. Mentor *Bouniatian's* objection against *Pigou's* pointing out the importance of the life time of the capital goods for the business cycle phenomenon. (*Industrielle Schwankungen, Bankkredite und Warenpreise, Archiv für Sozialwissenschaft und Sozialpolitik*. Bd. 58, 1927, p. 454): «Ausserdem entspricht die hier vorausgesetzte zehnjährige Periode nicht der mittleren Dauer der industriellen Zyklen, die verschieden ist und durchschnittlich für die letzten 60 Jahre, nach der Berechnung von Pigou, $7 \frac{4}{7}$ Jahre beträgt.»

PART III. STATISTICAL INVESTIGATION OF THE REINVESTMENT IN THE NORWEGIAN MERCANTILE MARINE 1883—1932

Introduction.

1. *Previous attempts to measure the replacement statistically.*

In Part II we have elaborated the theory of reinvestment cycles. Although in several points we have referred to results obtained in the present statistical part, we have in the theoretical part mostly confined ourselves to put up the theory in a *hypothetical* form. We have pointed out the importance it would have if the existence of such cycles could be proved. In the present part our problem is to analyse material for the Norwegian mercantile marine for the period 1883—1932 in order to prove the existence of such reinvestment cycles, if possible.

As far as I can see, none of the authors who previously have been working on the theory of reinvestment cycles — pure or secondary cycles — have made any investigation in order to point out directly reinvestment cycles in a statistical material.

As mentioned before *Marx* did not go further than to state the hypothesis of the influence of the reinvestment on the business cycles. His only attempt to verify the theory is his study of English statistics concerning the life-time of railway equipment. Comp. also his letter to Engels of March 2. 1858 (comp. p. 18). Other authors have not reached further than referring to statistical material which indirectly makes the reinvestment theory probable. *Schönheyder* is thus trying to show that recovery generally is introduced by an increase within the investment industry in contrast to the consumption industry (comp. 1927 pp. 115—116). He is further referring to the circumstance originally pointed out by *Aftalion* that the curve for the actual increase of the productive capital follows some years after the curve for the capital investment (comp. l. c. pp. 93—94). Further *Schönheyder* tries to find a basis for the theory in the rules for the length of the amortization period for various sorts of capital goods as put up by the taxation authorities.

D. H. Robertson in his paper of 1913 (Some Material etc.) among other things calculates the age, when a ship in the average will leave the British shipping register to be 16,8 years, and is trying on this basis to explain several tops in the British ship-building as reinvestment of tops in the ship-building 16,8 years previously.

Of more interest than the material which the reinvestment theorists are presenting, are the statistical investigations concerning the wearing-out time and other life characteristics which E. B. Kurtz¹ has made for capital goods of various sorts. Kurtz has also calculated the reinvestment curve for several sorts of capital instruments on the foundation of the results he is obtaining with regard to the wearing out time. There are, however, certain circumstances which make it impossible to draw extensive conclusions for the reinvestment theory on the basis of Kurtz' data.

Firstly, the sorts of capital goods for which Kurtz has compiled statistics are mostly simple and not intricate as telegraph poles, rails and sleepers in railways etc. The more complicated and expensive machinery is very poorly represented. Simple and uncomplicated capital goods will not, to the same extent as the more intricate ones, be exposed to obsolescence before they are worn out.

We must further be aware that the sorts of capital goods, which are most fully represented in Kurtz' material, in most countries will belong to public or half-public institutions, as telephone- and telegraph service, railways etc. In other countries private concerns will be the owners, but these concerns will to a great extent have an actual or legal monopoly. Consequently we are unable to conclude anything with regard to the replacement in private concerns in branches where competition is a work.

Ultimately we may mention that these concerns or state institutions regularly will have a very long life-time, so that the capital goods in this material nearly always will be replaced. On the basis of this material we are, therefore, not able to calculate how great per cent of the capital instruments will actually not be replaced because the concern ceases to exist.

2. *The possibility of directly measuring the replacement.*

It is evident that it would be of more value and of greater importance for the verification of the reinvestment theory than any of the previously published statistics, if one could procure a material where one could *directly* measure the reinvestment.

¹ Comp. Kurtz, E. B., Life Expectancy of Physical Property. 1930.

For this purpose it would be necessary to follow the stock of capital instruments in a branch of industry from year to year in order to measure how great a part of the new-constructed instruments are replacing worn-out older capital instruments and how great a parts is built for new-established firms or represents expansion of older firms. Further it would be of interest to follow the course of life of the capital instruments constructed in different years, in order to measure how great a part of them is reinvested later on and at what age replacement takes place.

It is obvious, however, that great difficulties usually will arise in procuring a material which makes it possible to trace a branch of industry throughout a longer period. As a rule it is hard enough to get information from existing concerns about their replacement, and it is nearly impossible to obtain such information from concerns which do not exist any longer.

In one special branch of business, namely *the shipping industry*, there are, however, in official shipping registers available material which makes it possible to trace individual concerns and individual capital instruments throughout a very long period.

In our statistical investigation, we have, with the purpose of measuring the replacement and on the basis of material from the registers of «Det Norske Veritas», followed every shipowner and every ship in the Norwegian mercantile fleet in the period from 1883 to 1932.

3. Special conditions in the shipping industry. The advantages and disadvantages in investigating replacement in the shipping industry versus other industries.

When we have chosen the shipping industry as our investigation object, it is primarily due to the fact that here is to be found available material for a very long period of time.

There is, however, another more special reason which makes it particularly interesting to investigate the reinvestment especially in the Norwegian mercantile fleet. During the Great War, Norway (in spite of its being neutral) lost through the submarine campaign nearly half of its mercantile fleet. (Exactly 49,3 per cent or 1 237 000 tons gross, Comp. Sjømannsboken, p. 18.) The per cent loss is greater than what any other country suffered. This loss was reestablished to a broad extent by the extraordinarily great number of new constructions in the years of 1920 and 1921. The Great War thus caused a pregnant concentration in the age distribution of the ships (comp. Curve 1, p. 112). In this way we have here a typical example of the *shocks* which may influence the

reinvestment. It is obvious that if this strong shock coincided with the former cycle in the reinvestment, this cycle would be strengthened enormously, so that the shock would work as a maintenance factor. If this shock occurs outside the former movement, we might expect it to originate a new strong cycle in the reinvestment beside this older one. Further it would be natural to conclude that there is a connection between the great new constructions of 1920—21 and the great new building of ships in the years 1929—31, presuming a concentration of the distribution of the replacement about 9—10 years age.

There are on the other hand many circumstances which make the ships no favorable material for a statistical investigation of the reinvestment.

a) Firstly it is very unfortunate that the ships have a very long lifetime (25—30 years) as compared to most other types of capital instruments. Thus the lifetime of the ships surpasses to a broad extent the usual lifetime of machines, which usually may be taken not to exceed 10 years. (Comp. for example Kurtz' data.) The reason for the long lifetime of ships is, as we have pointed out (pp. 48—50), among other things the fact that because of the violent strain to which they some day may be exposed (in hurricanes and the like), they have to be built much more solid than would be necessary when only exposed to usual wearing-out, and much more solid than indicated by economic factors alone.

The consequence is that the usual replacement age of the ships is much earlier than their usual age of being broken up. This relation may perhaps not be peculiar to ships alone, as many other capital instruments when they are replaced are not scrapped at once. *Comp. Friedrich Engels, Briefwechsel etc. p. 253: «Die alte verkaufte Maschinerie wird auch nicht gleich altes Eisen.»* There may, however, be reason to presume that this relation is especially typical for ships, so that here the replacement building as the newinvestment building, tends to increase the tonnage of the world's fleet. Here we cannot then expect to find the sharp division between the investment curve and the curve for the increasing capital which for instance *Schönheyder* will appropriate for the reinvestment theory.

When, therefore, the replacement age of the ships is determined mainly by moral, and not by physical, wearing-out, we may consequently not expect so strong a concentration of the replacement round the typical replacement ages, as we may expect in capital instruments, where both moral and physical wearing collaborate to a broader extent in determining the most usual replacement age.

This long life time of the ships is also the reason why we, as we shall see later on, find more than one top in the curve for age distribution of ships which are sold and replaced. That this curve has more than one maximum is of course also due to the fact that the life time of the ships is so long that it comprises several periods in the usual business cycles. However, we shall not yet deal with the causal relation, whether these tops are conjuncture determined or conjuncture determining, but only point out that naturally in this case we cannot expect the connection to be so simple between the reinvestment in one business cycle period and the entire investment in one earlier period, such as we might expect regarding more short-lived capital instruments which cannot live through more than one business cycle.

The lifetime of ships is long, not only in relation to the lifetime of most other machines and in relation to the business cycle, but also in relation to the average life time of the *shipping companies*. During the long time which elapses from the building of the ship till the most usual replacement age has been reached (19—20 years) a great many of the shipping companies, which originally constructed the ships, will have died a natural death, because they had been living so long that they understood no longer how to adapt themselves to the new conditions. Or they will have died through failure which put an end to their existence already at an early age. The consequence is that the percentage of falling off (i. e. that part of the ships which is not replaced) is much greater for ships than for more short lived capital instruments.

b) Another factor which also has the effect that we cannot expect so strong reinvestment cycles for the ships, is that they to a broader extent than most of the other capital instruments are exposed to be ruined by accidents. Even if we presume that the wrecked ships are replaced in the same scale as the sold ones, so that the falling off percentage is not greater owing to the shipwrecks, it is natural à priori to expect that the shipwrecks will be more evenly distributed throughout the life time of the ships than the sales, and therefore contribute to give the entire replacement curve a somewhat more flattened form than the replacement curve for sold ships alone. A great part of the ships will be wrecked before normal replacement age.

c) A third factor which possibly may make the ships a less favourable object for investigation of the reinvestment is that the shipping industry seems to be rather late in the general business cycle.

Aftalion observes (*Les crises periodiques etc.* Paris 1913 II, pp. 105—112): «... si les constructions navales suivent les oscillations périodiques générales, elles ne les suivent qu'avec des retards.»

Schönheyder, 1927 p. 87: «... the ship building, often does not increase in earnest before on the top of the business cycle and does not culminate till the recession has set in for good. In other words, the shipbuilding follows more the remaining groups than it follows the investment within the industry. Both 1900 and 1901 were typical ship building years, which assert themselves to a strong degree for England, and tend to damp or even repeal the tendency in the proper metal- and machine industry.»

If this is correct, naturally an increase of the shipbuilding can not be one of the factors which usually tend to start recovery in general business. This will then limit the range of the conclusions which can be drawn from an investigation concerning replacement in the shipping industry.

It is questionable, however, if not the fact that the shipbuilding industry in several periods apparently has been later than the general business cycle, in reality is due to the circumstance that the shipbuilding industry runs its own cyclical movement (period about 5 years) which does not always coincide with the general business cycle.

If, however, in spite of the here mentioned circumstances, which make the shipping industry a less favourable investigation object, we are nevertheless able to arrive at positive results in pointing out the existence of reinvestment cycles in our material, we must have the right to conclude that such cycles will exist and to a much greater extent in other industries and for other sorts of capital instruments, where all the here mentioned unfavorable circumstances are not present.

CHAPTER I. SOME HISTORICAL AND STATISTICAL DATES ABOUT THE NORWEGIAN MERCANTILE MARINE.

The growth of the Norwegian mercantile marine in the period we are going to investigate here, viz. from 1880 to 1932, will appear from the following table¹:

Year	Sailing ships Net-tonnage	Steam ships Net-tonnage	Motorships Net-tonnage	Total Net-tonnage
1880	1 460 596	58 062		1 518 658
1885	1 448 912	114 108		1 563 020
1890	1 502 584	203 115		1 705 699
1895	1 283 913	321 052		1 604 965
1900	1 002 675	505 443		1 508 118
1905	813 864	664 230		1 478 094
1910	630 287	893 000	3 000	1 526 156
1915	505 402	1 253 988	17 768	1 777 158
1920	203 944	1 199 284	124 876	1 528 104
1925	40 000	1 352 000	269 000	1 661 000
1930	12 000	1 414 000	868 000	2 294 000
1932	9 000	1 392 000	1 060 000	2 461 000

The figures for the total tonnage show a growth from 1519 thousand tons net in 1880 to 2461 thousand tons in 1932. As we see the constant growth in the total tonnage is broken on two places, namely in the periods from 1890 to 1905 and from 1915 to 1920. In the first period this decline is, however, merely apparent, as it is due to the transition from sailing tonnage to the more effective steam tonnage. This appears from the separate figures for sailing ships and for steamers. If we consider the so-called «calculated steamer tonnage» (i e. steam- and

¹ According to the Norwegian Official Statistics.

motortonnage net + sailing tonnage net divided by 3,6) the figures also for this period show a constant growth. The decrease in the period 1915 to 1920 is real and due to the losses during the Great War.

The size of the Norwegian mercantile marine as percentage of the world's fleet and Norway's position in the rank among the seafaring nations will appear from the following table:

The Norwegian mercantile marine in percentage of the world's fleet				Norway's position in the rank among the seafaring nations
Year	Total	Sail	Steam	
1890.....	7,2	14,6	1,9	—
1895.....	6,6	14,8	2,6	—
1900.....	5,7	13,3	3,4	—
1905.....	4,9	11,5	3,6	—
1910.....	4,8	12,8	3,8	—
1913.....	5,3	15,1	4,3	4
1919.....	3,6	8,6	3,3	—
1924.....	3,9	4,5	3,9	8
1925.....	4,1	—	—	7
1929.....	4,7	—	—	7
1930.....	5,3	—	—	5
1933.....	6,0	—	—	4

As seen above Norway was in 1913 no. 4 among the seafaring nations with 5,3 per cent of the world's tonnage. After the Great War the country was reduced to place number 8 with only 3,6 per cent of the world's fleet. In 1933 Norway had again advanced to the fourth place with 6,0 per cent of the world's tonnage. In the following table the foremost seafaring nations are placed in succession according to the size of the fleet per June 1st 1933:

Country	1000 tons gross	Per 1000 inhabitants
No. 1. Great Britain	21 820	471
» 2. U. S.	13 358	107
» 3. Japan	4 258	65
» 4. Norway	4 080	1 441
» 5. Germany	3 901	60
» 6. France	3 512	84
» 7. Italy	3 149	76

When we consider the size of the fleet in relation to the population Norway occupies the first place with 1441 tons gross per 1000 inhabitants. No. 2 is Danzig with 632 tons per 1000 inhabitants. Norway has consequently a greater part of its capital and working power employed within the shipping industry than any other country in the world.

A direct consequence of the size of the fleet as compared with the population is that only a small part of the tonnage is able to find employment within the Norwegian coastal trade or in the trade between Norway and foreign countries. How unimportant this part is may be concluded from the two first columns in the following table showing how great a percentage of the fleet was employed in *liner service*.

Percentage of the Norwegian mercantile marine employed in liner service:

Year	1) Along the coast of Norway	2) Between N. and foreign countries	3) Between foreign countries	4) Total
1911.....	4,4	9,2	0,2	13,8
1915.....	3,8	10,5	0,3	14,6
1920.....	4,7	11,2	4,1	20,0
1925.....	3,4	17,2	7,1	27,7
1930.....	3,0	14,9	9,1	27,0

(According to: Nogen statistiske oplysninger om norsk og utenlandsk skibsfart, 1925, and Skibsfartsstatistikk og konjunkturbetraktninger, 1930. Both edited by Norges Rederforbund.)

The Norwegian mercantile marine is then to a large extent obliged to seek employment between foreign ports, taking charge of freight service for foreign countries.

When Norway has come to play such a prominent part in the shipping industry of the world, it is above all due to the natural qualifications of the Norwegians as a seafaring people. At an early age the inhabitants of the coast to a large extent have been obliged to find their livelihood at sea, fishing and sealing. To this comes that the sea is the natural and often only way of communication for the inhabitants along the coast. From olden time the Norwegians have had to overcome the difficulties and face the dangers connected with seafaring in all seasons and in any kind of weather.

But when Norway in the international exchange of goods and services has chosen so prominently to specialize in sea transport, and here has been able to hold such a strong position in competition with the national

shipping industries of the countries themselves, it is undoubtedly also due to the fact, as for instance *Calvin* and *Stuart* have pointed out, that Norway from the hand of nature is a country with comparatively scarce means of subsistence. Other countries have to a great extent left it to Norway to do the sea transport, which in the long run is not very profitable, in order to concentrate in more profitable trades.¹ As is known, the classical economists called this principle in exchange between the countries the principle of the «comparative costs».

During the last century the Norwegian shipping maintained itself in the competition almost exclusively in offering cheaper service than the competitors. To a great extent Norwegian ship-owners bought second-hand tonnage from foreign countries, and as the Norwegian sailors furthermore worked efficiently and cheaply, the expenses were lower than those of the majority of the competitors.

It also appears in literature that Norway formerly was considered to be a typical purchaser of second-hand ships.²

That Norwegian shipowners formerly to an essential degree ran old tonnage, appears also in the comparatively late transition from sail to steam. Despite the figures for newly-built tonnage, showing that construction of sailing ships for Norwegian shipowners is quite insignificant already from 1892—93, it was not until 1907 that the entire steamer tonnage surpassed the sail tonnage. In 1890, when the steamers amounted to 58,7 % of the world's fleet, only 15,6 % of the tonnage in the Norwegian fleet were steamships. In 1900 the steam percentage for the world's fleet was 77,2 and for the Norwegian fleet 46,6. Comp. the

¹ Comp. H. C. *Calvin* and E. G. *Stuart*, *The Merchant Shipping Industry*, New York, 1925, p. 221: «The Case of Norway.. Lacking coal and iron ore it is not possible to build up a large industrial organisation. In spite of the fact that shipping is one of the poorest paying businesses in the world, Norwegian capital and labour force must go to sea. The return to both capital and labor from shipping is as good as that which can be obtained from domestic enterprises.»

² Thus C. Ernest *Fayle* writes in his book, *The War and the Shipping Industry*, Oxford 1927, p. 31, regarding the time before the Great War: «The Scandinavians and Greeks, running a large amount of cheaply acquired second-hand tonnage on cheap lines, were frequently able to undercut the British tramp» Comp. also p. 52. «.... the Scandinavian and other buyers who formed the normal market for second-hand tonnage.»

Comp. *Calvin and Stuart*, p. 226: «The Norwegians purchase a large number of steamers abroad, particularly in Great Britain. Many of their purchases are at second-hand, since there is not much capital in the country. By reason of its surplus of cheap, efficient labor and its serviceable fleet, Norway is prepared to do the cheap freighting of the world better and cheaper than any rival.»

figures p. 107 regarding the Norwegian mercantile marines as percentage of the world's fleet, sail and steam separately.

Later on, however, a change in this situation has taken place. Already before the Great War a great many steamer companies had come into existence, running essentially new, modern, firstclass ships.

The decisive turning point here is, however, caused by the Great War. As mentioned before, Norway suffered a greater loss in per cents by the submarine war than any other country, belligerent or neutral. A great part of this loss was restored by new constructions in the years immediately after the war. Later on Norwegian ship-owners have preferably ordered new constructions in stead of purchasing second-hand tonnage from foreign countries. Norway has therefore now gained a position among the seafaring nations chiefly running firsthand tonnage. When the ships grow older, the Norwegian shipowners mostly sell them to other countries, which now preferably run second-hand tonnage. (Greece, China a. o.)

This transition in the Norwegian shipping industry from chiefly second-hand tonnage to new modern ships will appear from the following tables of the age distribution of the ships at different points of time. First we will show a table from the Norwegian official statistics, which, however, record the age distribution only in great groups.

Age Distribution of the Norwegian Mercantile Fleet.

Groups of ages	1913 per cent	1921 per cent	1924 per cent	1928 per cent	1930 per cent
0—15 years	49,2	64,8	66,3	67,8	71,3
15—30 —	31,7	23,1	24,6	24,5	20,9
over 30 —	19,1	12,1	9,1	7,7	7,8

(Norges Skipsfart 1930. Norway's official statistics.)

No doubt one will get a better survey of the evolution of the age distribution from the following curves, which are computed from the Veritas registers and show the distribution at the beginning of the years 1900, 1914, 1923 and 1933

It is also characteristic that Norway, which, as shown above, was very late in the transition from sail to steam, is now one of the most advanced countries in respect to the transition from steamships to motor-ships. This will appear from the following table showing the distribution of the fleet on steam, motor and sailing-ships.

1931	Steam ships per cent	Motor ships per cent	Sailing ships per cent
World fleet	84,5	13,5	2,0
Norwegian fleet	58,2	41,5	0,3

We see that Norway in 1931 was owning a considerable greater part of the motorships of the world than of the steam ships. Of the steamers Norway had 4,1 per cent and of the motorships 17,4 per cent. With respect to the tonnage of motor ships Norway was Nr. 2 among the nations.

The qualitative improvement in the Norwegian mercantile fleet now compared to the time before the Great War is also indicated by a calculation by *Helander* of the so-called «qualified tonnage» of different countries.¹ If a ship should be included among the «qualified» ones it had to fulfill all the following three conditions:

- 1) to have at least a size of 5000 tons gross
- 2) to have a speed minimum 10 knots
- 3) not to be more than 25 years old.

It appears that while in 1914 only 0,44 per cent of the Norwegian tonnage fulfilled these conditions, 2,60 per cent did so in 1925 and 3,48 per cent in 1926. The corresponding percentages for the world fleet were in 1914 19,4, in 1925 18,77 and 1926 19,71. We see, therefore, that with respect to the mentioned three conditions the Norwegian fleet in this period shows a great development, while no such development is to be found as to the world fleet.

The three criterions which *Helander* has chosen for «qualified tonnage» do not of course give any complete expression as to the qualitative value of the different fleets. *Helander* therefore on p. 22 gives the following commentary: «Bei der Tabelle darf selbstverständlich nicht vergessen werden, dass nur drei, allerdings sehr wichtige Kriterien benutzt worden sind. Wäre die Möglichkeit gegeben, die Untersuchung auf noch weitere Momente auszudehnen, so würde die Reihenfolge vielleicht in einigen Fällen etwas geändert werden; voraussichtlich würde z. B. Norwegen etwas höher rücken, wenn alle technische Details berücksichtigt werden könnten.»

As a natural consequence of the fact that Norwegian ships mostly must do service between foreign ports Norwegian shipowners previously

¹ Comp. Dr. Sven *Helander*, Die internationale Schifffahrtskrise und ihre weltwirtschaftliche Bedeutung, Jena 1928, pp. 16 sq.

Reinvestment Cycles

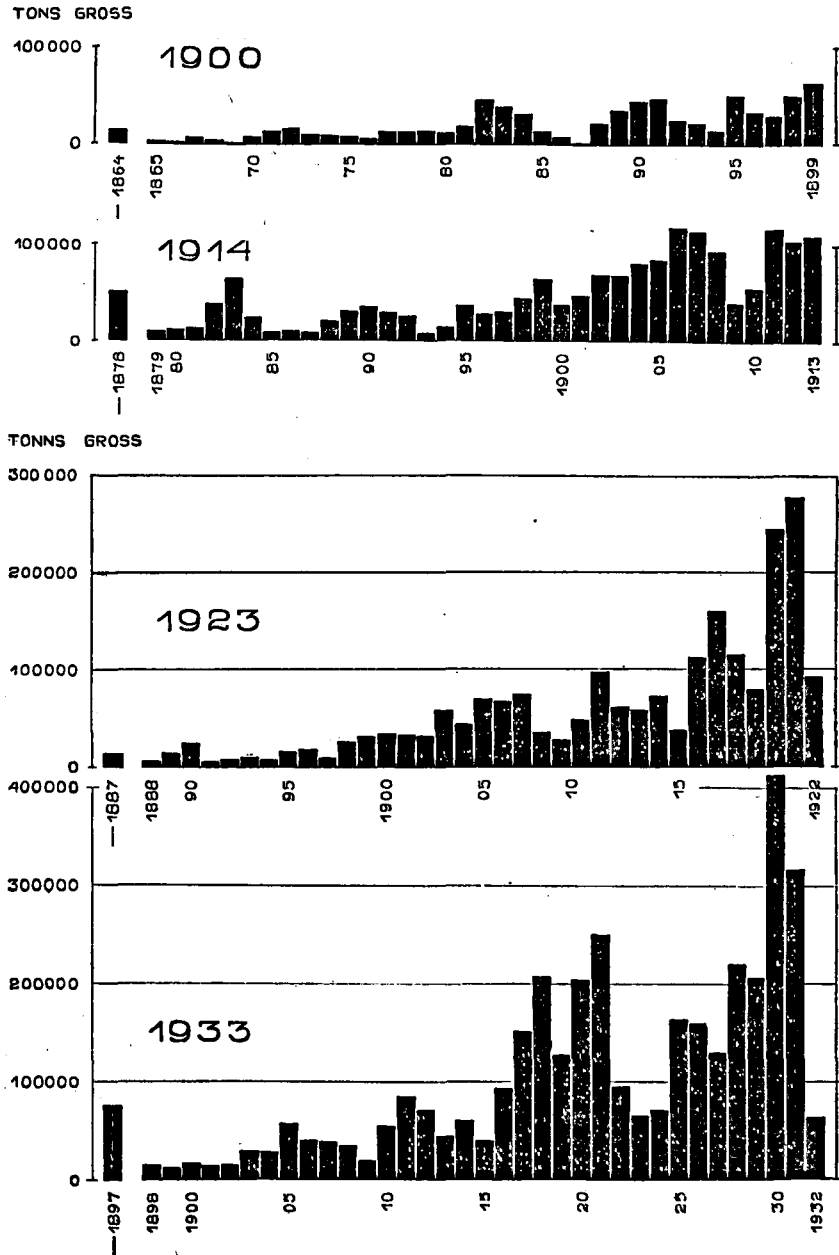


Fig. 1 a.

Age distribution of the Norwegian mercantile fleet at the beginning of the years 1900, 1914, 1923, and 1933. Steamships and dieselships. Computed from the registers of Det Norske Veritas. In tons gross.

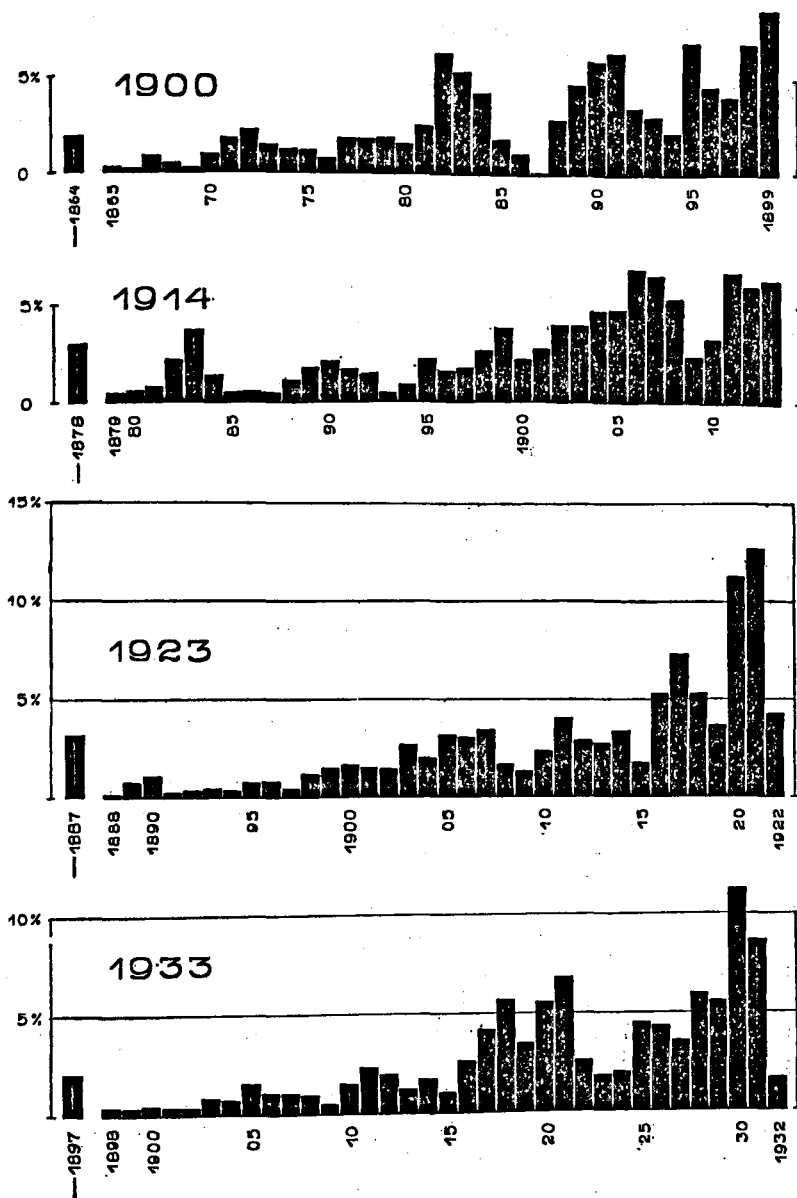


Fig. 1 b.

Age distribution of the Norwegian mercantile fleet at the beginning of the years 1900, 1914, 1923, and 1933. Steamships and dieselships. Computed from the registers of Det Norske Veritas. In per cent.

almost exclusively acquired trampships. In many trades where Norwegian ships previously played a dominant role they have later on been displaced by the national shipping industry of the countries concerned, especially when national liner companies have taken over the trade. This evolution has had the consequence that Norwegian shipowners constantly have had to look out for new trades and ever more far away to employ their fleet and to find possibilities for further expansion. Of late a great number of Norwegian ships has been employed in the far East for example. In this way the Norwegian trampships have often performed a pioneer service in finding and cultivating markets for sea-transportation, which later on have been taken over by the liner companies of other countries.

On the other side, however, the Norwegian shipping industry has also kept pace with the general transition from trampships to liners. This appears clearly from the above table (p. 108) showing the per cent of Norwegian tonnage that was employed at different times in the liner trade. As one will see the development has been especially great with regard to routes between foreign countries. In the year 1930 9,1 per cent of the fleet was employed in this way, as compared to 0,2 per cent in 1911.

This transition from tramps to liners is important to our investigation, because it has chiefly taken place within the older shipowner companies so that a great number of the shipowners in our material simultaneously are owners of tramps and liners. Consequently, it will be impossible for the period considered to divide our material in tramp companies and liner companies. We must treat both types of companies together and therefore get a less homogeneous material to analyse. This is significant because there is reason to presume that the typical liner companies will show characteristics with respect to replacement which are different from those of tramp companies. Most likely liner companies, because they will have to carry on the trade how bad the business outlooks may be, will replace their ships more regularly and perhaps also to a greater extent than do the trampowners. Further we may presume that the liner companies, as competition between them because of price agreements mostly takes place on the basis of service, are obliged always to have the best possible material, and therefore will have to replace their ships after a shorter time and also after more established rules than trampowners, who naturally are more speculative and therefore in their replacement policy lay more stress on the immediate business prospects. We may therefore expect that we would find replacement cycles which are more regular and of greater amplitude in a ma-

terial, exclusively comprising liner companies, than in a material also including tramp owners.

Comp. D. H. *Robertson*, Shipping and Shipbuilding, (Special Memorandum No. 3, July 1923, London and Cambridge Economic Service (p. 11): «The first wave of the revival of contracts at the end of 1922 was due rather to lowered costs than to improved shipping prospects, and derived its main strength from the liner companies. It is true that a line which has to replace tonnage to maintain its regular sailings may on occasion place orders almost regardless of costs; but its programmes of development are planned far ahead, and capable of postponement or acceleration in accordance with the cost of building. Tramp owners seem to be much more swayed by the immediate prospects of the freight market; and it was not until November 1922 that the expansion in imports, reinforcing, no doubt, the effect of lowered building costs, brought the tramp owners to the side of the liner companies.»

Lastly may be mentioned that the Norwegian shipowners of late have shown a strong interest in the trade of transporting oil in tankships. Especially from 1927—28 on the building of tankers for Norwegian shipowners increased to a great extent, and the tank speculation expanded during 1930—31 to a regular «tank bubble». In 1931 Norway was no. 3 of the nations with regard to tankers, and owned 17 per cent of the total tank tonnage in the world. Later on we shall deal with the tank building more in details.

CHAPTER 2. THE MATERIAL. PRELIMINARY WORK. STATISTICAL-TECHNICAL DIFFICULTIES.

§ 1. The Material. Sources.

The material for the following statistical investigation is taken from «Register over norske (skandinaviske) skib» edited by the ship classification institution «Det Norske Veritas», Oslo, established 1864 by Norwegian insurance associations.

The two first registers appeared in September 1865 and in March 1867. Later on the registers have appeared regularly at the beginning of every year, so that for instance the register for 1933 shows the situation at the turn of the year 1932—33. The changes in the register 1933 in relation to the register 1932 have then taken place in the year 1932, (or so late in 1931 that they could not be included in the register for 1932).

The registers comprise from 1896 all Norwegian (from 1919 also Swedish, Danish, Finnish and Icelandic) ships of 100 tons gross weight (for sailing ships before 1893 100 tons net) and more, together with the ships of smaller tonnage being classified by Det Norske Veritas. The registers from 1865 to 1895 comprise all ships classified by Det Norske Veritas and all ships insured by the insurance associations which were members of Det Norske Veritas. For the period before the register of 1896 the material does not therefore comprise completely the Norwegian mercantile fleet, as it does not include ships classified by other institutions than Det Norske Veritas and being *at the same time* insured by underwriters who were not members of Det Norske Veritas.

In order to get an approximate statistical expression for the percentage of the fleet that was not included in the registers before 1896, we have made a calculation giving the following result: of the steam tonnage built in the years from 1888 to 1893 21,1 per cent of the tonnage gross and 12,2 per cent of the number of the ships were not included in the registers. These figures show that preferably big ships were not included in the register. This is also indicated by a calculation of the average tonnage, which was 872 tons gross for ships included and 1507 tons gross for ships not included in the register.

The registers give complete and detailed information of many facts regarding the ships. For our investigation the following dates are of special interest: a) the name and type of the ship b) the owner c) tonnage gross d) year and month when built.

Supplementary numbers. In the periods between two editions of the register Det Norske Veritas publishes supplementary numbers in order to keep the register up to date. From the year of 1902 11 such supplements are sent out every year, namely at the beginning of every month except December. Before 1902 only 5 supplements were published every year, namely at the beginning of the months March, May, July, September and November. These supplementary numbers contain information of all alternations and additions that must be done in the register due to changes and accidents occurring in the course of the year. It happens, however, that changes occurring in the last months of a year are entered directly into the register of the next year without being mentioned in the supplements. Of the information given in the supplements the following dates are of special interest for our investigation: a) Transition of the ship to another Norwegian shipowner. b) Ships going out of the register and the reason for this. c) Entry into the register of newly constructed ships and of older ships purchased second-hand from abroad.

The supplements for the years before 1895 give, however, only exceptional information of ships leaving the register. When, therefore, a ship disappears from the register before 1895, we have in many cases no information whether this is due to shipwrecking, or to the ship being sold abroad, or — if the ship was not classified by Det Norske Veritas — its being insured by another underwriter who was not member of Det Norske Veritas.

In addition to the said publications Det Norske Veritas, in the years from 1895 to 1919, sent out a quarterly publication named: «Norske skib forlist eller av andre årsaker utgått av Norges handelsflåte». («Norwegian ships being shipwrecked or having left the Norwegian mercantile fleet for other reasons»). In many cases these publications give more detailed information than the supplements of the reason why and the point of time when the ships leave the register.

§ 2. Preliminary Work. Tabulation of the Ships Arranged after the Shipowners.

The register of Det Norske Veritas and its supplementary numbers give us, as we have seen, a material that makes it possible during a rather long period to trace the course of life and the fate of every single ship

in the Norwegian mercantile marine, from the moment when it is acquired by Norwegian owner, either as a new construction or because it is purchased second-hand from abroad, and till the moment when it leaves the register because of shipwrecking or because of its being broken up or sold abroad.

In the register of 1884 and in the later registers is also published a list showing what ships were owned by the different shipowners. This list enables us to follow the course of life not only of every single ship but also of every single shipowner company. We can trace the number and tonnage of ships of every shipowner company and note the points of time at which it purchases a ship and when they are shipwrecked, broken up or sold. As the main purpose of this whole investigation is to measure the *replacement* as it takes place within individual concerns, this is of special significance to us.

Therefore, as a *preliminary work*, we have made a tabulation on the basis of this list where we have followed the individual ships of every single shipowner for the period from 1883 to 1932. On the basis of the register and its supplements we have recorded the time when every ship was acquired by the shipowner and whether it was bought from another Norwegian shipowner or from abroad; further we have recorded at what time it passed to another Norwegian shipowner, or was sold abroad, or shipwrecked etc.

Because of the deficiency of the supplementary numbers of the registers for the first years (comp. above) it has not been possible to make this tabulation perfect for the period from 1883 to 1895.

On the basis of the registers of Det Norske Veritas from 1865 to 1883 we have further tried to find out and record at what time the ships that were present in the register of 1884 were acquired by their owners.

In this tabulation we have included all Norwegian ships of 100 tons gross and more (for sailing ships before the register of 1893 100 tons net). The following ships are excluded, however:

1. Ships constructed for special purposes as, for instance, railway ferries, tug ships, salvage ships, icebreakers and similar.
2. Ships for fishing, sealing and whaling. Of special significance is here that the great fleet of the Norwegian whaling companies is not included.¹

¹ With regard to the whaling companies we must be aware that some of them lately have acquired tankers for oiltransport, which are employed in the mineral oil trade and are not used to transport of whale oil. These ships should properly have been included in our material; however, as it is very

As a consequence of the fact that our tables do not comprise all sorts of ships, our figures of the total tonnage, of new constructions and of ships purchased and sold abroad etc. in most cases are somewhat lower than the corresponding figures of the official statistics.

This preliminary work was a very great task and its accomplishment required a very long time.

§ 3. Some Questions of Statistical-Technical Nature.

We shall here deal with some questions of statistical-technical nature, which had to be settled during the accomplishment of the preliminary work.

1) The first question was what *standard of measurement* we should use for a ships tonnage. For most ships the registers of Det Norske Veritas are bringing information both of gross and net tonnage. (Except for sailingships for which, in the registers before 1893, only tonnage net is given.)¹

There is no reason to assume that it will be of any significance for our results if we choose one standard of measurement or another. We have chosen to use *gross tonnage*, because for some great steamers the register does not give net tonnage. For those sailing ships which were present in our material before 1893, we must, however, use tonnage net. Presumably this is of no great importance, because, with regard to sailingships, the difference between tonnage net and tonnage gross is not great.

2) In some cases two succeeding editions of the register give *different*

difficult to distinguish between the tankers employed in the whaling trade and the others, we have preferred to exclude the entire fleets of the whaling companies from our material.

¹ Regarding the different standards of measurements comp. a. o. *Fayle* «The war and the Shipping Industry» p. 2, note: «*Gross Tonnage* represents the total cubic contents of a vessel, calculated at 100 cubic feet to the ton, including all permanent deck structures.

Net Tonnage represents the gross total less crew, navigation and engine space.

Deadweight represents the actual weight of cargo and bunkers a ship can carry without sinking below the marks.

A rough formula for conversion is 5 tons net = 8 tons gross = 12 tons deadweight; but though sufficiently accurate for general purposes, in dealing with large blocks of steam shipping, it is very unreliable to liner tonnage, especially as regards deadweight, and no formula can be given that will apply generally to individual ships.»

figures for the tonnage of the same ship. Most frequently the difference is not very great, in a few cases, however, it is quite considerable.

The difference may be due to several causes: a) alteration of the ship b) new measurement (different measurers very seldom will come to precisely same result). c) often ships purchased second-hand from abroad are at first registered temporarily with a tonnage in accordance with the rules of measurement of other countries.

For our investigation it will of course be an advantage if we stick to the same tonnage figure for a ship as long as it remains in our tables. There is no reason to expect that this will influence our results, because the differences in most cases are insignificant, and because there is no reason to assume that they have a tendency to go in one direction. As the most simple solution we have chosen to stick to the *first* figure of tonnage, except in cases where the tonnage at first preliminarily is given roughly in whole thousand tons (f. i. «about 5000»). In the last cases we use the first precise figures.

3) Difficulties also arise from circumstances concerning the *ownership* of the vessel.

In modern time the joint-stock company is the prevailing form for ownership of ships. In many cases one joint-stock-company will possess several ships, but of late it is more common that the ownership of every individual ship is organized as a separate joint-stock-company. In the last case consequently a ship-owner company (Rederei) running several ships will comprise several joint-stock companies. It happens, however, also that one shipping company includes several joint-stock-companies, of which every one possesses more than one ship.

Here the problem arises if we, in our statistical analysis, with regard to the replacement shall consider as one business unit the ships belonging to a shipping company or the ships belonging to the separate joint-stock companies. In deciding this question we must in every separate case take into consideration what solution is most in accordance with the purpose of our investigation namely: to investigate the replacement in the single units of business (Betriebe).

When the ownership is organized in single-ship-joint-stock-companies it is most reasonable to consider the entire fleet of the shipping-company as the unit. Most frequently in such cases the shipping-company that is running the ships will possess the majority of shares in the separate joint-stock companies, so that the transition of the ship to another shipowner-company in most cases will mean a real transference of ownership. In such cases, therefore, we consider the shipowner company and not the individual joint-stock-company as the business unit.

When on the other hand a joint stock company possesses several ships, there will be more reason to consider the joint stock company and not the shipowner company as the business unit. If therefore, as often is the case, such a joint-stock-company and all its ships are simultaneously transferred to another shipowner-company, we presume that no change in the ownership of the ships has taken place, so that they are still with the same owner.

It will, however, be evident that in this field there may occur many cases where the decision in one direction or another can only be based on valuation.

4) Also in other cases than the above mentioned it may be doubtful whether one shall reckon a change of ownership or not.

Very often we must decide at an estimate where the aim of the investigation, viz. to investigate the replacement in the ship stock of a concern, must be decisive.

Consequent to this aim we do not include change of ownership due to death, or due to transference to a son or some other relative inter vivos. It is logical for us to consider this as a continuation of the possession of the former shipowner. When calculating how long a ship has been in a shipping company, we add the time when the ship has been in the possession of father and son. We reckon then that the ship has been in the shipping company from new construction, when it entered into this stock of ships as new construction.

It is obvious, however, that we cannot always conclude from the registers whether there is sale or inheritance. Further there may be many transitional cases, for instance where the ships are distributed among several sons. Then it may be impossible to follow one single stock of ships in the hands of one family, especially if some of the sons in this case has ships of his one from before. In the cases where a stock of several ships is transferred simultaneously to another ship owner, it is, however, of no great importance to us to distinguish between sale or inheritance because this case will be included under next number 5). And the cases, when the ship-owner has only one ship, are not of much importance to our investigation concerning the replacement.

5) Also in other cases than inheritance it may occur that the whole stock of ships of a shipping company is transferred together to a new ship owner, so that the old shipping company ceases to exist. In these cases it is most in accordance with our purpose to consider the possession of the ships in the new shipping company as a continuation of the possession of the former owner. We then consider the stock of ships as a business unit without paying any attention to the transference to a new

ship owner. It is obvious, however, that many difficult transitional cases may occur.

6) *Difficulties in connection with the calculation of ages and time periods.*

For every ship we have recorded its *age* at its entrance into the material, and also when it changes owner or leaves the material. In most cases it would have been sufficiently exact to our purpose to have registered the number of completed years. The most simple method would be to consider what the actuaries call the «average duration», so that for instance we calculate that all ships, which have been built in 1916 and sold in 1926, have completed their 10 years at the time when the sale took place, and that a ship built in 1917 and sold in 1926 had completed its 9 years a. s. o. If we might presume that both the time when the ships were completed, and the time when they are sold, shipwrecked a. s. o., broadly speaking were evenly distributed throughout the months of the year, this way of calculation would naturally give sufficiently exact results. We cannot, however, presume that any of these hypotheses will do, as both new constructions and departures often display a strong concentration in special months, both due to seasonal fluctuations (the shipowners like to have all new constructions finished when the autumn season sets in, shipwrecks are most frequent during autumn and winter a. s. o.) and due to business cycles.

We have, therefore, chosen a more exact way of calculation, having *reckoned in months*. A ship constructed in December 1916 (1916₁₂), sold in March 1926 (1926₃) is then reckoned to have completed 9 years (9₃). And a ship constructed in July 1916 (1916₇) and sold in June 1927 (1927₆) is reckoned to have completed 10 years (10₁₁).

To be able to calculate age and period of possession of a ship according to this method we consequently need the following points of time recorded with the accuracy of one month: 1) The point of time when the construction of the ship was completed. 2) With regard to second-hand ships the point of time when they were purchased from abroad. 3) The point of time when the ships are sold to another Norwegian owner. 4) The point of time when the ships leave the Norwegian registers due to shipwrecking or due to their being sold abroad.

Re 1) *The month when the construction of the ship was completed.* Concerning almost all ships built for Norwegian shipowners in the period we consider, the registers give information about the month of their construction. In the whole material there are only a few exceptions. Also with regard to ships acquired second-hand from abroad in the last part of the material, the month of the construction is recorded with few

exceptions. In the the elder part of the material it is not seldom, however, that the month of construction is not recorded for ships purchased second-hand from abroad. This especially concerns sailings-ships.

In all these cases we have presumed that the ships were constructed *in the middle of the building year*, i. e. in the sixth month.

Re 2) The point of time, *when a ship is bought from abroad*, is not recorded in the supplements of the register. We have, therefore, here no other basis for our calculation than observing in which supplement the ship was first registered. We then presume that a ship which was for example first registered in the third supplement number of a year, was purchased from abroad in the period of time lying between the edition of the 2nd and the 3rd supplement number. We then assume, as one will see, that the ships generally are registered a short time after their acquisition. As to the period of time after 1902, when there are sent out 11 numbers of supplements every year, this method will give an accuracy of one to two months. As to the elder period, when there were sent out only 5 supplements a year, the accuracy is not so great.

Re 3) The point of time *when a ship is transferred from one Norwegian owner to another* is not recorded in the supplements. We must therefore here use the same method of calculation as under 2.

Re 4) *When ships leave the register* due to shipwrecking, foreign sales etc. the registers from 1909 give information in which month this has taken place (for example: Wrecked 1,13, Sold to Turkey 5.25). For the period 1895—1919 further the quarterly publication of Det Norske Veritas: «Norske skib forlist eller av andre årsaker utgått av registret» brings complete information of the point of time when the departure from the register took place. For the period before 1895 the register only rarely records the reason or point of time for the departure. In most cases therefore we must here reckon in whole years. We then presume that the departure always took place in the middle of the year, in the sixth month.

CHAPTER 3. TIME SERIES
OF NEWLY CONSTRUCTED SHIPS WITH AN
ATTEMPT TO DISTINGUISH BETWEEN NEW
INVESTMENT AND REPLACEMENT.

**§ 1. We Can Give a Statistical Expression only for the
Replacement, not for the Reinvestment.**

The main purpose of our great preliminary work in following all ships and shipowner-companies of Norway through the period from 1883 to 1932, has been to enable us to construct time series of newly constructed tonnage built for Norwegian shipowners, with an attempt to distinguish between *new* investment and *reinvestment*.

We easily tabulate the figures for the entire newly constructed tonnage, both total and divided into the different sorts of ships: sailingships, steamers etc. The difficulties arise when we will try to distinguish between new investment and reinvestment.

It is a consequence of our definition of the term *reinvestment* as «the purchase of a new machine, when and because an old machine of the same sort is amortized» (comp. p. 39), that we cannot, on the basis of the material we analyse here, get a direct expression for the reinvestment. In order to find figures for the proper reinvestment we would need economic data, i. e. we must analyse the accounts of the companies.

What we can hope to express approximately on basis of our tonnage data is the *replacement*, the shifting out of old ships with new constructions, on the part of individual shipowner companies. The method we will use here is, for every new construction, to investigate if, from the shipowner for whom the new ship is constructed, there has taken place within a reasonable period of time before and after the construction any departure of elder ships which may have a relation to the new construction. In consequence our distinction is between:

1) Newly constructed ships which are acquired in connection with departure of elder ships from the same shipowner. We call this *replacement*.

2) Newly constructed ships which are not acquired in connection with such departure. We call this *new investment*.

This distinction will of course only give a very imperfect expression of the reinvestment within the individual concerns, because, firstly, there is no doubt that many cases which we consider as «new investment» represent in reality reinvestment, because the new constructions are acquired by means which the shipowner company has got through amortization of ships, which are not yet sold (comp. p. 39: reinvestment without replacement). Secondly, it is probable that some cases which we tabulate as «replacement» in reality have nothing to do with reinvestment of amortization funds, so that the simultaneousness of the acquisition of new constructions and the departure from the company of elder ships in these cases is quite accidental, and does not indicate any causal relation.

§ 2. The Procedure in Constructing our Time Series.

We have proceeded in such a way as to gather firstly all new constructions of our material in accordance with their year of construction. We have distinguished between various types of ships; and used separate tables for sailingships, steamships and motorships. All tankers we have, however, gathered in special sheets, both steamtankers and motortankers together. On these sheets, of which every one represents the ships of a special type built in a single year, we have for each new construction recorded whether it is acquired in connection with a departure of elder ships from the same shipowner company (replacement) or not (new-investment). In the cases where the new constructions are considered as replacements we have further recorded the sale or shipwreck of what ship (or ships) may be connected with the new construction, its name, type, tonnage, year and month of its construction, the space of time it has been in the possession of the shipowner in question, year and month when it left the shipowner, and the reason of the departure.

Although this way of proceeding is simple enough in principle many problems have arisen in connection with its practical effectuation.

1) The first and most important question that must be decided is here: *for how long a period before and after the new construction was completed shall we permit the departure of elder ships from the shipowner company to take place in order that the new construction may be considered as replacement?*

It is here reasonable to take into consideration *the average period of time that is required to construct a ship*. For a steamer of average size the average period of construction for the time comprised in our material has been about twelve months.¹

Of course technical progress constantly tends to shorten this average period of construction. On the other hand, however, the constant increase of the average size of ships and the fact the machinery of the ships constantly becomes more delicate tends to extend the period of construction. When a change to a new technique takes place, — as for instance the transition from steamers to dieselmotorships — it is probable that the period of construction at least for the first time will be prolonged. The period of construction is generally longer for specially built ships than for common tramps or liners.²

Not only technical factors will, however, influence the period of construction, but also the phase of the business cycle. For ships built during a boom the period of construction often is prolonged from the general average time of twelve months to eighteen months or more.³

If we take into consideration not only the proper time of building the ship, but the whole «*période de construction*» as Aftalion understood the term, (comp. Part I) which also includes the time that usually is needed for the planning and ordering of the new construction, we come to a period that will surely cover *two years*.

With regard to *shipwrecked* vessels we have then reckoned that replacement has taken place when the replaced ship was wrecked within a period from $\frac{3}{4}$ to 2 years before the new construction was completed.

With regard to *sold ships* it is not so easy to find a reasonable limit for the difference of time we shall permit. We cannot here confine ourselves to include the cases where the old ship is sold *simultaneously* with

¹ Comp. *Tinbergen* «*En Schiffbauzyklus?*», p. 153: «*Bauzeit von rund einem Jahre.*»

² *D. H. Robertson*, *Some Material for a Study of Trade Fluctuations*, *Journal of the Royal Statistical Society*, 1914, p. 162: «... In view of the large part played by tank-steamers in the recent record shipbuilding boom, it is significant that it takes much longer to build an oil-tank steamer than an ordinary steamer.»

³ Comp. *D. H. Robertson*, *Some Material*, pp. 161—162: «The actual time occupied in building a tramp steamer of the usual size, i. e., about 7000 tons, under favourable conditions — i. e., if there is no exceptional scarcity of labour and materials — is under a year as the tide flows the period of gestation lengthens, for — (1) the capacity of the yards is limited, so that some months may elapse after the placing of an order before the vessel is begun; (2) there is a growing pressure on the supplies of labour and materials, so that delays occur also *after* construction has begun. Thus the period is

the completing of the new construction, so that we can conclude that the new ship directly has taken over the work of the old ship. It might perhaps have been reasonable to draw such narrow limits with regard to liner companies. With regard to tramps, however, which are dominating our statistical material, it is natural that we are content with a more indirect connection between the new construction and the replaced vessel. It is of interest to include all cases where it is reasonable to presume that there may be a causal connection between the departure of the old ship and the new construction. It may then of course happen that the old ship is sold even some time before the ordering of the new construction. On the other side it may be reasonable to include also cases where the old ship is sold *after* the new construction was completed, as it may often be profitable to wait some time before the old ship is sold.

We must, however, realize that the longer period we permit before and after, the smaller is the probability of any existing causal connection between the departure of old tonnage from the company and the acquisition of the new construction, and the less our time series will answer their purpose: to give a statistical expression of the connection between the shipbuilding at one point of time and the shipbuilding at a previous point of time.

With regard to *sold ships* we have chosen an upper limit for the difference between the point of time when the old ship was sold and the month of building of the new construction of ± 24 months. Only if a case comes between these limits it may be reckoned as replacement.

In this connection it may be of interest to show the distribution of the included cases between these upper limits. This will appear from the curve showing the number of sold and replaced vessels in our material distributed in accordance with the distance from the month of building for the new construction.

prolonged to as much as eighteen months. For instance, the flood of new ships launched early in 1906 seems to have been composed largely of those ordered late in 1904, and at the end of 1912 builders were stated to be full of work well into 1914.»

Comp. *Helander*, Die internationale Schiffahrtskrise, Jena 1928, Seite 176: «... im Jahre 1913 auf den englischen Werften 99 % der Tonnage konstruiert wurde, die am Anfang des Jahres in Arbeit war, was die Schlussfolgerung nahelegt, dass die durchschnittliche Arbeitszeit pro Schiff ein Jahr betrug. In den Jahren 1919 und 1920 ist jene Proportion 72 % und 69 % gewesen, d. h. die durchschnittliche Bauzeit ist auf siebzehn Monate gestiegen.»

Comp. p. 191: Durchschnittliche Bauzeit pro Schiff

Jahr	Grossbritannien u. Irland	Weit
1920	17 Monate	16 Monate
1925	14,5 »	13,5 » .»

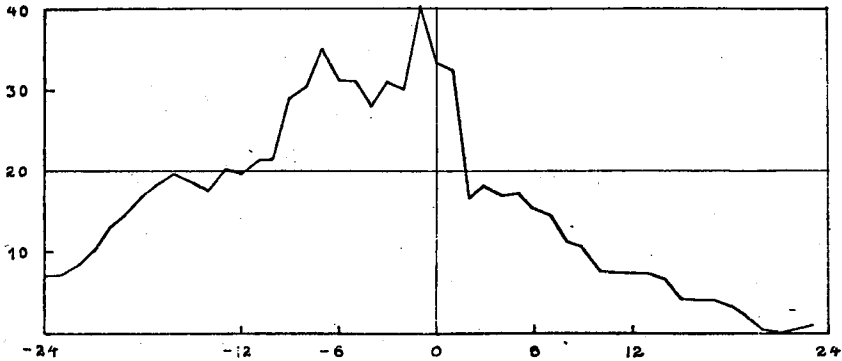


Fig. 2.

Number of sold and replaced vessels included in our material, distributed in accordance with the distance from the month of construction of the new construction.

The most conspicuous characteristic of this curve is its *skewness*, as most departures have taken place *before* the new construction was completed. For both sold and shipwrecked tonnage the average time difference for the whole period 1884—1931 (except the war) was 5,8 months. Even if the sold tonnage is considered separately the same characteristic feature remains, the difference being then about 2,66 months.

Other questions that had to be decided in connection with our distinction between new investment and replacement are the following:

2) In those cases where the ships of a ship-owner company are distributed between several joint-stock-companies, we have already discussed (comp. pp. 120—121) whether we shall include those cases only where both the newconstruction and the replaced tonnage belong to the same joint-stock-company, or if we shall consider it sufficient that both ships belong to same shipowner company.

3) In many cases where a shipping company acquires a new construction, a departure takes place of *several elder ships* from the company, of which every one might be connected with the new construction. In these cases we have recorded *all* the sold or wrecked ships as replaced by the new construction.

4) In most cases the new construction and the replaced ship (or ships) will have a *different tonnage*.

When the tonnage of the replaced ships is in excess of the tonnage of the new construction there can be no doubt that the whole new construction is to be regarded as replacement. When the new construction is greater than the departed tonnage, two ways of proceeding might be

possible: a) One might — as for instance Professor Frisch suggests (in his mimeographed lectures, *Makrodynamik*, Høstsem. 1933 p. 8526,2) calculate in tons so that we, if a new construction is of 2500 tons and the departed tonnage of 1500, regard 1500 tons of the new construction as replacement and 1000 tons as new investment. Or one might b) consider the whole new construction as replacement no matter whether its tonnage surpasses the departed tonnage or not.

We have chosen this last method of proceeding because we think that what is of interest is to find for how great a part of the newly built tonnage the departure of elder tonnage may have played the rôle of an impulse. Then it is not unreasonable that the departure of one ship may give the impulse to the ordering of a greater ship. In periods when the average size of the ships constantly increases, this will even be the rule. We have here a typical case where the investment of amortization funds and of the other saving of the concern of technical reasons necessarily must take place simultaneously (comp. Part II p. 68).

If we here calculate in tons we must group the exceeding tonnage of the new constructions built in connection with replacement together with the new constructions not built in connection with replacement, and this result is not satisfactory.

In connection with questions 3) and 4) above we may mention that we have calculated tables which show the tonnage of the departed, replaced ships in every quarter of a year. In the decenniums we find the following difference between the tonnage of the new constructions built in connection with replacement, and the tonnage of the replaced ships.

Years	Departed Ships tons gross	New constr. replacement tons gross	Difference	
			tons gross	Per cent of departed tonnage
1884—1893	105 133	136 895	31 762	30,2
1894—1903	224 246	274 707	50 461	22,5
1904—1913	278 340	371 536	93 196	33,5
1914—1923	504 750	650 209	145 459	28,8
1924—1933	471 040	732 805	261 765	55,6
1884—1933	1 583 509	2 166 152	582 643	36,8

The difference between new constructions for replacement and replaced tonnage, as we see, for most periods amounts to about 30 per cent. In the last decennium, 1924—1933, however, the difference is 55,6 per cent. The reason is that the average size of new constructions in the last period

shows a considerable increase, especially if tankers are included in the calculation.

5) When a shipowner acquires *several new constructions* in a period where the departure of older ships takes place from the same shipowner, it may in some cases be difficult to decide which of the new constructions shall be considered as replacements and which as new investments, or to decide the departure of what ships is to be put connection with the different new constructions. When deciding these questions we have, above all, put stress on the time for departure and the month of construction, and in this way we consider a connection between the cases where the difference of time is lowest. But we have also considered the character and size of the ships, so that ships of same character and size order preferably are considered to replace each other.

6) It occurs very often that a shipping company acquires new constructions and at the same time *purchases older ships*. It might then be just as reasonable to calculate the departed older ships as being replaced by the purchased older ships as by the new constructions.

We have, however, neglected this possibility, and in these cases we have reckoned that the new construction has been replaced by the departed ships. We have then been working on the view that our investigation aims at finding which connection there is between departure of older ships and the building of new ships, while the shifting out of older ships against each other to us is only a case of secondary importance.

It will appear from the preceding that our division of new construction in replacement and new investment in several cases has met difficulties, which in every individual case may only be decided according to the best *judgement*. This is naturally a weak point in such an investigation, as it may be difficult, even with the best intention of objectivity, to prevent subjective factors — in this case the wish that the statistical data shall be in accordance with the made hypothesis — to contribute to a certain selection.

We think, however, that there is no reason to expect that the result, obtained by other people on the basis of our material, to any essential degree would differ from our result, because:

1) In most cases it will be obvious, according to our definition of replacement and new investment, whether a new construction shall be considered as belonging to one group or the other. Further in most cases it will not be any difficulty in deciding which ships shall be considered as replacement of new constructions. The number of cases, in which the decision is dubious, is insignificant in relation to the obvious cases.

2) The calculations in the actuarial part of the present work (Part

IV) of the probability of replacement in relation to the probability of departure (the maintenance per cent) indicate that the judgement has led to no bias, as the typical years of replacement (9 and 19) are not dominant in the maintenance probability. And it may here be mentioned that the departure probabilities are objective material.

§ 3. Distinction between Replacement for Sold Ships and Replacement for Wrecked Ships.

At new constructions built in connection with replacement we have further made a division between replacement of sold ships and replacement of wrecked ships.

It may, however, occur that a new construction is replacing *both* sold and wrecked ships. In such cases the following different methods might be used:

a) The tonnage of the new construction might be divided *proportionally* between replacement for sold and replacement for wrecked ships. A new construction of 7500 tons is for example considered to replace a sold ship of 2000 tons and a wrecked ship of 4000 tons. We then divide the tonnage of the new construction, so as to put up 2500 tons for replacement of sold ships and 5000 tons for replacement of wrecked ships.

b) The new construction might be included in the group showing the *greatest* tonnage for departure. In the example mentioned above we might then consider the 7500 tons of the entire new construction as replacement of wrecked ships.

c) The new construction might be considered as replacement of sold ships, if among the departed ships which it is considered to replace, are to be found sold ships at all, even if the tonnage of wrecked ships is greater. If this principle is applied the whole new construction in the mentioned example would be considered as replacement of sold ships.

We have chosen this third method (c) from the view, that to us it is of greatest interests to find how great a part of the replacement-new-constructions on the whole may be put into connection with willed departure of older ships.

§ 4. We Have Made the Following Time Series for Quarterly Dates.

We have chosen to compute our time series for quarterly dates, as the results are not good enough when we use yearly or half-yearly dates. On the basis of our material it would also have been possible, of course, to make series for monthly dates. When using monthly dates, however,

the figures would have been disproportionally small, so that casualties might play too great a part.

We then have made the following time series for quarterly dates for the period from 1883 to 1932:

1. Total shipbuilding for Norwegian shipowners.
2. Shipbuilding for Norwegian shipowners in connection with shifting out of older tonnage (replacement).
3. Shipbuilding for Norwegian shipowners not in connection with shifting out of older tonnage (new investment).
4. Replacement separately for sold ships.
5. Replacement separately for wrecked ships.

These different time series are made for all sorts of ships together and for sailingships, steamers (less tankers), motorships (less tankers) and tankships separately. For the last period series are further made for all sorts of ships less tankships.¹

Of the total new constructed tonnage for the period from 1883 to 1932 we have calculated that of the tonnage 44,8 per cent was replacement and 55,2 per cent was new investment. Of the number of ships the corresponding per cents were 43,7 and 56,3.

¹ From our material we have excluded ships fitted with motors for *raw oil*. Our figures for motorships therefore only include ships with diesel motors (internal combustive motors). Of raw-oil-motor ships there were in the years from 1915 to 1920 constructed a considerable number for Norwegian shipowners, mostly sailing ships fitted with auxiliary motors. Most of these ships, however, left the Norwegian registers of shipping after few years, both because of their being poorly built and because they proved to be unprofitable.

CHAPTER 4. ANALYSIS OF TIME SERIES.

§ 1. Three Components.

In the curves we have made for quarterly dates of the shipbuilding for Norwegian shipowners for the period 1883 to 1932, already in the raw data the three following cyclical components seem to be present:

- 1) a cyclical movement with a period of 5—6 years.
- 2) a wave of about 2 years.
- 3) a quite short wave, resembling a seasonal movement, but not quite regular.

We will confine ourselves to discuss the 5 years cycle.

§ 2. The Five Year's Cycle.

The five year's cycle is present in our material for the whole period from 1883 to 1932 and is to be observed already in the curves of raw data.

In the smoothed curve¹ we find the following summits and bottoms.

Summit year	Distance from summit to summit. Number of years	Bottom year	Distance from bottom to bottom. Number of years
(1884)		1887	
1890	(6)	1893	6
1895	5	1897	4
1899	4	1902	5
1906	7	1909	7
1912	6	(1914)	(5)
(1916)	(4)	(1918)	(4)
1920	(4)	1923	(5)
1925	5	1927	4
1929	4	1932	5
Sum 0 excluded	31: 6 = 5,016		31: 6 = 5,016
Sum 0 included	45: 9 = 5,000		45: 9 = 5,000

Reinvestment Cycles

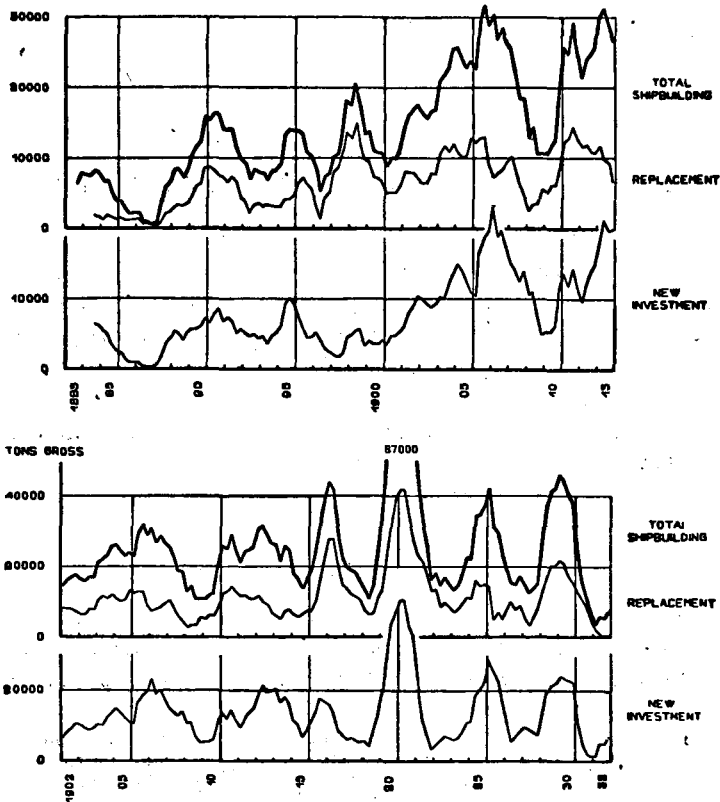


Fig. 3.

Ships constructed for Norwegian shipowners in the years 1883—1932, total and divided into replacement and new investment. Quarterly dates. Oil tankers not included.²

The average distance from summit to summit and from bottom to bottom amounts to rather exactly 5 years.

¹ The curve is smoothed by first using a moving average of 7 quarters on raw data and then using a moving average of 10 quarters on the result. This operation eliminates all waves with periods shorter than 10 quarters, but leaves cycles with periods longer than 10 quarters intact.

² This curve comprises, for the years after 1925, only steam and motor tonnage. We have excluded the oil tankers because their construction in this period seems to follow its own laws, different from those of the other shipbuilding.

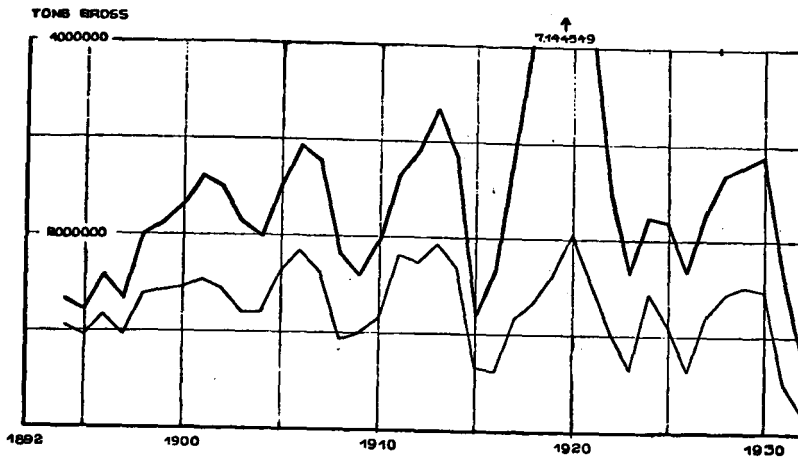


Fig. 4.

The mercantile shipbuilding in the world (thick curve) and in Great Britain and Ireland (thin curve) 1894—1932. Yearly dates. After Lloyd's Register of Shipping, Annual Survey of the Mercantile Shipbuilding of the World.

A similar five years' cycle can be observed for the same period of time in the world shipbuilding. This will appear from the curve in fig. 4 after Lloyds List.

As one will see there is in most cases a good agreement between the curve for Norwegian data and that for world data. For the period from 1898 to 1903, however, the shipbuilding for Norwegian owners has two summits (comp. fig.) viz. in the years of 1899 and 1902. The world shipbuilding has only one summit, namely in the year of 1901. This disagreement no doubt is due to the fact that the general rising conjunctures were interrupted prematurely in Norway, owing to circumstances peculiar to this country.

Further we see that the curves are not running parallel in the period from 1914 to 1921. While the world shipbuilding is ascending regularly and steadily from 1915 to 1919 and then descending to 1922, the curve for the shipbuilding for Norwegian owners has two summits, at first one about 1916/17 and then one great summit 1920/21. In the years of 1918/19 when the world shipbuilding reached its climax, the building for Norwegian owners was rather insignificant.

That the building of ships for Norwegian owners in this period is much later than the world shipbuilding can be explained by the special situation during the Great War. The summit of the world shipbuilding in the

year of 1919 is to a great extent due to the huge new construction in the new yards being established during the war partly in the non-belligerent European countries (Holland) and partly oversea (U. S. A., Japan). The new tonnage consisted to a great extent of ships of inferior quality, for instance the fleet of wooden ships, fitted with steam engines or with motors for raw oil, constructed in U. S. A. The shipyards of Great Britain, having delivered the greatest part of new construction before the war were during the war mostly employed with the building of warships. Summit of mercantile shipbuilding of Great Britain therefore was not reached before the years of 1920—21.

When Norwegian shipowners had to wait until 1920/21 to have the greatest part of their war-losses restored, this is mainly due to an agreement made by the governments of Great Britain and Norway, according to which Norwegian shipowners were to have preference to place orders with English dockyards after the war.

Comp. C. Ernest *Fayle*, *The War and the Shipping Industry*, Oxford 1927, p. 342: «It was a term of the tonnage agreement with Norway in 1917 that 260 000 tons might be laid down to Norwegian orders during each of the three years immediately following the war, to assist in making good the heavy losses suffered by Norwegian shipping.»

§ 3. The Replacement is Leading.

We will now regard the separate curves for replacement and new investment. First we will look at the curves for the years from 1904 to 1914 because some characteristic features in these two periods of the 5 years' cycle are especially perceptible. In both periods we see that the curve of the total shipbuilding has two tops, and then in the first period in the 1st quarter of 1905 and in the 4th quarter of 1906, in the second period in the 3rd quarter of the year 1911 and in the 2nd quarter of 1913. In both cases we see that the difference in time between the minor tops was seven quarters.

If we now regard the separate curves for replacement and new investment, we find that in both cases the first top is mainly due to replacement and the second to new investment. We see that replacement during these years is obviously preceding new investment.

The same relation of phases between replacement and new investment, however, can also be observed for the other part of our time series, though we cannot here always point out one particular top of the curve of the total shipbuilding as the replacement top and another as the new investment top.

As one will see replacement is leading in every period except about

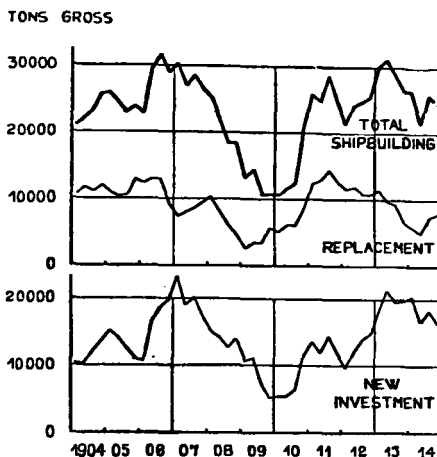


Fig. 5.

Ships constructed for Norwegian shipowners 1904—1914. Total and divided into replacement and new investment. Quarterly dates. The curves are smoothed by a moving average of four links.

Replacement summit		New investment summit		Distance between repl. and new inv. Quarters
Year	Quarter	Year	Quarter	
1890	4	1891	2	+ 2
1899	1	(1899)	(3)	(+ 2)
1905	1	1906	4	+ 7
1911	3	1913	2	+ 7
1924	1	1925	4	+ 7
1929	4	1929	4	0
Replacement bottom		New investment bottom		
1897		1898		
1903		1903		
1909	1	1910	1	+ 4
1914	2	1915	2	+ 4
1927	2	1927	4	+ 2

1895. We see too, that the lag between replacement and new investment in most periods is not so great as in the years 1904—1914.¹

¹ In these series oiltankers are not included. This may be the reason that the series do not show the same distance in time for the last period included, because new investment in this period preferably took the form of oiltankers.

§ 4. That Replacement is Leading is in Accordance with the Theory of Pure Reinvestment Cycles. The Exceptions may be Explained by Robert Liefmann's Theory.

That replacement in most cases takes the lead is in good accordance with our hypothesis that the impulse to recovery comes from pure reinvestment cycles. The increase in the activity of construction due to the ascending replacement building effects better prospects of profitability in general and is followed by increasing new investment. Partly due to the fact that the production of capital instruments requires time, new investment will continue to rise some time after replacement has culminated.

The exceptions we have found in our time series from the rule that replacement leads may perhaps be explained by the fact that in the years concerned, a transition to a revolutionising new technique was taking place. As we have mentioned in the theoretical part (Part II, pp. 77—79) a German economist Robert *Liefmann* has pointed out that newly established concerns have great advantages in relation to older ones when a transition to a new technique of production is taking place, because they are able to acquire the new machines at once, and not like older companies have to wait for the time when the machines in function are sufficiently amortized. This factor, however, should be applicable also as to the relation between replacement building and new investment in general. Normally revival is opened by an increase in the replacement activity due to pure reinvestment cycles, and the new investment will not increase until the prospects of profitability have improved. When a transition to a quite new technique takes place, however, the investment in new machines will appear profitable even during the period of depression, so that revival in these cases may be started by the new investment, which is then later on followed by the replacement.

It is plausible that the fact that new investment in our series in the period from 1894—97 precedes replacement can be explained by such a transition to new technique, namely the transition from sailing ships to steamers. This transition, as pointed out above (p. 109) took place rather late in the Norwegian shipping industry. At the time when our investigation begins, that is in the years of 1833—34, the fleet consisted — apart from the fleet of the town of Bergen — almost exclusively of sailing ships. The old sailingship companies showed very little ability to adapt themselves to the new situation, and waited so long as possible to shift out their sailing ships against steamers. The steamships that were constructed for Norwegian owners during these years, were therefore mostly ordered by newly established shipping companies, who had no

old ships to replace. The old sailing ship companies, however, were at last forced by competition to replace their sailingships with steamers. Therefore it is probable that the great replacement building of steamers in 1896 mostly comes from such finally converted sailing ship companies. This is also indicated by the following statistic, showing the shifted out tonnage for the years 1894—1897 separate for sailing ships and steamers.

Replaced for newly constructed steamers.

Year	Replaced steamers	Replaced sailing ships
	Tons Gross	Tons Gross
1894	3 046	1 687
1895	7 052	3 748
1896	6 813	13 370
1897	3 438	10 348

We see that while the replacement of old steamers reached its climax in 1895, the replacement of old sailing ships did not reach its maximum before 1896.

We here find two different tendencies at work: Normally revival is started by pure reinvestment cycles. But when transition to a revolutionisingly new technique takes place, the advantages of new concerns may be so dominating, that the increasing new investment starts recovery. It will, however, be clear that the influence of the new technique will not always be so strong as to give the new investment a definitely leading position. It is probable that in some cases the new technique will only cause a shortening of the difference in time that is normally existing between replacement and new investment.

In this way we may for instance explain that the lag between replacement and new investment is very short in the periods 1925—27 and 1929—31. In these periods the transition from steamers to dieselships had a strong influence. This is also supported by the fact that the two periods when the lag is greatest, namely 1904—07 and 1910—13, are also the two periods when technical changes were less significant.

§ 5. Our Time Series do not say anything about the Reason why the Replacement is Leading.

We have pointed out that our time series of newly constructed ships divided between replacement and new investment show that replacement in most cases is preceding new investment in the business cycle. This result will of course in itself be of some interest.

We further have mentioned that this result is in accordance with our hypothesis that the impulse to recovery normally comes from pure reinvestment cycles. We must, however, realize that the leading position of replacement is not sufficient to prove the theory, as it may also be explained by other factors than pure reinvestment cycles.

A very plausible explanation of the fact that replacement increases faster than new investment at the beginning of the revival we might for instance get from the theory of the *secondary* (generated) reinvestment cycles. As mentioned above this theory says that replacement generally is neglected during depression, because a great part of the capital instruments who are then worn out, or who then reaches their normal age of replacement, are not shifted out against new ones. Therefore, in the last part of the period of depression there will be an accumulated need of replacement, that will have the effect to make replacement building dominate at the beginning of revival.

Further, when replacement reaches its maximum before new investment, this may be explained by the fact that one does not any more shift out older machines during prosperity, but aim at increasing the producing capacity before all. Also old-fashioned machines may prove profitable during the period of prosperity.¹

In order to get evidence that the leading place of replacement in the business cycle is due to pure reinvestment cycles, it will, therefore, be necessary to investigate in details at what ages ships are by preference replaced. We must try to find out if there exists any typical replacement age of ships, and further investigate what form the age distribution curve of replaced ships is having during different phases of the business cycle.

¹ This is a. o. pointed out by Gustav Cassel in his *Theoretische Sozial-ökonomie*, Leipzig, 1927, p. 518: «In den Hochkonjunkturen war man öfters genötigt, Hochöfen, die in der Depression ausser Betrieb waren, wieder in Dienst zu nehmen, auch wenn sie vielleicht schon als veraltet betrachtet werden müssten.»

CHAPTER 5. AGE DISTRIBUTION OF REPLACED SHIPS

§ 1. The Purpose of this Chapter. The «Cyclical Factor».

In order to prove that the leading place of replacement in our material during the revival is due to pure reinvestment cycles, it will be of interest to investigate if there exists a typical replacement age (or several typical ages) for ships.

We must, however, realize that the pointing out of the existence of typical replacement ages in itself will not be sufficient to decide anything regarding what causes recovery. The existence of such a typical age would not prove that recovery sets in *because* a great many of ships then reaches this age. This will appear from the following reasoning:

Even if the probability of replacement was the same for all ages of ships, we might get an age distribution of replaced ships concentrated about a «typical replacement age (or several ones)» when shipbuilding had a cyclical course and replacement followed (or followed with a not too great lag). This because the greatest replacement would take place at the top of the shipbuilding cycle (or a short time before), and when the probability of replacement was the same for all ages, the effect of the age distribution of the fleet would then be that more ships were replaced of the ages that corresponded to the distance from the actual top of the shipbuilding curve to one of the previous tops than of other ages. The age distribution of replaced ships would then show typical replacement ages that would correspond to the period of the shipbuilding cycle. In this way the very cyclical course of the shipbuilding and replacement curves would even generate a typical replacement age of the ships, because of the uneven age distribution that the cycles would create in the fleet. It is however clear that the age distribution of the replaced ships due to this factor alone — we may call it the *cyclical factor* — never could be more concentrated than what would correspond to the age distribution of the fleet.

To be able to prove anything with respect to the causation, it will therefore be necessary to study in details the age distribution of the replaced ships during the different *phases of the business cycle* in order to point out:

1) That the concentration about the typical replacement age during revival is greater than would be effected by the cyclical moment alone.

2) That the main characteristics of the age distribution of replaced ships for the total also are to be found for replacement during the separate phases of the business cycle.

With regard to the *depression* we must especially be aware that the cyclical factor will have the effect that the majority of ships in this period will be of a non-typical age. Therefore it will be of special importance to us if it appears that the age distribution typical to total replacement also is to be found as to replacement during depression.

§ 2. Age Distribution of Ships Sold and Replaced. Typical Replacement Ages for the Whole Material and for Separate Periods.

In this chapter we will confine ourselves to study the age distribution of ships that are *sold* and replaced, because we may expect that these will be of the greatest importance for our purpose. We will return to the question of wrecked and replaced ships later (in Part IV).

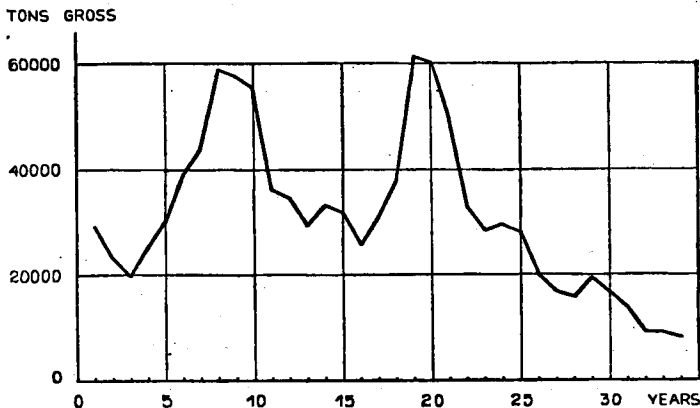


Fig. 6.

Age distribution of ships sold and replaced 1884—1932. The period of war 1914—1919 excluded. All ships. The curve is smoothed by a moving average of three links.

The curve (Fig. 6) shows the age distribution of sold and replaced ships for the whole period of our investigation 1884—1932. The period of war 1914—18 is excluded.¹

The curve shows clearly one top at the age of about 9 years and one top at the age of about 19 years. In addition we find one smaller top about the age of 30 years.

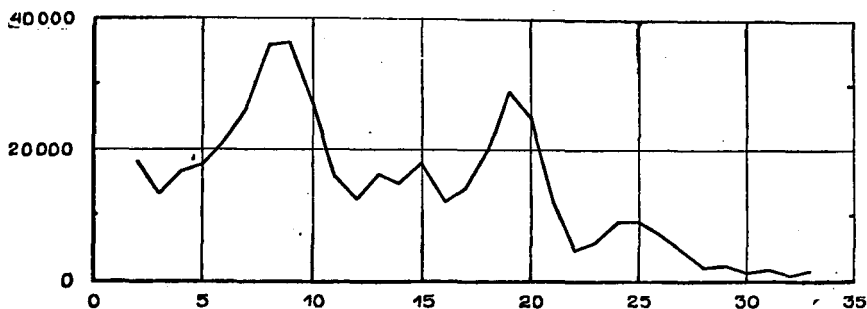


Fig. 7.

Age distribution of ships sold and replaced 1884—1932. The period of war 1914—1918 excluded. Only ships which have been at the same owner from new constructions. The curve is smoothed by a moving average of three links.

The curve in Fig. 7 shows the age distribution of sold and replaced ships when only the ships having been at the same owner from new constructions (first-owner-ships) are included. We find here the same tops as in curve 6, but as one might expect, the 9 year top is here greater compared to the 19 years top than in curve 6.

In order to find out if these tops are characteristic for our material or if they are due to mere casualties, we have divided the material in different ways.

The curves in Fig. 8 show the age distribution of sold and replaced ships separately for the periods before the war (1884—1913) and after the war

¹ In the Part IV we also find curves regarding the probability of replacement in different ages. We must, however, be aware that the present curves are constructed on the basis of more material than those of Part IV, as the last ones only include steamers built in the years from 1883—1927 who have been at Norwegian owners from new constructions. In contrast to Part IV the present material also includes 1) sailing ships 2) steamers constructed before 1884 (and after 1927) 3) steamers constructed in the years 1884—1927 who were purchased second-hand from abroad.

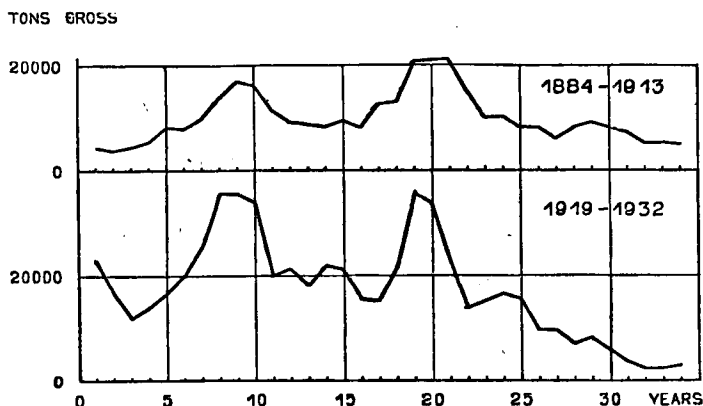


Fig. 8.

Age distribution of ships sold and replaced 1884—1913 (above) and 1919—1932 (below). The curves are smoothed by a moving average of three links.

(1919—1932). These two curves show clearly that the two tops of 9 and of 19 years are real phenomenons. The differences between the curves are insignificant. The main differences are the following: Firstly, a tendency to shorten the age of replacement seems to manifest itself. We see that the tops in the period after the war was lying about $\frac{1}{2}$ —1 year before the pre-war period. Secondly we see that in the earlier period the tops of 19 and 30 years are greater in relation to the 9 years top than after the war. This may be explained by the differences of the age distribution of the fleet at the different periods (comp. Fig. 1 pp. 112—113).

The Fig. 9 shows the same material divided into 10 year periods. Through this detailed division of the material there appears, as one might expect, some irregularity in the curves, but the main characteristics, the tops about 9 and 19 years remain. For the first 10 year-period 1884—93 the typical ages do not manifest themselves very clearly. We must, however, be aware that the material for this period is very scanty.

For the period 1904—13 we see that the top of 19—20 years is very dominating in relation to the top of 9 years. This may be explained by the fact that this was a very quiet period with no great technical progress in shipbuilding. We see that the main characteristics of the age distribution curves — tops about 9 and about 19 years — return even if the material is split into rather small parts.

We have then not only one typical age of replacement, but several ones.

Tops in the age distribution curve about 9 and 19—20 years naturally is in good accordance with a 5 years cycle in the shipbuilding.

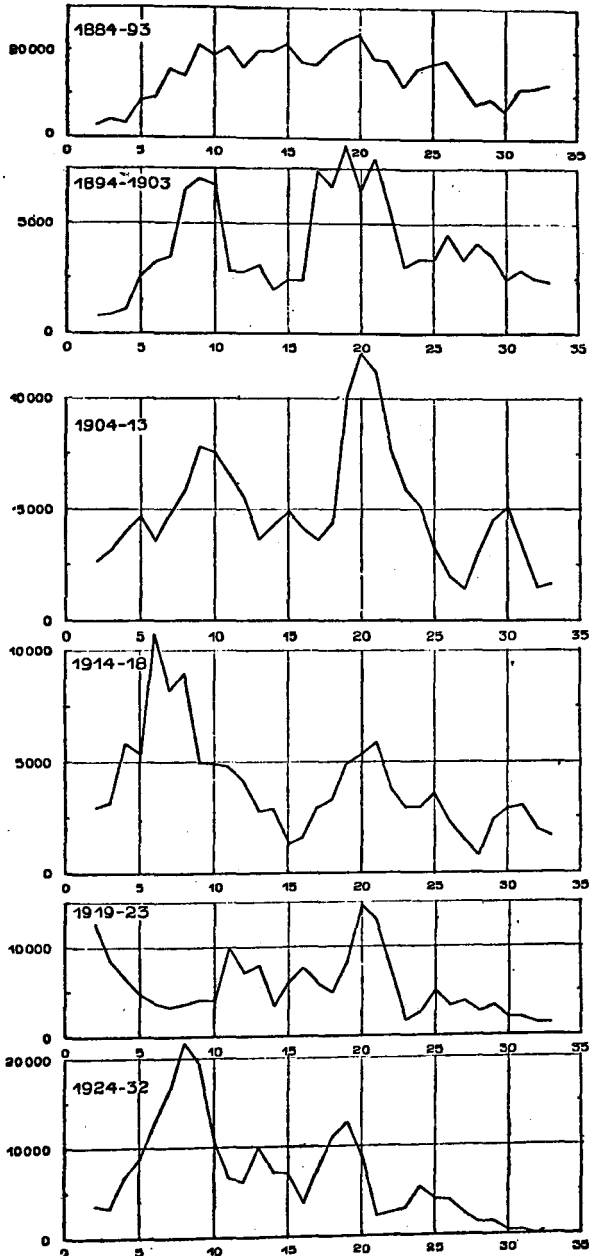


Fig. 9.

Age distribution of ships sold and replaced 1884—1932. Ten-year periods. The curves are smoothed by a moving average of three links.

The replacement of the ships constructed in the top years will then by preference take place at the second and fourth top of the 5 years ship-building cycle that they survive. The tops at the ages of 5 years and 15 years are as one will see not very significant in the age distribution curves. (In the curves in Part IV the 15 years top manifests itself more clearly.)

The typical age of replacement at 19—20 years is in accordance with the practical experience in this field. The opinion among shipowners is that a ship has to be replaced when it is 20 years old. This information I have personally got in every case when I have asked Norwegian shipping men about the question.

This seems to be the predominant opinion among British shipping men too. Comp. a. o. D. H. *Robertson*, *Some Material for a Study of Trade Fluctuations*, Journ. of the Royal St. Soc. 1914 p. 166: «... the estimate given me by a Liverpool shipowner of twenty years as the average length of life of a vessel upon the British register.»

In his attempts to explain some features of the curve of shipbuilding in England by pure reinvestment cycles, Robertson does not, however, base his calculations on this typical age of 20 years, but on an average figure of 16,8 years. For our Norwegian material this figure will be about the lowest point of the age distribution curve for replaced ships, and it is not probable that British data are very different in this respect. (The age distribution of second-hand tonnage acquired by Norwegian Shipowners does not seem to indicate any difference). In the discussion of the paper of Robertson in the Royal Statistical Society it was objected that his calculations would only hold good if the distribution about this age of 16,8 years was unimodal and very typical. Robertson replied (l. c. p. 178) that: «he was assuming that the average period in both cases corresponded with the most frequent period — that the average corresponded with the mode and that the distribution about the mode was not very widely dispersed. He thought that was perhaps a legitimate assumption.» Our investigation indicates that these assumptions do not hold good. This case illustrates the danger of operating with a single average figure without knowing the dispersion about it. One then runs the risk of falling between two chairs.

§ 3. Age Distribution of Sold and Replaced Ships Divided in Phases of the Business Cycle.

We pointed out in § 1 that it will be of great importance to study the age distribution of sold and replaced ships separately for ships sold during revival, prosperity, recession, and depression. Only through such an investigation we may be sure that the typical age distribution of the

replaced ships in our material is not due to what we have called the cyclical factor.

With regard to the question of the age distribution of ships sold and replaced during the different phases of the business cycle we must, however, be aware that also other tendencies may exert some influence than the two mentioned ones, the pure reinvestment cycles and the cyclical factor.

As for the age distribution during the period of *prosperity*, it may thus be of some importance that pure reinvestment cycles according to our theory will call forth secondary reinvestment cycles. Shipping companies are tempted by the improved prospects of profitability to extend their transporting capacity by ordering new constructions, but as many of them are not well equipped with capital, they are obliged to sell older ships. In such cases they will sell old ships because they have acquired new constructions and not conversely.

During the period of *recession* a similar procedure may take place, because several shipping companies, who have ordered new constructions, originally meant as new investments, due to difficulties in obtaining loans must sell older tonnage to be able to pay the new ones. (There is reason for thinking that the top of the replacement during the years of 1907—08 (comp. Fig. 5) following a considerable time after the climax may be explained in this manner.)

The circumstances here mentioned should be supposed to have the effect that the age distribution of ships sold and replaced during prosperity and recession will not show so strong a concentration about the typical ages, as for instance those replaced during revival.

During the period of *depression* on the other hand there should be no reason to think that such secondary cycles would exert any disturbing influence.

We will now speak about how we have divided our material, and about the results we have obtained.

It was not so easy to divide the curves for total shipbuilding for the years 1884—1932 in periods of revival, prosperity, recession and depression, with the accuracy of a quarter of a year. Naturally such a division must to some extent be arbitrary. In determining the limit between revival and prosperity we have in cases of doubt examined the separate curves for replacement and new investment. We have then used the point of view that the revival lasts so long as replacement is dominating, so that the dividing line between revival and prosperity is where replacement stagnates but new investment is still increasing.

We have then come to the following result:

Division in Phases of the Business Cycle.

Prosperity			Recession			Depression			Revival		
From (incl.)	To (incl.)	Duration in quarters	From	To	Duration	From	To	Duration	From	To	Duration
year qt.	year qt.		year qt.	year qt.		year qt.	year qt.		year qt.	year qt.	
1883 1	1884 4	8	1885 1	1885 4	4	1886 1	1888 2	10	1888 3	1890 3	9
1890 4	1892 2	7	1892 3	1893 1	3	1893 2	1894 4	6	1895 1	1895 2	2
1895 3	1896 2	4	1896 3	1897 1	3	1897 2	1897 4	3	1898 1	1898 4	4
1899 1	1899 3	-	-	-	-	-	1903 4	-	1904 1	1905 4	8
1906 1	1907 4	8	1908 1	1909 2	6	1909 3	1910 3	5	1910 4	1911 4	5
1912 1	1913 4	8	1914 1	1914 4	4	-	-	-	1919 3	1920 2	4
1920 3	1921 4	5	1922 1	1922 3	3	1922 4	1924 2	7	1924 3	1925 3	5
1925 4	1926 3	4	1926 4	1927 1	2	1927 2	1928 4	7	1929 1	1929 4	4
1930 1	1930 4	4	1931 1	1931 4	4	1932 1	1932 4	-			

TONS, GROSS

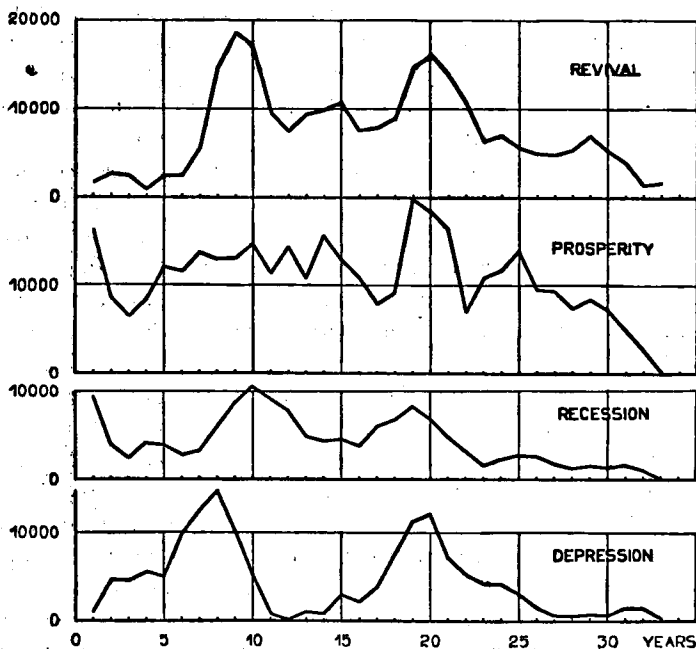


Fig. 10.

Age distribution of ships sold and replaced 1884—1932. The period of war 1914—1918 excluded. Divided according to the phases of the business cycle.

The curves are smoothed by a moving average of three links.

The division does not include the period from 1899, 2 qt. to 1903, 3 qt. The reason is that the development of the business cycle in this period in Norway is not clear (comp. p. 135). Further we have omitted a period from 1915, 1 qt. to 1919, 2 qt., in what period the special situa-

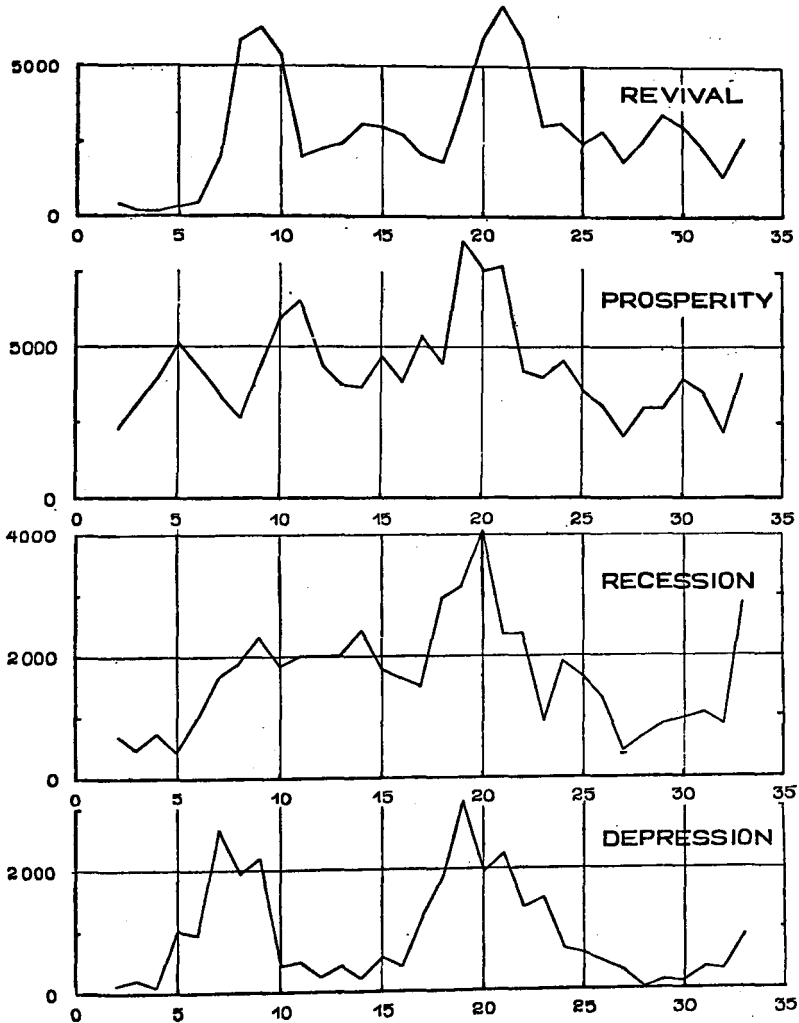


Fig. 11 a.

Age distribution of ships sold and replaced. Prewar period. Divided according to the phases of the business cycle. The curves are smoothed by a moving average of three links.

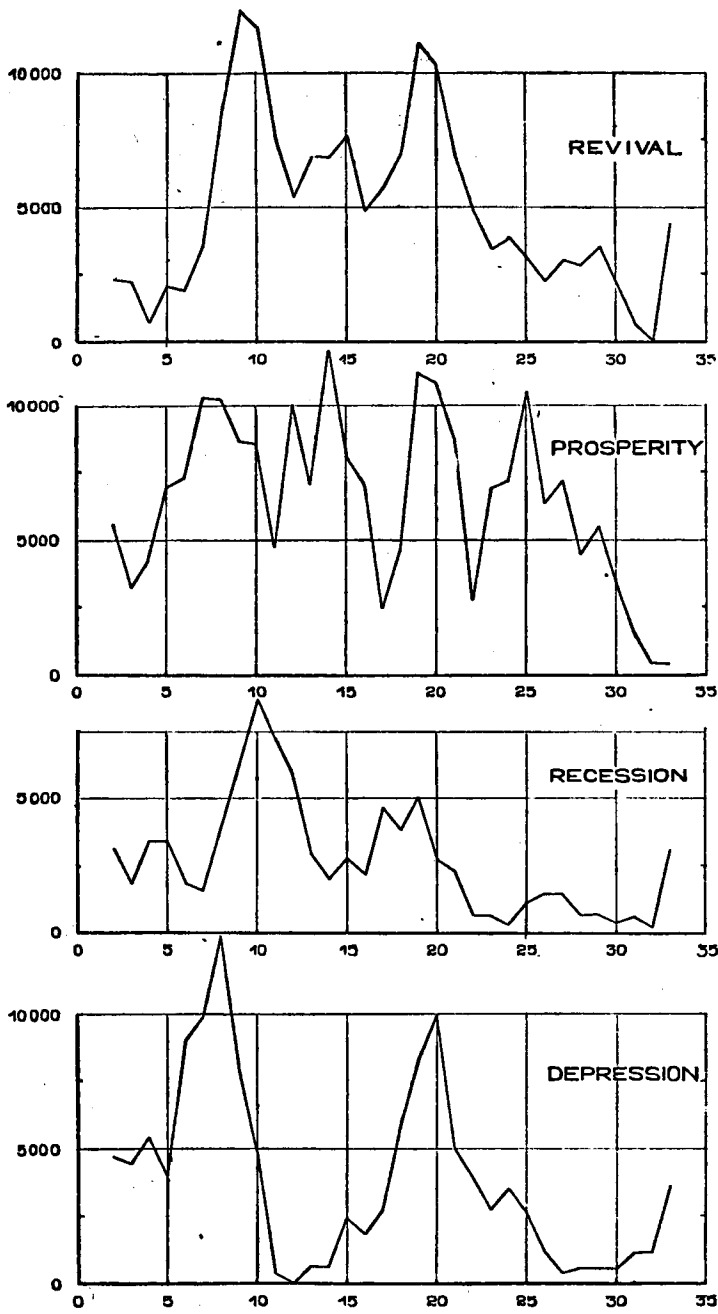


Fig. 11 b.

Age distribution of ships sold and replaced. Postwar period. Divided according to the phases of the business cycle. The curves are smoothed by a moving average of three links.

tion created by the Great War must be expected to have exerted a dominating influence.

The curves in Fig. 10 show age distribution of ships sold and replaced 1884—1932 (1899—1903 and 1915—1919 exclusive) divided in accordance with the phases of the business cycle.

As one will see, the top about 19—20 years remains rather stable through all phases of the business cycle. The 9 years top can also be found in all phases, but not so regularly. The main difference is that the top during prosperity and recession shows a tendency to move to the right, to somewhat higher ages than during depression and revival.

Also with regard to the phases of business cycle we have divided the material in two periods, viz. the period before the war and the period after the war. This division gives the result that the age distribution during the different phases shows the same main characteristics in both periods, although special circumstances, for instance the concentrated age distribution after the war, also exert some influence.

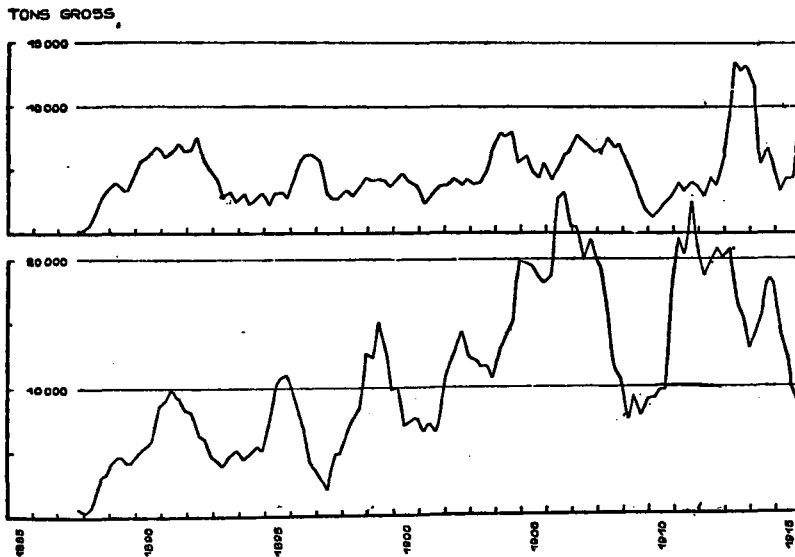


Fig. 12 a.

Ships constructed for Norwegian shipowners 1887—1915. Divided according to the age of the shipping companies. Oil tankers not included. Quarterly dates. Above: Ship built for shipping companies of ages 0—7 year. Below: Ships built for shipping companies which were 8 years old or more. The curves are smoothed by a moving average of four links.

§ 4. Total Investment with Regard to the Age of the Shipping Companies.

We have further divided the total investment in two groups after the age of the shipping company that acquired the new construction. The first group comprises ships built for companies that have an age from 0—7 years and the second group ships built for 8 year old companies and older. One may then assume that the younger shipping companies will represent new investment, while the ordering of new ships

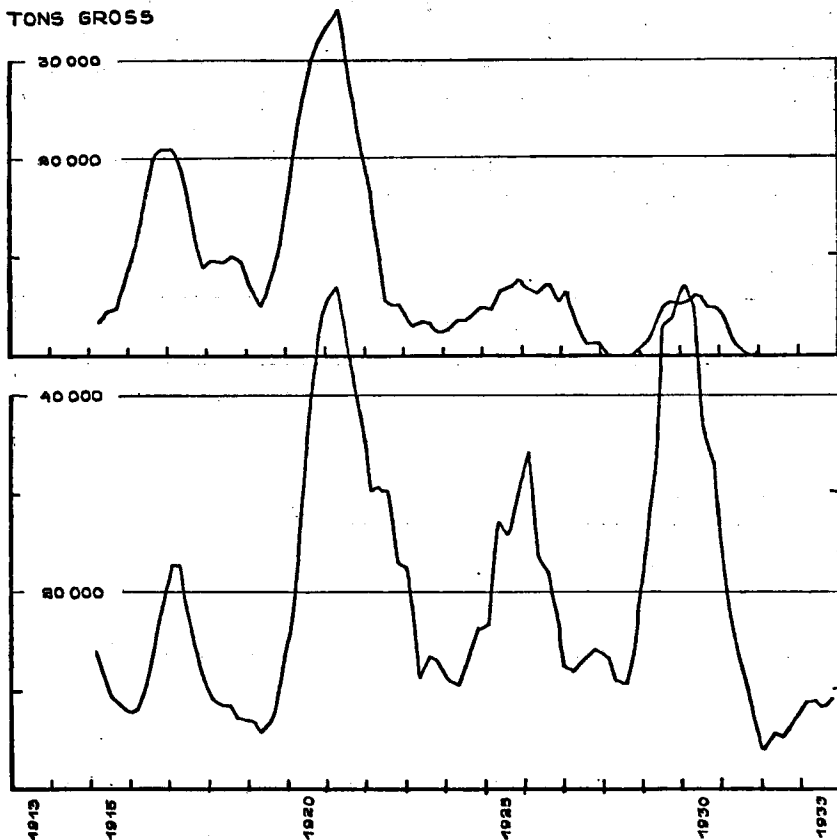


Fig. 12 b.

Ships constructed for Norwegian shipowners 1915—1933. Divided according to the age of the shipping companies. Oil tankers not included. Quarterly dates. Above: Ships built for shipping companies of ages 0—7 years. Below: Ships built for shipping companies which were 8 years old or more. The curves are smoothed by a moving average of four links.

from older companies to a great extent will be determined by the need of replacement. We should then expect the curve of total investment of the older companies to reach its maximum before the corresponding curve of the newer companies.

The curves in Fig. 12 show that this hypothesis holds good for the prewar period, (except in the year of 1904). For the postwar period the two curves seem to move more synchronously. We must, however, be aware that the tank-tonnage is not included in these curves and new investment in the last years has to a great extent taken the form of tank-tonnage.

§ 5. Excurs I. The Tankshipbuilding. A Typical «Pig Cycle»?

As we have pointed out in Chapter 1, the Norwegian shipowners have lately shown a great interest in the tankship trade.

Several circumstances have cooperated to make this special branch a profitable one, in spite of the general tendency of an almost perpetual depression of the shipping industry. The permanently increasing use of mineral oil has called forth an increasing demand for transportation of oil. A factor that has had some influence in this relation is the transition from steamships to ships fitted with diesel-motors. The oil trade requires specially built ships, so that consequently the surplus of ordinary ships here does not exert any influence, at least not directly. The freight rates in the oil trade therefore as distinct from the general level of freight rates have also in the postwar period been so good that the profitableness was sure, and in good years considerable profits were attained.

Although some few Norwegian shipowners entered this trade at an early point of time, and already before the war ordered several tankers, it was not till about the year of 1925 that the construction of tankers for Norwegian owners reached a great extent. One had from then on an increasing ordering of new tankers which culminated in the years 1930—31 in a regular «Tankbubble».

A factor that no doubt contributed to stimulate the great interest among Norwegian shipowners for this trade is the fact that many British tanksteamers built in the last years of the war were offered for sale in the years from 1926—29. One may perhaps assume that here, in most cases, the question was of replacement sales. Several of these secondhand steamtankers were acquired by Norwegian shipowners who due to the increasing rates of the oil freights made good profits from their investment. Therefore we also see that in the years 1930—31 when many

motortankers were ordered from Norwegian shipowners a considerable part of the orders came from companies, that some years previously had acquired second-hand tankers.

As will be seen from Fig. 13, the curve of the construction of tankers has a form that is different from the curves for the construction of other ships. For example there was a great building of tankers for Norwegian

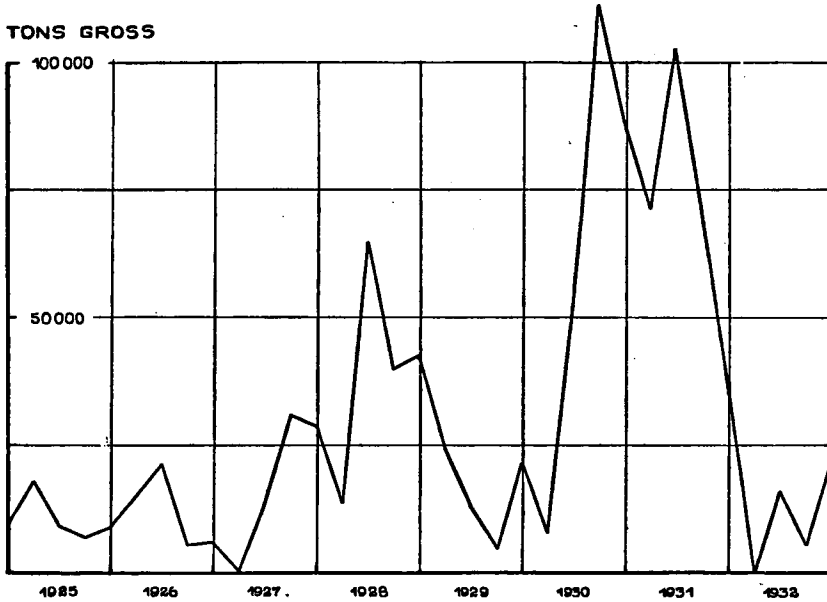


Fig. 13.

Oil tankers constructed for Norwegian shipowners 1925—1932. Quarterly dates.

shipowners in the years of 1927 and 1928 when the building of other tonnage was insignificant. And on the other hand the tankbuilding was very small in the year of 1929 when shipbuilding in general increased greatly. Further the tankbuilding reached a colossal top at the end of the year of 1930 and in 1931, when the rest of shipbuilding already had decreased.

It is apparent that the building of tankers, in this period at least, has been ruled by its own laws, independent of or perhaps contrasted to those ruling general shipbuilding. Seemingly the best explanation of the oscillations of the building of tankers is to be found in the relation between tankfreights and the offer of tankers for transportation.

A comparison between the curve for the freight rates for tankers and the curve for the construction of tankers for Norwegian owners

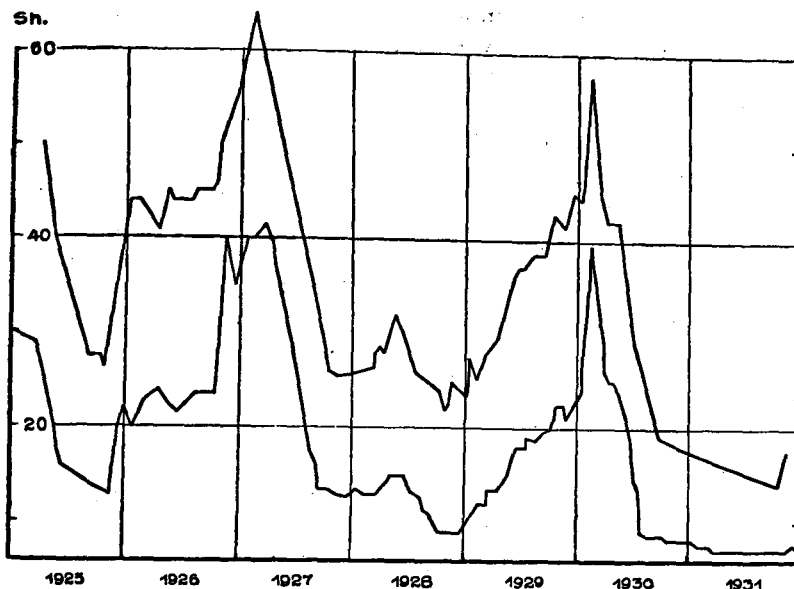


Fig. 14.

Freight rates for oil tankers 1925—1931. (Medium-rates for clean tankers 65/9500 tons fixed to U.K. Cont. E/H with loading one upto two months after fixture.) Above: California. Below: Russian Black Sea. After a curve computed by the shipbrokers Conrad Boe Ltd. A/S Oslo.

(Fig. 13 and 14) shows a lag between the tops of the two curves of from 1 year to 1½ year:

Summit of tank rates. year quarter		Summit of construction of tankers. year quarter		Difference in quarters of a year
1924	1	1925	1	+ 4
1925	1	1926	2	+ 5
1926	1	1927	3	+ 6
1927	1	1928	2	+ 5
1928	2	1929	4	+ 6
1930	1	1931	1	+ 4

The size of this lag is of course determined mainly by the period of time required to construct an oil-tanker. High rates call forth a great offer of newly constructed tankships about one year later and low prices are followed by a small offer about one year later.

That this swinging can go on relatively independently of the swinging of the general shipbuilding is a consequence of the independence of the market of tankers from the ordinary freightmarket. The scarce material we have here seems however to give just reason for believing that both the construction and freight rates of tankers have a tendency to move not only independently of, but opposite to the motions of general shipbuilding and ordinary freight rates. If we here suppose 1) either that the demand for oil fuel from the part of the motorships is of importance 2) and/or the cycles for the construction of motor tonnage runs parallel with the curve for the construction of oil-consuming capital instruments in general, the contrast might perhaps be explained by the circumstance that the greatest demand for oil fuel will not rise when the machines are constructed, but when they are finished and come into function.

It is obvious that we here with respect to the construction of tankers have to deal with a marked «pig cycle», that is: «eine endogene zyklische Bewegung, die dadurch entsteht, dass das Angebot nur mit Verzögerung dem Preise folgt, und die durch die «Reaktionsintensität» beeinflusst wird, mit der das Angebot auf vom normalen abweichende Preise antwortet.» (*Tinbergen*, Ein Schiffbauzyklus?, *Weltwirtschaftliches Archiv* 34. Band, 1931 II, p. 164).

There is reason for believing that similar circumstances are at work with regard to ordinary shipbuilding, and that they here call into existence a cyclical movement with a period of about 2 years. This minor cycle is however not so dominating for ordinary ships as for tankers, a fact that may be explained 1) by the fact that the tank trade is a new trade, where replacement does not yet play any significant part and 2) by the fact that this branch has lately undergone a very strong expansion, which to a great extent has been of a pronounced speculative character.

§ 6. Excurs 2. Tinbergens «Schiffbauzyklus».

In his paper «Ein Schiffbauzyklus?» (*Weltwirtschaftliches Archiv*, 34. Band 1931 II, pp. 152 sq.). *J. Tinbergen* attempts to point out the existence of an endogen elementary cyclus with a period of about 8 years in the world shipbuilding. This cyclus he explains by the hypothesis that there exists a relationship between the increase of world tonnage at one point of time and the size of the world tonnage about two years previously.

We have demonstrated, (§ 5) especially with regard to the building of tankers, that there exists an elementary cycle with a period of about

two years. Of course the existence of one such cycle does not, however, exclude the existence of cycles with different period. It is a well known fact that the same complex of causes may very well create several cycles of different periodical length.

A factor that will be of importance is the breaking up of ships. Owing to the fact that most old ships ripe for being broken up are in the hands of typical second-hand companies, one may assume that it will require a long time before new constructions will influence the breaking up of ships.

The main difference between Tinbergens Schiffbauzyklus and our replacement cycles, is that Tinbergens cycle stands in relationship to the «death curve» of ships and our cycle stands in relationship to other «life characteristics» of ships.

PART IV. LIFE CHARACTERISTICS OF SHIPS

§ 1. Introduction.

In Part III we have put up times series, as we for every quarter in the period 1884 to 1933 have found how much tonnage was built for Norwegian account, and how much of this may be considered as new investment, and how much has been built in connection with replacement of older ships.

In the present Part IV we proceed in a somewhat different way, following the total tonnage of ships built in the same year in their further course of life. We follow all ships built in the years from 1883 to 1927 from their entering our material and up to the turn of the year 1932/33, or until they depart from the material again.

Our main purpose is to find out how great a part of the ships built in the different years was replaced and at what ages the replacement has taken place.

We have here confined ourselves to follow steam-, diesel-, and tank-ships. The reason for excluding the sailing-ships from this part of our investigation is that only sailing ships constructed in the last years before the definite transition to steam ships would have been included. There is reason to presume that the life course of these lastly built sailing ships has not been characteristic to sailing ships in general.

Of the included ships we further follow only those having belonged to Norwegian shipowners from their construction, consequently we exclude ships purchased from abroad as second-hand tonnage. Further we only follow ships as long as they are belonging to Norwegian ship-owners, that is only until they leave the register, or are enlisted in the register with foreign owners.

We must here be aware that our material of ships built in the years from 1883 to 1895 is not complete. (Comp. p. 116).

§ 2. We have Used Actuarial Methods.

Our task, to follow a stock of ships on their way from the ship building yard to the day of their being broken up, gives marked points of resemblance to that of the life-insurance statistician when he follows a number of people from their birth to the grave, and for every year of life tries to find so-called «life characteristics» of the material, as death probability, number surviving, life expectancy, average life time a. s. o. It is therefore natural that we here tackle our problem as much as possible in accordance with actuarial methods, and use the terms and symbols of the actuaries whenever possible. There is indeed nothing new in the application of these methods on physical capital instruments. Comp. for instance *Kurtz'* and *Winfrey's* investigations mentioned above. (Comp. p. 51).

We must, however, be aware that the analogy with the life insurance statistics won't do in all details. The characteristics we try to find for the ships are not identical with the «death characteristics» traced by actuaries and also by Kurtz. What our investigation above all is aiming at is, naturally, to find figures characterising *the replacement* of ships. And, as pointed out above (comp. p. 103) it is characteristic for ships that — apart from replacement after shipwrecks — there is no connection between the replacement curve and the death curve of the ships. Due to the strong tension, to which they may be exposed, the ships must be built so solidly that their average life time will surpass that which economical considerations alone would imply. Technical development, therefore, has the consequence that ships regularly become obsolete a long time before they are physically worn out, so that, when the first-hand owner sells them in order to replace them by new constructions, they may still for a long time be kept in activity by second-hand owners.

This distinction between the death curve and the replacement curve for ships is a fact which renders the actuarial and econometric analysis of the replacement of the ships much more intricate than it is in other material where a closer connection between the two curves is to be found.

§ 3. The Distinction Between First-Owner Ships and Others. Characteristics We find for First-Owner Ships.

It has been advantageous in this investigation to make a division of the material between ships belonging to *first-owners*, i. e. owners who first acquired the ships as new constructions, and ships belonging to

later owners. We call the first ones «first-owner ships» and the rest «second-owner ships», not regarding whether they are belonging to the second owner or have changed owners several times. We have put up most of the following tables both for first-owner ships separately and for total, i. e. for first-owner ships + second-owner ships.

The reason for our making this distinction will appear from the following, so we need not go further into that now.

The fundamental tables in Part IV we have put up separately for ships built in every year from 1883 to 1927. As to first owner ships we have put up tables for

1) *Departure* from first owner, both total and separately as to various causes of departure, viz.:

a) *Wrecking*, we here do not only comprise actual nautical shipwrecking, but all accidents making a ship unrepairable, as fire, explosion, torpedoing or mine sinking during the Great War a. s. o.

b) *Sales*. As to first owner ships it is of no importance whether a ship is sold to another Norwegian owner or abroad.

Further causes of departure are possible, for instance breaking up, condemnation, dismantling, reconstruction to lighter. It appears, however, that in the present material there are exceedingly few steamers which die a natural death in Norway. Only in a very few cases during the whole period ships are recorded to be: «sold to be broken up» or similar. We have then included these few cases in sales.

During the Great War it appeared further in a couple of cases that ships left the owner because they were taken as prizes. We have put up these cases together with shipwrecks (war losses).

In this connection we may also refer to what we have said above (comp. p. 117) about the supplementary numbers of the registers for the period before 1895 in most cases only giving information concerning the transition to another Norwegian owner, not concerning other causes of departure. We have therefore for the oldest part of our material for the first living years of the ships a group with cause of departure: *not recorded* (this is the case with some of the 1883-ships, in their age from 0 to 12—13 years, some of the 1884-ships in their age from 0 to 11—12 years a. s. o. until some of the 1895-ships in the age of 0 years). We have reckoned these unknown cases together with wrecks. During the first years, then, wrecks probably show a little to high figures. These cases of unknown departure are not many, however, and play an insignificant part in relation to the entire material, so it is likely that they do not influence our characteristics discernibly.

2) On the basis of the original size of the tonnage built in a year (the primary stock) and the tables for total departure from first-hand owner, we have further calculated tables for *stock at first-hand owner* at every age. I. e. how great a part of the ships built in every year which, in the possession of the first-hand owner, lived through the commencement of the 1st, 2nd, 3rd, a. s. o. age year. This table corresponds to a table of «number surviving», (a decrement table) of the life insurance statistics.

3) *Replaced* for first-hand owners. Total and separately for:

a) sold and replaced

b) shipwrecked and replaced.

Naturally we reckon here, as elsewhere in our investigation, only replacement through *new constructions* (comp. p. 130).

Further we must be aware that here, in contrast to table 1, we are considering the tonnage of the departed ships, not that of the new constructions. Further we consider the replacement age for the age of the ship, when leaving first-hand owner, not for the age that it had, or might have had, at the time when the new construction was finished.

§ 4. List of symbols.

We apply following symbols:

$L_{x,t}$ = tonnage built in the year t , entering the age of x years.

$D_{x,t}$ = departure of tonnage built in the year t , during its x th year of living.

$D_{x,t}^{(s)}$ = departure of tonnage built in the year t during its x th year of living owing to sales.

$D_{x,t}^{(w)}$ = departure of tonnage built in the year t during its x th year of living owing to shipwrecks.

$C_{x,t}$ = tonnage built in the year t , departing during its x th year of living and being replaced.

$C_{x,t}^{(s)}$ = tonnage built in the year t departing during its x th year of living owing to sales and being replaced.

$C_{x,t}^{(w)}$ = tonnage built in the year t departing during its x th year of living owing to shipwrecks and being replaced.

All quantities are measured in tons gross.

Further we have formed the following probabilities:

$$q_x = \frac{D_x}{L_x} = \text{probability of departure}$$

$$q_x^{(s)} = \frac{D_x^{(s)}}{L_x} = \text{probability of departure owing to sale}$$

$$q_x^{(w)} = \frac{D_x^{(w)}}{L_x} = \text{probability of departure owing to shipwrecks.}$$

$$q_{x,t} = \frac{D_{x,t}}{L_{x,t}}$$

$$m_x = \frac{C_x}{D_x} = \text{maintenance percentage}$$

$$m_x^{(s)} = \frac{C_x^{(s)}}{D_x^{(s)}} = \text{maintenance percentage for tonnage sold}$$

$$m_x^{(w)} = \frac{C_x^{(w)}}{D_x^{(w)}} = \text{maintenance percentage for tonnage wrecked}$$

$$r_x = \frac{C_x}{L_x} = \text{probability of replacement}$$

$$r_x^{(s)} = \frac{C_x^{(s)}}{L_x} = \text{probability of replacement for tonnage sold}$$

$$r_x^{(w)} = \frac{C_x^{(w)}}{L_x} = \text{probability of replacement for tonnage wrecked}$$

$$l_x = l_0 (1-q_0) (1-q_1) \cdots (1-q_{x-1}) =$$

decrementable of tonnage entering its xth year of living,
when $l_0 = 100\,000$ tons gross.

$$d_x = l_x - l_{x+1} \text{ departure during the xth year of living, when}$$

$l_0 = 100\,000$ tons gross.

§ 5. Characteristics for Total.

For the total (first-owner ships + second-owner ships) we have put up the following fundamental tables:

1) *Departure* from total. We must here be aware that one of the reasons for departure concerning first-owner ships, viz. sales to another Norwegian owner, will not be present here, as the ships do not leave the material. Consequently we have here only two reasons for departure, for which we have put up separate tables:

- a) shipwrecking
- b) sales abroad

2) *Total stock*. On the basis of the original stock, (which here is the same as for first-owner ships), and the departure from total we find table for stock total (the surviving table). This table displays to us for

every year how great a tonnage being in the possession of *Norwegian owners*, lived to see the beginning of the age of 0 year, 1 year a. s. o.

3) Total *replacement*. Combined and separately for:

a) replacement at shipwrecking

b) replacement at sales. Sales comprise here both sales abroad and sales to another Norwegian owner. A ship may here both be sold and replaced without leaving the stock. Further the same ship may be sold and replaced *several times*.

There may, however, be reason to presume that replacement of ships, which have been belonging to the second owner for a short time, will take place very casually, and we have then put up the rule that we do not consider other replacements than those which take place *three years* or more after the acquisition of the ship by the second owner. As to second-owner ships, we then claim a *time of rest* for at least 3 years. (Reckoned in full years.) This limit is rather arbitrarily chosen.

We have then for the total introduced the same symbols as for first owner ship, viz. L = stock, D = departure (notice here the difference from first owner ships, viz. that the sales to another Norwegian owner are not included). C = replacement.

On the basis of these characteristics we have further calculated

$$\text{probability of departure } q_x = \frac{D_x}{L_x}$$

$$\text{probability of replacement } r_x = \frac{C_x}{L_x}$$

For the total it would however have no meaning to calculate a maintenance percentage on the basis of C_x and D_x as these have no relation to each other. As C_x comprises replacement also on the basis of sales to another Norwegian owner, which is not included in D_x , a maintenance percentage on this basis might be greater than 1, indeed it might turn out to be infinite.

It would naturally here be possible to calculate a maintenance percentage for total by putting up the C_x replacement in proportion to the departure D_x + sales to another Norwegian owner.

It is, however, scarcely worth while to calculate this maintenance percentage because:

1) This maintenance percentage would not be of any use, because the replacement is not put up in relation to the departure.

2) Secondly it is not so natural here in the total as it is with regard to first-owner ships to put the replacement in relation to change of owner or shipwrecks. The conditions will appear wholly differently for first owners as compared with typical second owners.

A first owner will usually represent a shipping company running first class modern tonnage, and accustomed to renew his stock of ships through acquisition of new constructions. Further a first owner will have purchased his ships at full price as new constructions. When the amortization period has elapsed he will consequently normally have the full value of a newly built ship ready for reinvestment. It is therefore natural to expect that departure from the first owner will be followed by replacement through new constructions.

A second owner, on the other hand, will have purchased the ship secondhand and will to a broad extent represent the typical «second-hand» shipping companies. While the first owners often are competing on the basis of first class service, the second owners will compete on the basis of cheapness of price. Further the second owner will have purchased the ship at a price which usually will be considerably below the new building price, he will not, therefore, have such a great amount of money to amortize and to reinvest which is necessary for the purchase of a new ship. Therefore it will not be the typical proceeding of a second owner to replace by new constructions.

It appears further that ships, sold from the first owner very usually are changing owners at short interval later on. There is then no logical reason for placing these ownerchanges in connection with replacement by new constructions.

As to the second owner it is further obvious that the replacement probability not only is dependent of the age of the ship at the departure, but also of the age of the ship at the acquisition (or, as we might put it: of the «time of rest»). It would, however, be a very complicated task if the consideration of this factor should also be included. (The age and time of rest as to the first owner ships are coincidental.)

From the tables for first-owner ships and for total we may calculate as a difference:

Replacement for second-hand ships.

Replacement probability for second-hand ships

The difference will give no result as to departure. On the basis of stock and replacement for second hand ships we might further calculate:

Replacement probability for second-hand ships $\frac{C_x}{L_x}$

§ 6. The Elimination of the Material of the Period of the Great War.

In our material the stock of ships constructed in every one of the years from 1883 to 1918 (included) will, in one period of their course of life, be influenced by the Great War. The 1900-ships, for instance, will be influenced by the War when they are between the ages of 13 and 18 years. The 1901-ships between 12 and 17 years a. s. o. until the 1918-ships, which, as to some of the ships, will live through the time of war in their 0th year.

The conditions during the Great War were extraordinary both with regard to departure and replacement. The most important factor is that we get a new cause of departure, *the war losses*, which have a very strong influence.

If we shall succeed in obtaining normal characteristics of the ships, we must try to eliminate the effects of the Great War from our material.

This problem will be analogous to the one which insurance statisticians had to face, when trying to eliminate the effects of «The Spanish Influenza» from their tables of mortality. In solving this problem they put up the Spanish Influenza as a separate cause of death. (It is obvious, however, that it will not always be possible to decide which deaths were due to the Spanish Influenza and which not.)

We might proceed in the same way and be content to put up a *separate* group with the *cause of death: shipwrecks during the war*. It is obvious, however, that it is not easy to eliminate the effects of the Great War on departure and replacement from our material.

1) Firstly, it will be difficult to distinguish between war losses and shipwrecks not due to war. During the Great War, also the wrecks, not being directly due to war operations, were to a broad extent indirectly caused by the extraordinary situation created by the war. In many ways the conditions of the shipping industry were completely changed, among other things because many of the usual *sea ways* were closed, so that the ships had to find new, unknown routes. Any distinction between war shipwrecks and ordinary shipwrecks will, therefore, be rather an arbitrary one during this period.

2) Secondly, departure through sales was strongly influenced by the situation. During certain periods of the Great War, many ships changed their owner nearly every month.

3) Also the figures for replacement are extraordinary during this time of war. During the last years of the war there was an unusually small number of new ships built on Norwegian account. Comp. the

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If we shall succeed in obtaining normal characteristics of the ships, we must try to eliminate the effects of the Great War from our material.

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2) Secondly, departure through sales was strongly influenced by the situation. During certain periods of the Great War, many ships changed their owner nearly every month.

3) Also the figures for replacement are extraordinary during this time of war. During the last years of the war there was an unusually small number of new ships built on Norwegian account. Comp. the

figures for new constructions in 1918 and 1919. Many ships, which departed during the Great War, were therefore replaced rather a long time afterwards. This, in connection with the numerous and frequent sales of ships during the War, makes it of course very difficult to find connection between departure and replacement in the individual cases. The figures for replacement during the War and the following period are, therefore, necessarily of a far more arbitrary character than during more quiet periods.

4) In the fourth place we may in this connection mention the effect which the war wrecks may have on the figures of the various probabilities, because they will influence the stock in the course of the year. We calculate for instance the probability for sales in the x th year ($Dx(s)$) by putting departure through sales *during* the x th year in relation to the stock, Lx , *at the beginning of the year*. When this stock is strongly reduced during the year due to war shipwrecks, it is obvious that the percentage we calculate for departures on this basis will be too low. (This objection might of course be raised also against our method of calculation in general. No doubt it would be more correct to put departure during a year in relation to stock at the middle of the year. In normal periods of time departure Dx will, however, mostly be so insignificant that this does not count.)

As the purpose of this investigation above all must be to find *normal* life characteristics of ships, it is no doubt most correct to *exclude the whole period of war* from our material.

In the present form of our tables it is not possible to exclude the exact time from August, 1914, to November, 1918, from them. Our tables are recorded according to the age of the ships, their years of life reckoned in months. Thus the period of time, when a ship built in the year 1900 has completed its 10 years, but has not yet completed its 11 years, may comprise a period from the 1st month in 1910 (when ships built in the first month of 1900 complete their 10 years) to the last month in 1911 (when ships built in the last month of 1900 complete their 11 years), a period of nearly two years.

We have chosen the following method: At every age we have excluded 5 succeeding years, thus from 0-year ships we exclude the ships built in the years 1914, 15, 16, 17 and 18, from 1-year ships the ships built in the years 1913—1917 (1917 included) a. s. o.

This method is not quite exact. Firstly, we exclude a little too much material. Thus we exclude all the 0-year ships of the year 1914, but a ship built in the first month 1914 will not be influenced by the time of war during the first 8 months of its 0th year. For 1913 ships the same

is the case as to 1-year old ships a. s. o. Further we exclude all 0-year ships of the year 1918. A ship constructed in the end of 1918 will, however, not at all be influenced by the War.

Secondly, we have excluded rather little material. The 1913 ships are thus only excluded from the material as 1 year old ships, but a ship built in the last month of 1913 will be about 8 months old at the outbreak of the war. There is, however, no reason to presume that this will be of any importance.

Thus we have got a material in which we may find the life characteristics of the ships built in the years 1883—1927 for the period 1883—1932, the period of war eliminated.

This does not mean, however, that we have totally eliminated *all* effects of the Great War. Thus it is not certain that for instance the 1910 ships, having been abnormally strongly reduced at an age from 4 to 9 years due to the Great War will display the same probabilities with regard to departure and replacement later on as they might have displayed without any war. We might have eliminated this source of error from our material in not including the ships existing during the Great War longer than to the outbreak. It is doubtful, however, whether we ought to make this deduction, as it will be the actual probabilities for the period after the Great War which are of special interest to us.

Further, the concentrated age distribution of the fleet, due to the forced reconstruction during the years immediately after the war, will influence various probabilities. And the reduced size of the fleet after the Great War may also have some influence.

§ 7. Calculated Tables.

On the basis of the departure — and replacement — probabilities found in our material, we have constructed so-called «calculated tables», where we start with an original stock of new constructions amounting to 100 000 tons, and calculate how this stock will die out and how it will be replaced.

From these calculated tables we may then directly observe how great a part of the original stock of 100 000 tons would exist at the beginning of the 1st, 2nd year a. s. o. according to the found probabilities. From our earlier tables we were able to see that a ship would have this and that probability for departure from its, let us say, 14th and until its completed 15 years. It is obvious, however, that it would be of greater interest to us to find the rate of probability as to whether a 0-year ship is existing at the entrance of, let us say, the 15th year of age, and this we may observe directly from the calculated tables for stocks.

Further a table, calculated for replacement of 100 000 tons of new constructions, will show how the replacement of this original stock will be distributed throughout the various ages.

§ 8. Smoothed Probabilities.

As to some of the probabilities for first-owner ships we have moreover formed smoothed tables, and on the basis of these smoothed tables we have formed calculated tables of stock and replacement. The purpose of the smoothing is to eliminate casualties.

The smoothing has been performed by a linear operation which eliminates the erratic factor and short cycles, but leaves the longer cycles intact. The applied operation is a so-called «smoothing operation» with a levelling period for periods between 0 and 4.

§ 9. Results for the Material Not Divided in Time.

We shall now look at the results we have obtained in this part of the investigation. Of the greatest interest to us are the *probabilities* that we find for departure and replacement of the ships and the *calculated tables* we find on this basis. Of general interest are further preferably the tables calculated on basis of a material where the effects of the extraordinary situation during the years of the *Great War* are *eliminated*. We will mainly regard the results for *first-owner ships*.

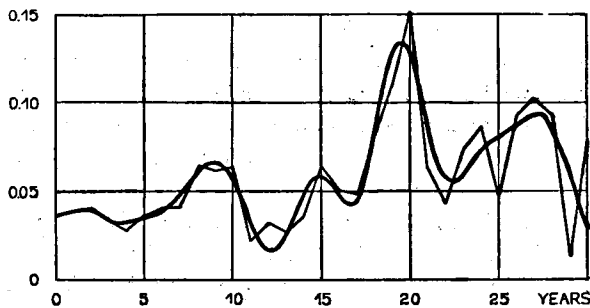


Fig. 15.

Probability of departure for first-owner ships. $\left(q_x = \frac{D_x}{L_x} \right)$

¹ Comp. Ragnar Frisch, lectures on time series analysis, mimeographed 1934 (in Norwegian).

$$1) \text{ Probability of departure } q_x = \frac{D_x}{L_x}$$

The curve for the probability of departure shows summits at following ages:

- 1) 8—10 years
- 2) 20 years (maximum).

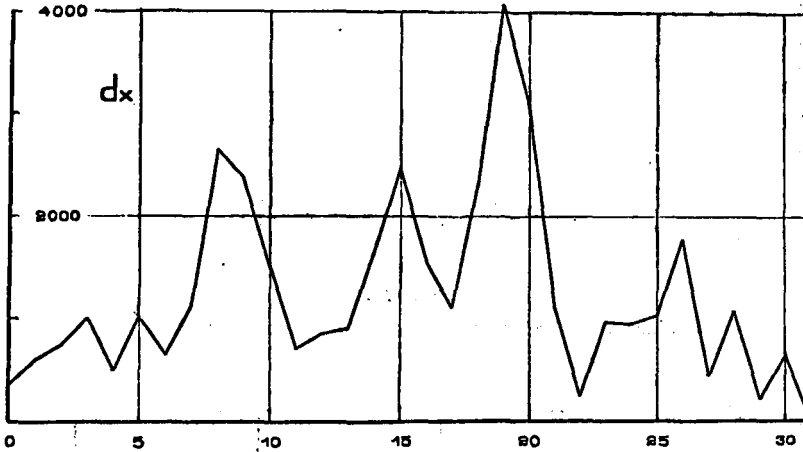


Fig. 16.

Calculated departure. (dx = departure during the x th year when $l_0 = 100\ 000$ tons) First-owner ships.

2) A better expression for the importance that is to be given to these tops we get from the table for *calculated departure* dx (dx = departure in the x th year when $l_0 = 100\ 000$ tons). This table shows how great a part of a stock of 100 000 tons newconstructed ships will leave the firstowner in different ages. We also here refind summits at 8—10 and 20 years. But the first of these tops here is relatively of more importance than in the curve of the probability of replacement. The top at 20 years is, however, still the greatest one.

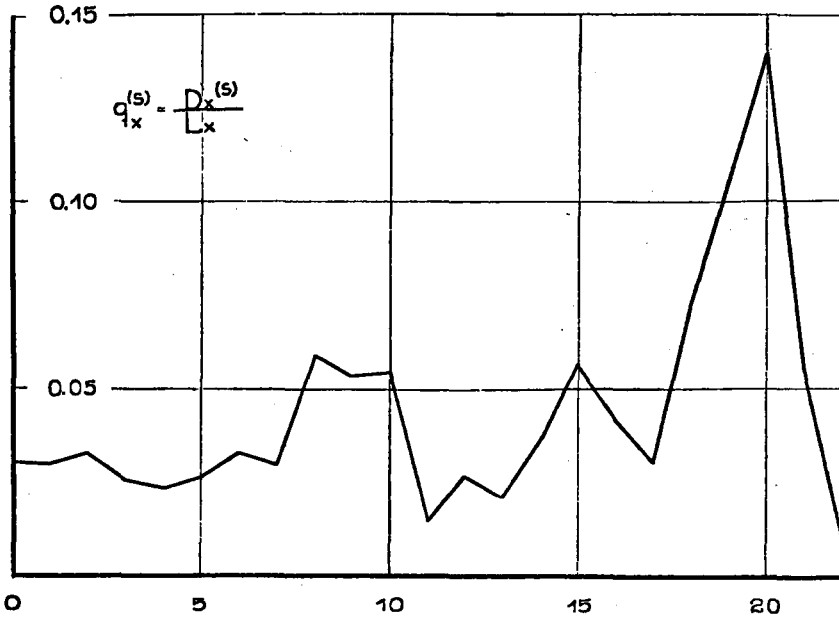


Fig. 17 a.

Probability of departure owing to sales. First-owner ships.

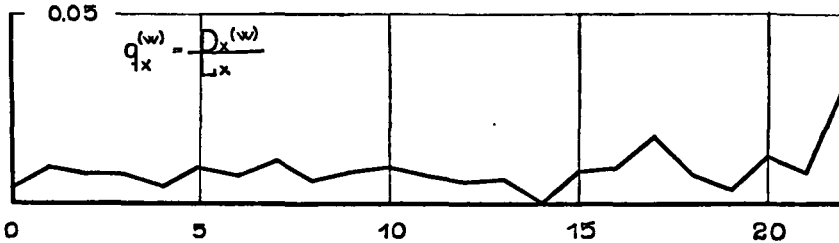


Fig. 17 b.

Probability of departure owing to shipwrecks First-owner ships.

When we regard the separate curves for the probability of departure owing to sales $q_x^{(s)}$ and departure owing to shipwrecks $q_x^{(w)}$ it becomes evident that the characteristic features of the total curve are due to economic factors. We see that the curve of the probability of departure for shipwrecks only shows accidental oscillations about a constant level. The curve of the probability of departure for sales, however, shows the same tops that characterize the curve of the total departure.

3) Probability of replacement

$$r_x = \frac{C_x}{L_x}$$

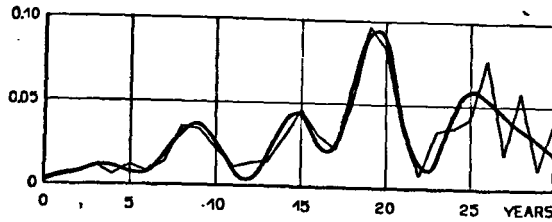


Fig. 18.

Probability of replacement. First-owner ships.

The curve for probability of replacement has tops at the following ages:

- 1) 8—9 years
- 2) 19—20 years.

We see that we here get the same tops as we found for the probability of departure, there is, however, a tendency of moving forwards to somewhat lower ages.

4) «The replacement forecast».

$$P = d_x p_x = d_x \frac{C_x}{D_x}$$

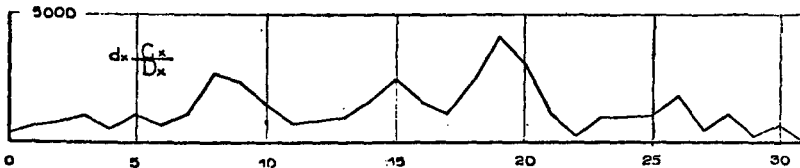


Fig. 19.

The replacement forecast. First-owner ships.

The curve shows how the replacement of an original stock of 100 000 tons will be distributed over the time. (Calculated in relation to the time of departure of the shifted out tonnage, not the time when the new constructions are finished.)

We also here find tops at the ages of 8—9 year and 19—20 years. This curve will be of special importance for our later work, because it will be especially apt as a basis for forecasting the replacement.

5) Percentage of maintenance

$$p_x = \frac{C_x}{D_x}$$

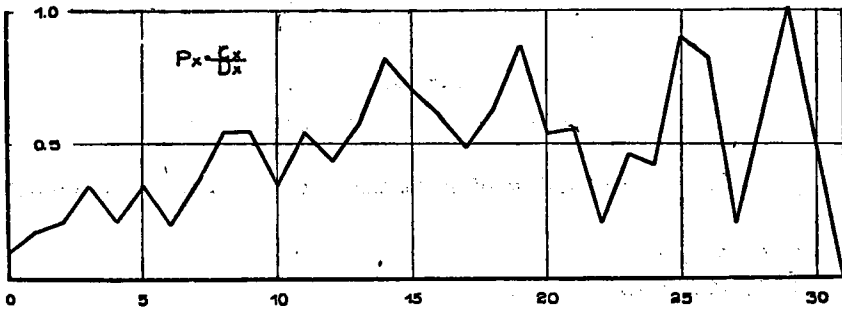


Fig. 20.

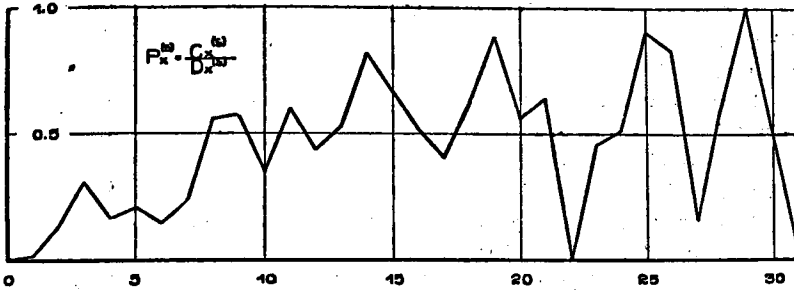
Percentage of maintenance. First-owner ships.

The curve showing percentage of maintenance has a different form from that of probability of replacement. One may express the difference by saying that while the probability of replacement showed a difference of level, the percentage of maintenance oscillates about a level.

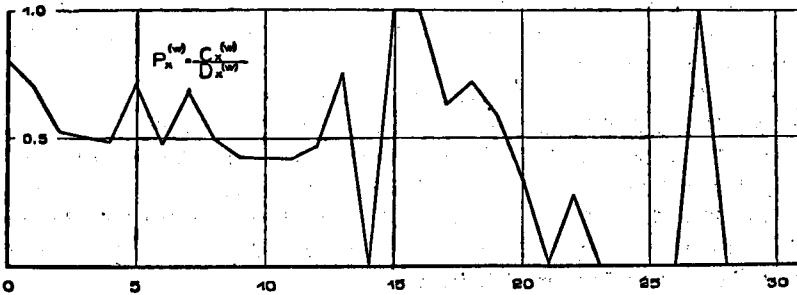
For the curve of the percentage of maintenance we find, however, tops at the «typical» ages of 8—9 years and 19 years as well. We could expect this because *a priori* it was to be supposed that of the ships that depart in the typical ages of replacement a somewhat greater percentage will be replaced than of ships departing in non-typical ages.

On the other side, the difference in our curve between the percentage of maintenance in typical and non-typical years is not so great as to indicate that any systematic error has come into existence because of a subjective preference in the handling of the material.

The level about which the percentage of maintenance is swinging in our curve has a rising trend. The explanation of this increase with the age becomes evident when one regards separately the curves for the percentage of maintenance for sold ships and for wrecked ships.



Percentage of maintenance for sold ships. First-owner ships.



Percentage of maintenance for wrecked ships. First-owner ships.

The percentage of maintenance for the sold ships starts from zero and increases steadily till it reaches a level of about 0,7, where it remains. This is also in accordance with what one might expect beforehand. The shipowners who part with a ship that is practically new will in most cases do so because they are obliged to «go out of business» or of similar causes, and not because they want to replace it with a new construction.

The percentage of maintenance for wrecked ships, on the other side, has a quite different form. It starts from a relatively high level (about 0,7) and then sinks slowly to a level about 0,55 where it remains.

§ 10. Dividing the Material.

1) The purpose for our dividing the material.

The probabilities we have discussed in § 9 are calculated for all ships included in this part of our investigation and for all the years from 1884—1932 (except the war period). It is, however, clear that it will be

of great interest to try if these probabilities will bear that the material is divided. We will find out if separate parts show the same characteristics as we have found for the whole material.

If the material should prove not to be homogeneous, the reasons might be:

1 A *trend*, a development in time that for a later period causes characteristics different from those of an earlier period.

2 *Systematical* differences, that certain years (years of prosperity, for instance) have other characteristics than others.

3 *Accidental* differences. It will then be a question, into how small parts the material can be divided without the casualties playing a dominant part.

It will of course be of greatest interest to divide the material where the period of war is omitted. We have only divided the material for first-owner-ships.

2) *Different ways of dividing the material.*

A. The material may be divided with regard to, firstly

a) *The year in which the ships are constructed. (Jahrgang.)* One may for instance regard separately the ships constructed during the years 1883—1892, 1893—1902 etc. As the ships constructed during the same year are placed on one line in our tables, we will call this way of dividing a *horizontal division*.

b) Secondly, the material may be divided with regard to the *year when the departure takes place*. We then for example calculate characteristics separately for the years 1884—1893, 1894—1903 etc.

As, however, our tables in Part IV are set up with reference to the age of the ships and not with reference to the calendar year, we are only able to get an incomplete expression for the division in years. We here use the same method that we used in eliminating the years of the Great War from our material. (Comp. pp. 165—167.)

We call this way of dividing the material *zigzag division*, because the years follow a zigzag line in our tables.

B. For every one of the under A. mentioned ways of division the division may further be done

a) in *periods of time*, for example (a) ships constructed in the years 1883—1892, 1893—1902 etc. (b) ships sold in the years 1884—1893, 1894—1903 etc.

or β) in different *phases of the business cycle*: revival, prosperity, recession, depression.

For example separately a) ships constructed during revival, prosperity etc. or b) ships sold during revival, prosperity etc.

What ways of division we choose will of course in the single cases be determined by the purpose of the proceeding, for instance if we want to find out whether there exists a trend or a systematic error.

3) Division of the material in two periods of time.

We have elaborated this division both with regard to ships built in the same year and with regard to ships sold in the same year.

A) Division in periods of time with regard to the year when the ships are constructed. (Jahrgang.)

We have here calculated characteristics separately for ships constructed during the years 1883—1902 and for ships constructed during the years 1903—1927.

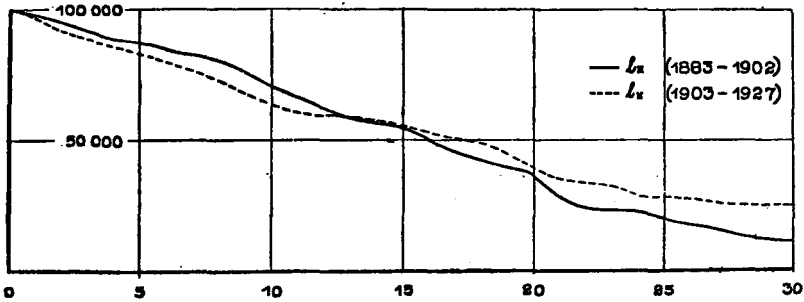


Fig. 22.

Calculated stock (number surviving) for the ships built in the years 1883—1902 and 1903—1927. First-owner ships.

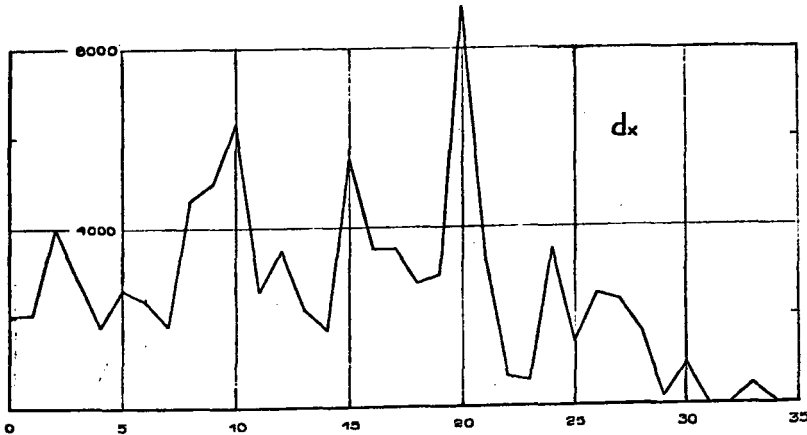


Fig. 23 a.

Calculated departure for the ships built in the years 1883—1902. First-owner ships.

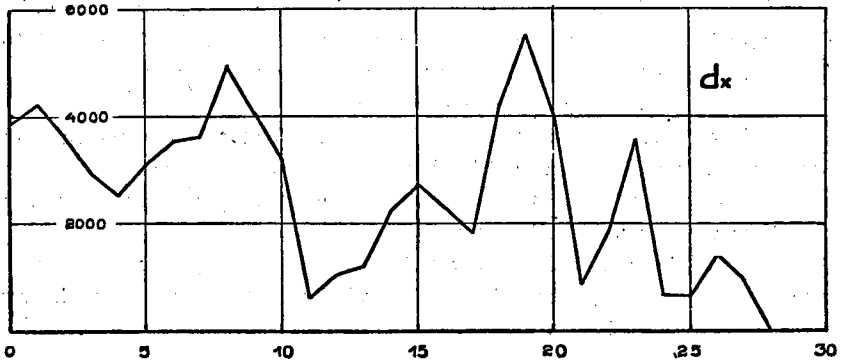


Fig. 23 b.

Calculated departure for the ships built in the years 1903—1927.
First-owner ships.

The curves for *calculated stock* (number surviving) and *calculated departure* for the two parts show a great conformity. However, the curves also indicate a certain trend as ships constructed in the years 1833—1902 did not so frequently leave their first-owner at young ages as ships constructed 1903—1927, and conversely as to the higher ages. The curves cross each other at the age of 13 years. (One must be aware that this concerns depart from firstowner, and has nothing to do with the age reached by the ships in the possession of Norwegian shipowners, nor with the age at which the ships are broken up.)

Calculated replacement.



Fig. 24 a.

Calculated replacement for the ships built in the years 1883—1902.
First-owner ships.

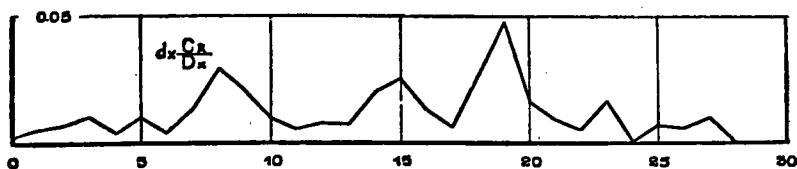


Fig. 24 b.

Calculated replacement for the ships built in the years 1903—1927.
First-owner ships.

The curves show that the tops are lying about one year previous for the ships constructed in the second period.

B. Division i periods of time with regard to the year when the ships were sold.

We have parted the material in the prewar period, comprising the years from 1884 to 1913, and the postwar period, 1919 to 1932.

Probability of replacement.

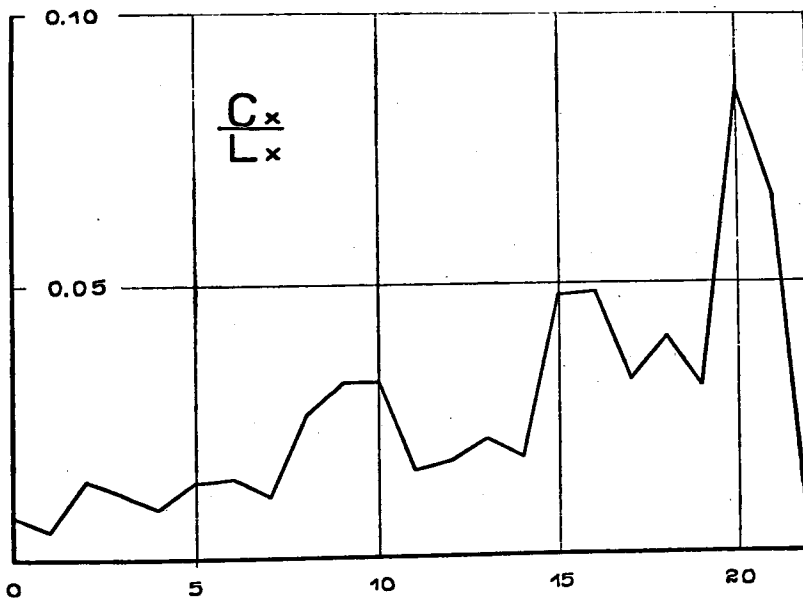


Fig. 25 a.

Probability of replacement for the ships sold or shipwrecked in the period 1884—1913. First-owner ships.

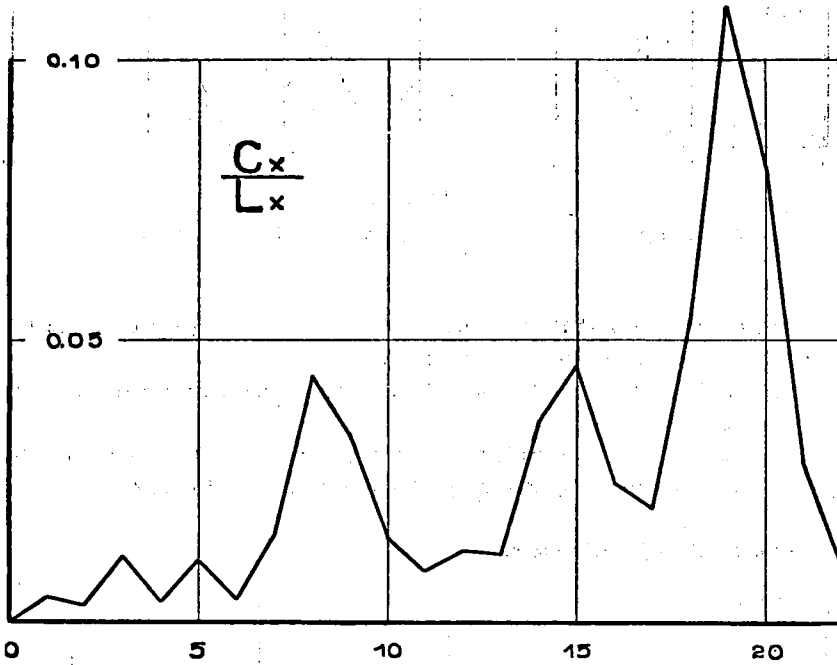


Fig. 25 a.

Probability of replacement for the ships sold or shipwrecked in the period 1919—1927. First-owner ships.

The two periods show the same main characteristics as the total curve. Some difference is however to be noticed, as the tops of the post-war are lying somewhat earlier.

Calculated replacement.



Fig. 26 a.

Calculated replacement for the ships sold or shipwrecked in the period 1884—1913. First-owner ships.

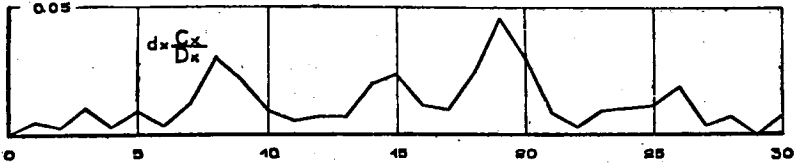


Fig. 26 b.

Calculated replacement for the ships sold or shipwrecked in the period 1919—1927. First-owner ships.

The curves for calculated replacement show the same main characteristics for the prewar and postwar periods. However, a certain tendency to replacement at younger ages manifests itself for the postwar period, as the curves show a difference in phase of about $\frac{3}{4}$ years.

4) Division into phases of the business cycle.

The dividing into phases of the business cycle is worked out after the same lines as the corresponding division in the Part III (comp. pp. 147—148). The only difference is that we then divided with the accuracy of a quarter of a year while in the present part we only divide in years. We have divided as follows:

Division into phases of the business cycle.

Revival years	Prosperity years	Recession years	Depression years
1888	1883	1885	1886
1889	1884	1892	1887
1890	1891	1896	1893
1898	1895	1908	1894
1904	1899	1914	1897
1905	1906	1922	1909
1911	1907	1927	1910
1919	1912		1923
1924	1913		
1925	1920		
	1921		
	1926		

We have only worked out this division after phases of the business cycle with regard to the year when the ships were constructed. (Horizontal dividing.) That is we have grouped the ships regarding whether they

were *constructed* in years of revival, prosperity etc. This division will, firstly, say something about the homogeneity of the material. Secondly, we can find out something about the question whether it is the age of the ships or the actual phase of the business cycle that plays the most important part for replacement.

A somewhat simplified example will show this. We assume that the curve of the shipbuilding has the form of a regular sinus with a period of 5 years. We then see that ships constructed in a period of depression will have an age of 5, 10, 15, 20 etc. years in the succeeding periods of depression that they live to see, and the ages of 2,5, 7,5, 12,5, 17,5 etc. years in the periods of prosperity. If the actual phase of the business cycle is the dominant factor for replacement, so that replacement preferably takes place during periods of prosperity, the age distribution curve of replaced ships (constructed in periods of depression) should consequently show tops at the ages of 2,5, 7,5 etc. years. And in the same manner curves for ships built during revival, prosperity, recession would have their peculiar distribution curves. Only for ships built during revival and during prosperity we could expect the distribution curves to have tops at the ages we have found to be «typical» for the whole material.

If, however, the distribution curves for ships built in all phases have the same tops, we are justified in concluding that it is the age of the ships and not the phase of the business cycle that decides when a ship shall be replaced. Of special importance it will be, of course, if the ships built in years of depression show the same tops in the age distribution curve as found in the whole material.

Our curves show that the material is very homogeneous. The same tops are to be found for ships constructed during different phases of the business cycle. The top of 8—9 years we find for all phases, although less explicit for prosperity. The top of 18—20 years in all phases except that of depression.

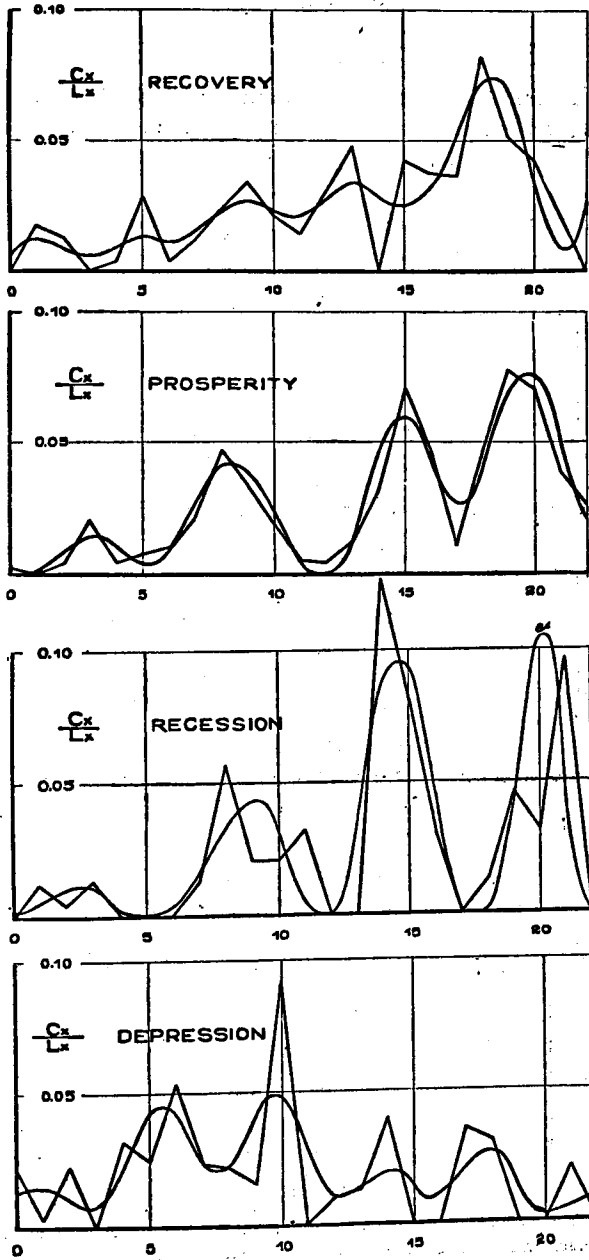


Fig. 27.

Probability of replacement for ships built during different phases of the business cycle. First-owner ships.

§ 11. Curves for Total.

For total, that is first-owner ships and others, we have also included two curves, namely Fig. 28 calculated stock and Fig. 29 calculated departure.

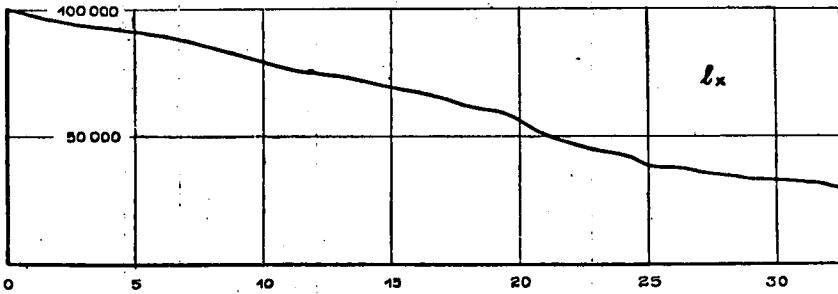


Fig. 28.

Calculated stock (number surviving) for total (first-owner ships and others).

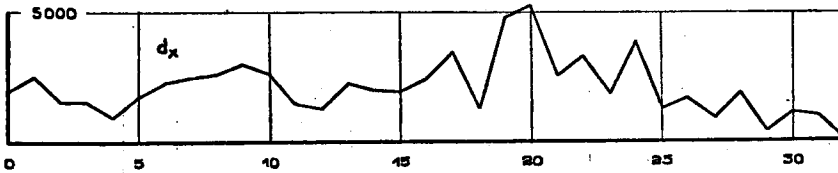


Fig. 29.

Calculated departure for total (first-owner ships and others).

§ 12. Appendix. Forecast of the Shipbuilding for Replacement in the Norwegian Shipping Industry.

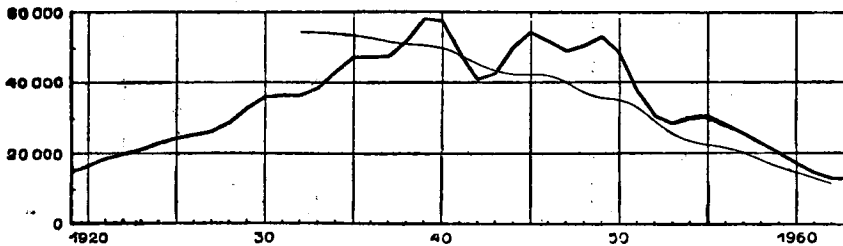


Fig. 30.

Forecast of the replacement shipbuilding in the Norwegian mercantile marine under the assumption that there was no new investment shipbuilding later than 1932.

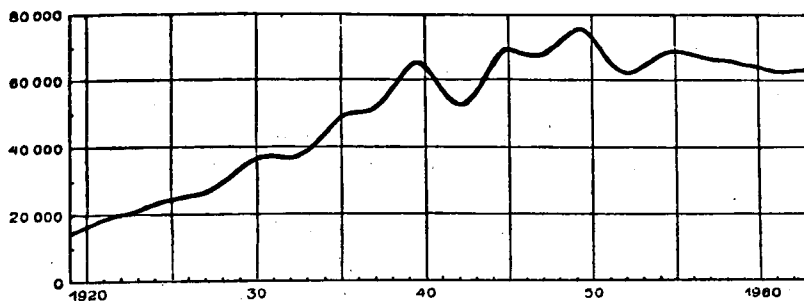


Fig. 31.

Forecast of the replacement shipbuilding in the Norwegian mercantile marine under the assumption of a constant yearly new investment shipbuilding from 1933 of 110 000 tons gross.

Fig. 30 and Fig. 31 show the results of some attempts we have made to forecast the replacement building in the Norwegian fleet from 1919 on under various presumptions.

For these calculations we have used smoothed probabilities of departure and replacement for first-owner-ships on a material consisting of the stock of Norwegian ships of different ages at the beginning of the year 1919, and where the ships constructed in the years from 1919 to 1932 are by degrees included. We have not made the forecast for the period before 1919, because it evidently would be illogical to calculate replacement shipbuilding for the war-period on basis of normal probabilities.

We will here expressively emphasize that these calculations must not be regarded as complete forecasts of the future shipbuilding for Norwegian shipowners. First, we must be aware that our calculations only take into account one part of the future shipbuilding, namely the replacement-building. Further the material used only comprises ships which were acquired by Norwegian shipowners as new constructions. Replacement due to ships which were purchased second-hand from abroad is not included.

We have calculated the future replacement construction under various conditions. We will first consider the curve in Fig. 30, which is calculated under the assumption that there is no new investment construction later than 1932. This curve shows as one will see a rising trend until about year 1940 and then a sinking trend. The rising trend in the first period is a real phenomenon due to two causes, namely, first the rising trend in the total shipbuilding and secondly the fact that the amounts of tonnage

constructed in the years before 1919 had been much reduced by the war. The sinking trend in the last period is merely due to the fact that there is no new investment included in our material later than 1932. The percentage of falling-off will then have the effect that the replacement building must diminish as the stock of ships is reduced. For the last part of the curve, consequently, not the trend, but only the oscillations about this trend are of real interest.

We must, however, be aware that the oscillations around this sinking trend will not be pure Eilert Sundt waves, that is waves that are due to the age distribution of the material. Even if we consider a stock of ships with normal age distribution — that is one which is the result of an unchanged total construction during a long period of years — there will arise oscillations around the sinking trend if from a point of time all new investment suddenly stopped. Such oscillations are due to the fact that the probabilities of replacement and departure are different at different ages of the ships. The thin curve in Fig. 30 shows how the replacement would decrease if we had a stock of ships of the same total size as that which we have used by calculating the thick curve, but where the tonnage constructed in the different years had been constant.

In order to eliminate these effects of the sinking trend we have made the forecast shown in Fig. 31. We have here made the assumption that the new investment from the year 1933 on was a constant magnitude (110 000 tons yearly) corresponding to the average yearly new investment in the previous period. This curve shows a cycle with a rather regular period of five years. The tops are at the years of 1925, 1930, 1935, 1939/40, 1945, 1949/50 and 1955/56.¹ The first three of these tops correspond fairly well with the tops which can be observed in actual statistical series of shipbuilding for Norwegian shipowners.

The curve indicates that the replacement building will reach extraordinarily big tops in the years of 1940 and 1950. This we might also have expected because of the age distribution of the fleet. About the year 1940 the great amounts of tonnage constructed in the years of 1920 and 1921 will reach their second typical age of replacement of 19—20 years and *simultaneously* the tonnage constructed in the years 1929—31 will reach their first typical age of replacement of about 9 years. The great decline of the curve in the years succeeding 1940 is in the same way due to a cumulation of the small amounts of tonnage constructed in the periods 1922—23 and 1932—33. The top about 1949/50 is due to

¹ The ordinates to the year t in the curves in Fig. 30 and Fig. 31 give the calculated replacement in the time from July 1st in year t to June 30th next year.

the fact that the 1929/31 ships at that time reach the age of 19—20 years.

The present calculations must naturally as all forecasting build on the assumption that the characteristic features of the past will remain unchanged in the future. We assume that the probabilities of replacement and departure — and consequently also the percentage of falling-off — in the future will be the same as we have found for the period of time from 1883 to 1932. This assumption may seem well founded when we regard the long period of time covered by our investigation, in which no substantial changes in these characteristics took place. On the other hand, we must take into consideration the circumstance that the main part of the new constructions for Norwegian shipowners in recent years has been dieselships and to a great extent special-built oiltankers. It is plausible that these ships due to their more delicate machinery will have other «life characteristics» than those which we have found from a material mainly consisting of steamships. Further it is very difficult to predict anything about the future percentage of falling-off in the Norwegian mercantile fleet. This will to a great extent depend on the progress or decline of international trade.

Table 1.

Total¹⁾ new constructions for Norwegian shipowners.

Years Quarters	New constructions in all		Of this:				Replaced for:						
			New investment		Replacement		Wrecked ships only		Sold ships		Not recorded		
	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	
1883	1.	4	1 337	-	-	-	-	-	-	-	-	-	
	2.	14	7 351	-	-	-	-	-	-	-	-	-	
	3.	18	9 489	-	-	-	-	-	-	-	-	-	
	4.	13	7 460	-	-	-	-	-	-	-	-	-	
1884	1.	9	6 707	5	4 028	4	2 679	-	-	1	1 132	3	1 447
	2.	15	7 225	12	5 244	3	1 981	-	-	1	1 422	2	559
	3.	18	8 832	16	8 034	2	798	-	-	-	-	2	798
	4.	16	10 127	13	8 227	3	1 900	-	-	1	401	2	1 499
1885	1.	8	4 923	4	3 244	4	1 679	-	-	1	423	3	1 247
	2.	6	2 571	5	2 276	1	295	-	-	-	-	1	295
	3.	17	9 202	12	5 511	5	3 691	-	-	1	476	4	3 215
	4.	7	2 834	5	2 360	2	474	-	-	2	474	-	-
1886	1.	3	1 013	1	304	2	709	-	-	2	709	-	-
	2.	5	1 883	2	1 024	3	859	-	-	2	613	1	246
	3.	10	4 921	7	2 086	3	2 835	-	-	-	-	3	2 835
	4.	1	442	1	442	-	-	-	-	-	-	-	-
1887	1.	3	1 513	1	490	2	1 023	-	-	1	663	1	360
	2.	6	1 940	2	624	4	1 316	-	-	-	-	4	1 316
	3.	-	-	-	-	-	-	-	-	-	-	-	-
	4.	1	419	-	-	1	419	-	-	-	-	1	419
1888	1.	-	-	-	-	-	-	-	-	-	-	-	-
	2.	7	3 019	6	2 285	1	734	-	-	1	734	-	-
	3.	7	6 693	6	5 195	1	1 498	-	-	1	1 498	-	-
	4.	12	14 478	7	7 967	5	6 511	-	-	1	411	4	6 100
1889	1.	4	2 539	3	2 219	1	320	-	-	1	320	-	-
	2.	12	10 252	8	6 676	4	3 576	-	-	4	3 576	-	-
	3.	9	6 567	6	3 381	3	3 186	-	-	3	3 186	-	-
	4.	15	9 608	8	4 170	7	5 436	-	-	6	5 237	1	199

1890	1.	10	7 520	9	6 898	1	622	-	-	-	-	1	622
	2.	27	18 763	16	8 641	11	10 122	-	-	4	4 520	7	5 602
	3.	18	10 844	6	3 322	12	7 522	-	-	9	5 686	3	1 836
	4.	17	12 529	8	5 554	9	6 975	-	-	4	2 239	5	4 736
1891	1.	21	21 096	13	11 252	8	9 844	-	-	3	4 452	5	5 392
	2.	20	16 827	9	6 268	11	10 559	-	-	10	10 054	1	505
	3.	21	14 341	11	8 750	10	5 591	-	-	4	2 425	6	3 166
	4.	21	12 366	14	8 341	7	4 025	-	-	4	2 303	3	1 722
1892	1.	15	13 361	4	3 902	11	9 459	-	-	6	4 059	5	5 400
	2.	22	15 954	12	8 629	10	7 325	-	-	6	4 124	4	3 201
	3.	19	14 831	11	6 446	8	8 385	-	-	6	5 242	2	3 143
	4.	7	2 768	4	1 731	3	1 037	-	-	3	1 037	-	-
1893	1.	5	6 934	4	6 259	1	684	-	-	1	684	-	-
	2.	14	11 661	9	6 196	5	5 465	1	715	2	3 564	2	1 186
	3.	11	6 788	8	5 023	3	1 765	-	-	1	478	2	1 287
	4.	10	8 284	5	2 688	5	5 596	-	-	4	5 191	1	405
1894	1.	3	5 409	2	3 804	1	1 605	1	1 605	-	-	-	-
	2.	11	11 088	9	7 536	2	3 552	1	558	1	2 994	-	-
	3.	6	3 198	1	395	5	2 803	3	1 915	2	888	-	-
	4.	15	13 007	8	8 211	7	4 796	4	2 405	3	2 391	-	-
1895	1.	6	5 946	3	4 691	3	1 255	1	221	2	1 034	-	-
	2.	10	14 909	8	11 351	2	3 558	-	-	2	3 558	-	-
	3.	12	19 826	7	12 470	5	7 356	3	3 835	2	1 521	-	-
	4.	10	16 258	7	11 716	3	4 542	-	-	3	4 542	-	-
1896	1.	4	4 718	1	1 878	3	2 840	-	-	3	2 840	-	-
	2.	12	15 114	6	3 453	6	11 661	3	7 324	3	4 337	-	-
	3.	16	18 189	7	7 613	9	10 576	2	964	7	9 612	-	-
	4.	4	5 137	4	5 137	-	-	-	-	-	-	-	-
1897	1.	1	1 921	1	1 921	-	-	-	-	-	-	-	-
	2.	8	9 080	6	6 417	2	2 663	1	1 329	1	1 334	-	-
	3.	6	4 892	1	1 860	5	3 032	4	2 820	1	212	-	-
	4.	15	14 287	4	1 935	11	12 352	4	1 963	7	10 389	-	-

1) Total new constructions comprises 1883-1902 Sailingships and steamers.
 1903-1915 Steamers.
 1916-1924 Steamers and dieselships.
 1925-1932 Steamers and dieselships and tankers.

Table 1. (continued)

Total¹⁾ new constructions for Norwegian shipowners.

Years Quarters	New constructions in all		Of this:				Replaced for				
			New investment		Replacement		Wrecked ships only		Sold ships		
	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	
1898	1.	6	2 933	1	242	5	2 691	-	-	5	2 691
	2.	11	18 881	4	4 054	7	14 827	3	2 917	4	11 910
	3.	5	5 944	1	1 041	4	4 903	1	1 135	3	3 768
	4.	17	25 289	4	4 211	13	21 078	2	1 570	11	19 508
1899	1.	14	22 765	5	8 945	9	13 820	-	-	9	13 820
	2.	11	16 377	5	5 212	6	11 165	1	1 032	5	10 133
	3.	13	18 298	4	3 960	9	14 338	3	5 776	6	8 562
	4.	8	12 111	4	4 717	4	7 394	-	-	4	7 394
1900	1.	6	7 079	-	-	6	7 079	1	995	5	6 084
	2.	18	17 155	8	7 687	10	9 468	2	1 198	8	8 270
	3.	7	7 879	2	2 528	5	5 351	1	1 215	4	4 136
	4.	15	10 930	7	4 741	8	6 189	1	910	7	5 279
1901	1.	8	7 115	2	1 947	6	5 168	2	1 578	4	3 590
	2.	11	9 940	7	5 736	4	4 204	1	1 387	3	2 817
	3.	11	12 587	6	7 396	5	5 171	4	4 012	1	1 159
	4.	11	10 841	5	4 942	6	5 899	1	1 027	5	4 872
1902	1.	11	12 994	4	4 104	7	8 890	3	3 810	4	5 080
	2.	21	22 356	11	9 543	10	12 813	2	2 829	8	9 984
	3.	15	18 597	12	13 986	3	4 611	2	2 939	1	1 672
	4.	9	14 709	6	9 102	3	5 607	1	1 384	2	4 223
1903	1.	13	14 749	7	9 228	6	5 521	1	1 130	5	4 391
	2.	11	17 888	6	7 798	5	10 090	1	2 987	4	7 103
	3.	12	15 779	9	11 119	3	4 660	1	506	2	4 154
	4.	14	18 663	5	7 484	9	11 179	4	6 704	5	4 475
1904	1.	13	15 199	9	10 788	4	4 411	1	920	3	3 491
	2.	20	34 205	8	11 850	12	22 355	3	5 661	9	16 694
	3.	14	19 134	7	10 098	7	9 036	1	947	6	8 089
	4.	10	23 948	8	15 753	2	8 195	-	-	2	8 195

1905	1.	15	24 826	9	16 425	6	8 401	2	1 291	4	6 210
	2.	17	35 395	9	17 991	8	17 404	2	7 656	6	9 748
	3.	9	13 006	5	6 099	4	6 907	-	-	4	6 907
	4.	12	18 350	9	9 461	3	8 889	-	-	3	8 889
1906	1.	17	28 645	6	10 481	11	18 164	1	2 984	10	15 180
	2.	15	31 244	8	16 190	7	15 054	2	4 475	5	10 579
	3.	20	39 553	14	30 045	6	9 508	1	3 819	5	5 689
	4.	14	27 075	9	17 939	5	9 136	1	1 749	4	7 387
1907	1.	10	17 548	8	14 310	2	3 238	2	3 238	-	-
	2.	20	37 371	16	30 251	4	7 120	1	2 730	3	4 390
	3.	15	25 884	8	13 392	7	12 492	2	5 574	5	6 918
	4.	21	33 333	15	22 572	6	10 761	2	5 867	4	4 894
1908	1.	9	10 064	3	2 900	6	7 164	1	1 290	5	5 874
	2.	17	31 817	13	21 277	4	10 540	4	10 540	-	-
	3.	11	14 260	8	10 167	3	4 093	-	-	3	4 093
	4.	10	17 912	8	16 010	2	1 902	-	-	2	1 902
1909	1.	7	9 720	6	8 601	1	1 119	1	1 119	-	-
	2.	11	11 087	8	7 942	3	3 145	1	715	2	2 430
	3.	10	19 157	6	11 759	4	7 398	1	1 130	3	6 268
	4.	3	2 473	1	460	2	2 013	-	-	2	2 013
1910	1.	7	10 222	1	453	6	9 769	1	710	5	9 059
	2.	8	10 295	7	9 317	1	978	-	-	1	978
	3.	14	23 254	8	11 535	6	11 719	3	7 756	3	3 963
	4.	5	5 996	3	4 172	2	1 824	-	-	2	1 824
1911	1.	12	41 991	6	21 814	6	20 177	2	6 553	4	13 624
	2.	14	32 523	6	16 544	8	15 979	1	959	7	15 020
	3.	7	18 635	2	5 328	5	13 307	1	2 418	4	10 889
	4.	9	22 125	5	13 754	4	8 371	2	5 665	2	2 706
1912	1.	10	24 887	5	11 587	5	13 300	-	-	5	13 300
	2.	11	19 938	6	8 295	5	11 643	2	2 577	3	9 066
	3.	16	29 702	7	15 024	9	14 678	1	1 920	8	12 758
	4.	12	24 824	9	20 866	3	3 958	-	-	3	3 958

*) Total new constructions comprises 1883-1902 Sailingships and steamers.
 1903-1916 Steamers.
 1916-1924 Steamers and dieselships.
 1925-1932 Steamers and dieselships and tankers.

Table 1. (continued)

Total¹⁾ new constructions for Norwegian shipowners.

Years Quarters	New constructions in all		Of this				Replaced for				
			New investment		Replacement		Wrecked ships only		Sold ships		
	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	
1913	1.	14	28 093	7	15 191	7	12 902	—	—	7	12 902
	2.	15	38 294	5	22 886	10	15 408	1	1 371	9	14 091
	3.	17	34 127	10	26 743	7	7 384	1	942	6	6 442
	4.	7	15 798	5	14 104	2	1 694	1	987	1	707
1914	1.	9	18 338	7	15 766	2	2 572	—	—	2	2 572
	2.	15	37 029	9	24 967	6	12 062	—	—	6	12 062
	3.	8	15 263	5	11 583	3	3 680	—	—	3	3 680
	4.	15	32 506	10	20 884	5	11 622	1	2 368	4	9 254
1915	1.	10	12 971	7	8 356	3	4 615	1	1 118	2	3 497
	2.	12	10 722	6	4 662	6	6 060	—	—	6	6 060
	3.	8	10 354	7	8 680	1	1 674	—	—	1	1 674
	4.	13	20 185	5	5 687	8	14 498	1	401	7	14 097
1916	1.	13	22 597	8	15 800	5	6 797	2	2 496	3	4 301
	2.	13	23 045	8	16 025	5	7 020	—	—	5	7 020
	3.	16	29 421	11	17 588	5	11 833	—	—	5	11 833
	4.	23	61 532	12	22 450	11	39 082	2	10 118	9	28 964
1917	1.	18	42 992	6	11 456	12	31 536	3	7 804	9	23 732
	2.	19	41 338	7	13 043	12	28 295	5	12 595	7	15 700
	3.	10	20 891	6	8 226	4	12 665	2	4 071	2	8 594
	4.	6	13 092	2	2 286	4	10 806	3	5 135	1	5 671
1918	1.	10	14 160	6	6 754	4	7 406	4	7 406	—	—
	2.	12	30 771	7	7 243	5	23 528	2	5 820	3	17 708
	3.	6	17 067	4	10 182	2	6 885	2	6 885	—	—
	4.	6	10 037	1	624	5	9 413	5	9 413	—	—
1919	1.	5	5 676	3	3 368	2	2 308	2	2 308	—	—
	2.	12	19 666	6	9 239	6	10 427	6	10 427	—	—
	3.	5	7 509	3	4 056	2	3 453	2	3 453	—	—
	4.	18	27 298	12	17 050	6	10 248	5	8 643	1	1 605

1920	1.	21	41 191	10	20 509	11	20 682	4	8 590	7	12 092
	2.	23	63 879	15	44 905	8	18 974	4	7 401	4	11 573
	3.	32	82 263	17	39 540	15	42 723	5	17 217	10	25 506
	4.	38	96 564	21	50 750	17	45 814	7	21 152	10	24 662
1921	1.	28	85 161	11	33 730	17	51 434	5	7 926	12	43 505
	2.	26	83 623	18	57 135	8	26 488	4	9 918	4	16 570
	3.	22	80 455	10	41 547	12	38 908	4	10 037	8	28 871
	4.	16	36 569	9	20 395	7	16 174	5	12 168	2	4 006
1922	1.	15	48 609	9	23 140	6	25 469	-	-	6	25 469
	2.	8	16 693	2	3 800	6	12 893	1	1 856	5	11 037
	3.	8	32 754	1	1 597	7	31 157	1	1 849	6	29 308
	4.	3	4 068	2	2 316	1	1 752	-	-	1	1 752
1923	1.	5	12 350	3	5 988	2	6 362	-	-	2	6 362
	2.	8	23 316	3	8 549	5	14 767	-	-	5	14 767
	3.	9	18 565	5	6 516	4	12 049	1	1 168	3	10 881
	4.	6	13 581	4	7 500	2	6 081	-	-	2	6 081
1924	1.	4	5 034	3	3 925	1	1 109	-	-	1	1 109
	2.	7	16 008	2	6 406	5	9 604	-	-	5	9 604
	3.	7	23 526	4	8 692	3	14 834	-	-	3	14 834
	4.	10	27 039	5	14 177	5	12 862	1	4 435	4	8 427
1925	1.	14	40 981	10	32 591	4	8 390	-	-	4	8 390
	2.	9	24 918	5	17 397	4	7 521	-	-	4	7 521
	3.	22	79 790	12	44 203	10	35 587	2	7 229	8	28 358
	4.	10	36 565	7	21 982	3	14 583	-	-	3	14 583
1926	1.	14	48 530	10	32 092	4	16 438	-	-	4	16 438
	2.	12	56 512	9	40 495	3	16 017	-	-	3	16 017
	3.	6	33 006	6	33 006	-	-	-	-	-	-
	4.	6	26 740	3	7 697	3	19 043	-	-	3	19 043
1927	1.	2	9 285	1	5 020	1	4 265	-	-	1	4 265
	2.	7	31 436	4	16 469	3	14 967	-	-	3	14 967
	3.	10	45 041	5	18 539	5	26 502	1	6 732	4	19 770
	4.	7	46 413	4	26 988	3	19 425	-	-	3	19 425

*) Total new constructions comprises 1883-1902 Sailingships and steamers.
 1903-1915 Steamers.
 1916-1924 Steamers and dieselships.
 1925-1932 Steamers and dieselships and tankers.

Table 1. (continued)

Total¹⁾ new constructions for Norwegian shipowners.

Years Quarters	New constructions in all		Of this				Replaced for			
			New Investment		Replacement		Wrecked ships only		Sold ships	
	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross	Number of ships	Tons gross
1928 1.	8	32 944	3	9 775	5	23 169	-	-	5	23 169
2.	13	74 799	10	58 328	3	16 471	-	-	3	16 471
3.	6	44 358	5	34 807	1	9 551	-	-	1	9 551
4.	10	64 610	4	26 697	6	37 913	-	-	6	37 913
1929 1.	10	49 889	3	8 829	7	41 060	1	6 700	6	34 360
2.	15	68 749	10	43 728	5	25 021	-	-	5	25 021
3.	13	49 201	9	32 121	4	17 080	-	-	4	17 080
4.	15	63 064	6	25 506	9	37 558	1	6 604	8	30 954
1930 1.	8	35 169	4	15 169	4	20 000	-	-	4	20 000
2.	28	122 393	19	89 780	9	32 613	-	-	9	32 613
3.	28	149 046	18	95 334	10	53 712	-	-	10	53 712
4.	21	113 203	11	50 775	10	62 428	1	9 718	9	52 710
1931 1.	16	91 141	9	55 265	7	35 876	-	-	7	35 876
2.	16	116 072	6	50 125	10	65 947	1	5 407	9	60 540
3.	11	76 111	6	48 214	5	27 897	1	8 215	4	19 682
4.	9	40 714	8	39 124	1	1 590	-	-	1	1 590
1932 1.	1	1 570	1	1 570	-	-	-	-	-	-
2.	3	17 030	2	15 463	1	1 567	1	1 567	-	-
3.	3	19 498	3	19 498	-	-	-	-	-	-
4.	4	26 603	4	26 603	-	-	-	-	-	-
Total less tankers.										
1925 1.	12	22 765	8	14 375	4	8 390	-	-	4	8 390
2.	8	15 622	4	8 101	4	7 521	-	-	4	7 521
3.	21	72 449	11	36 862	10	35 587	2	7 229	8	28 358
4.	9	27 540	7	21 982	2	5 558	-	-	2	5 558
1926 1.	12	33 982	9	23 094	3	10 888	-	-	3	10 888
2.	9	35 735	8	31 621	1	4 114	-	-	1	4 114
3.	5	27 766	5	27 766	-	-	-	-	-	-
4.	5	20 818	3	7 697	2	13 121	-	-	2	13 121

1927	1.	2	9 285	1	5 020	1	4 265	-	-	1	4 265
	2.	5	18 543	2	3 576	3	14 967	-	-	3	14 967
	3.	5	14 195	3	6 547	2	7 648	1	6 732	1	916
	4.	3	17 507	2	13 197	1	4 310	-	-	1	4 310
1928	1.	6	19 094	3	9 775	3	9 319	-	-	3	9 319
	2.	3	10 011	3	10 011	-	-	-	-	-	-
	3.	1	4 258	1	4 258	-	-	-	-	-	-
	4.	5	22 003	2	9 038	3	12 965	-	-	3	12 965
1929	1.	6	25 547	2	5 814	4	19 733	1	6 700	3	13 033
	2.	13	55 780	9	36 138	4	19 642	-	-	4	19 642
	3.	12	44 134	8	27 054	4	17 080	-	-	4	17 080
	4.	12	41 426	5	17 620	7	23 806	1	6 604	6	17 202
1930	1.	7	27 961	3	7 961	4	20 000	-	-	4	20 000
	2.	21	70 098	13	43 677	8	26 421	-	-	8	26 421
	3.	12	37 784	8	24 228	4	13 556	-	-	4	13 556
	4.	9	25 422	6	15 431	3	9 991	-	-	3	9 991
1931	1.	7	19 259	3	6 265	4	12 994	-	-	4	12 994
	2.	3	13 792	-	-	3	13 792	1	5 407	2	8 385
	3.	2	5 957	-	-	2	5 957	-	-	2	5 957
	4.	4	6 903	3	5 313	1	1 590	-	-	1	1 590
1932	1.	1	1 570	1	1 570	-	-	-	-	-	-
	2.	1	1 567	-	-	1	1 567	1	1 567	-	-
	3.	2	13 652	2	13 652	-	-	-	-	-	-
	4.	1	4 633	1	4 633	-	-	-	-	-	-

*) Total new constructions comprises 1893-1902 Sailingships and steamers.
 1903-1915 Steamers.
 1916-1924 Steamers and dieselships.
 1925-1932 Steamers and dieselships and tankers.

Table 2a.

Years Quarters	Age of the shipping company:				
	0-7 years		8 years and more		
	Number of ships	Tons gross	Number of ships	Tons gross	
1887	1.	1	490	2	1 023
	2.	1	305	5	1 735
	3.	-	-	-	-
	4.	1	419	-	-
1888	1.	-	-	-	-
	2.	4	1 705	2	1 185
	3.	3	3 421	4	3 426
	4.	5	6 039	7	8 439
1889	1.	3	2 219	1	320
	2.	6	4 356	6	5 890
	3.	3	2 416	6	4 151
	4.	7	3 516	8	6 110
1890	1.	9	6 469	2	719
	2.	16	9 864	11	9 154
	3.	7	3 677	8	5 863
	4.	6	5 007	11	7 531
1891	1.	9	8 994	12	12 093
	2.	8	6 241	12	10 586
	3.	10	4 953	12	9 721
	4.	14	8 366	9	4 000
1892	1.	7	6 074	9	8 525
	2.	12	6 476	10	9 937
	3.	14	9 863	4	3 195
	4.	1	541	6	2 227
1893	1.	2	3 316	3	3 627
	2.	7	2 971	6	8 431
	3.	8	5 057	2	1 167
	4.	3	2 035	7	6 249
1894	1.	-	-	3	5 409
	2.	6	6 080	5	4 908
	3.	2	977	4	2 221
	4.	5	3 709	10	9 298
1895	1.	3	2 216	3	3 667
	2.	3	1 355	7	13 548
	3.	5	5 887	7	13 939
	4.	3	3 733	7	12 525
1896	1.	-	-	3	4 206
	2.	7	8 758	5	6 562
	3.	10	11 264	7	7 231
	4.	4	5 137	-	-
1897	1.	-	-	1	1 921
	2.	4	5 706	4	3 374
	3.	2	2 072	4	2 820
	4.	5	2 966	10	11 221
1898	1.	2	790	4	2 143
	2.	6	8 038	5	10 857
	3.	-	-	5	5 944
	4.	6	5 775	11	15 313

Total new constructions divided with regard

Years Quarters	Age of the shipping company:				
	0-7 years		8 years and more		
	Number of ships	Tons gross	Number of ships	Tons gross	
1899	1.	4	4 328	10	18 437
	2.	5	6 783	6	9 594
	3.	1	364	12	17 934
	4.	3	5 992	5	6 099
1900	1.	1	1 566	5	5 513
	2.	5	9 549	13	10 422
	3.	2	2 528	5	5 351
	4.	5	2 373	10	8 557
1901	1.	1	1 117	7	5 998
	2.	4	3 601	7	6 339
	3.	4	4 159	7	8 444
	4.	5	5 726	6	5 115
1902	1.	2	2 353	9	16 523
	2.	6	3 360	14	17 876
	3.	6	6 425	9	12 072
	4.	3	2 989	6	11 720
1903	1.	4	4 861	8	8 135
	2.	1	1 253	10	16 635
	3.	7	7 055	6	9 819
	4.	4	6 833	10	11 829
1904	1.	9	11 019	4	4 180
	2.	4	7 113	16	27 092
	3.	4	6 831	10	12 303
	4.	4	7 250	6	16 698
1905	1.	1	1 111	14	23 710
	2.	3	9 821	14	25 610
	3.	1	1 436	8	11 570
	4.	6	5 101	6	13 249
1906	1.	4	6 488	13	22 157
	2.	3	3 488	12	27 756
	3.	4	4 231	16	35 322
	4.	6	11 292	8	15 783
1907	1.	4	6 150	6	11 398
	2.	7	9 866	13	27 495
	3.	2	1 899	13	23 985
	4.	6	9 875	15	23 458
1908	1.	4	4 208	5	5 855
	2.	8	10 310	9	21 407
	3.	5	5 924	6	8 336
	4.	5	6 883	3	8 695
1909	1.	3	5 341	4	4 379
	2.	3	2 917	8	8 170
	3.	4	2 825	6	16 332
	4.	1	460	2	2 013
1910	1.	2	1 163	5	9 059
	2.	1	1 454	7	8 841
	3.	3	4 255	11	18 999
	4.	3	4 018	2	1 978

to the age of the companies that ordered the ships.

Years Quarters	Age of the shipping company:				Years Quarters	Age of the shipping company:					
	0-7 years		8 years and more			0-7 years		8 years and more			
	Number of ships	Tons gross	Number of ships	Tons gross		Number of ships	Tons gross	Number of ships	Tons gross		
1911	1.	2	1 662	10	40 129	1922	1.	2	4 476	13	44 133
	2.	2	6 899	12	25 624		2.	6	13 451	2	3 242
	3.	1	1 467	6	17 168		3.	1	1 315	7	77 439
	4.	2	6 753	7	15 372		4.	1	1 756	2	2 312
1912	1.	-	-	10	24 887	1923	1.	2	3 734	3	8 616
	2.	3	3 336	8	16 602		2.	1	5 040	5	17 276
	3.	5	7 682	11	22 020		3.	2	1 924	7	16 641
	4.	4	4 921	8	19 903		4.	1	1 123	5	12 458
1913	1.	4	5 960	10	22 133	1924	1.	-	-	4	5 034
	2.	4	18 885	11	19 409		2.	3	6 988	4	9 020
	3.	8	24 524	8	7 883		3.	4	6 892	3	14 832
	4.	2	2 425	5	13 373		4.	1	1 686	8	24 046
1914	1.	5	7 739	4	10 599	1925	1.	3	3 878	10	35 800
	2.	5	11 332	10	25 697		2.	2	5 366	7	19 553
	3.	1	720	5	12 681		3.	6	22 685	16	57 105
	4.	5	7 827	10	24 679		4.	1	3 700	7	27 654
1915	1.	2	2 958	8	9 913	1926	1.	3	6 785	11	41 795
	2.	2	1 885	10	8 837		2.	-	-	12	56 512
	3.	5	5 024	3	5 330		3.	3	19 646	3	13 360
	4.	7	8 142	6	12 072		4.	3	8 559	3	18 181
1916	1.	9	15 598	4	6 999	1927	1.	-	-	2	9 285
	2.	9	16 280	4	6 767		2.	3	9 156	3	20 650
	3.	12	18 844	4	10 577		3.	1	5 187	8	38 984
	4.	17	29 646	6	31 886		4.	1	6 362	6	40 051
1917	1.	11	19 281	7	23 711	1928	1.	1	7 350	5	19 165
	2.	10	16 359	9	25 069		2.	4	20 641	9	53 916
	3.	6	11 173	4	9 718		3.	1	5 702	5	38 656
	4.	3	3 284	2	4 137		4.	1	7 624	8	52 183
1918	1.	4	5 393	6	8 767	1929	1.	1	8 038	9	41 851
	2.	5	19 173	7	13 740		2.	2	6 180	13	62 569
	3.	4	10 178	2	6 885		3.	2	5 922	11	43 279
	4.	3	6 411	3	3 626		4.	4	17 688	12	89 870
1919	1.	2	2 447	7	3 233	1930	1.	1	7 208	7	27 961
	2.	6	6 482	6	13 184		2.	8	36 995	20	85 398
	3.	4	5 021	1	2 488		3.	8	47 164	20	101 882
	4.	13	19 516	5	7 782		4.	5	28 735	16	84 468
1920	1.	9	16 678	12	24 513	1931	1.	3	24 619	13	66 532
	2.	12	34 406	11	29 473		2.	2	17 998	14	98 092
	3.	15	26 701	14	44 993		3.	4	32 976	7	43 135
	4.	18	41 840	20	54 699		4.	4	25 827	5	14 887
1921	1.	15	25 985	18	59 086	1932	1.	-	-	1	1 571
	2.	12	41 541	14	41 182		2.	-	-	3	17 031
	3.	8	31 917	14	48 538		3.	-	-	3	19 498
	4.	5	11 032	11	25 537		4.	-	-	4	26 621

Reinvestment Cycles

Table 2b. Total new construction less tankers divided with regard to the age of the companies that ordered the ships.

Years Quarters	Age of the shipping company:				Years Quarters	Age of the shipping company:					
	0-7 years		8 years and more			0-7 years		8 years and more			
	Number of ships	Tons gross	Number of ships	Tons gross		Number of ships	Tons gross	Number of ships	Tons gross		
1925	1.	3	3 878	8	17 584	1929	1.	-	-	6	25 547
	2.	2	5 366	6	10 257		2.	2	6 180	11	49 600
	3.	5	15 344	16	57 105		3.	2	5 922	10	38 212
	4.	1	3 700	6	18 629		4.	3	10 134	10	75 786
1926	1.	3	6 785	9	27 247	1930	1.	-	-	7	27 961
	2.	-	-	9	35 735		2.	4	6 236	17	63 862
	3.	2	14 406	3	13 860		3.	2	7 999	10	29 785
	4.	3	8 559	2	12 259		4.	2	4 743	7	20 679
1927	1.	-	-	2	9 285	1931	1.	-	-	7	19 269
	2.	2	3 576	2	13 337		2.	-	-	3	13 972
	3.	-	-	4	13 325		3.	-	-	2	5 957
	4.	-	-	3	17 507		4.	-	-	4	6 903
1928	1.	-	-	4	12 660	1932	1.	-	-	1	1 571
	2.	-	-	3	9 771		2.	-	-	1	1 567
	3.	-	-	1	4 258		3.	-	-	2	13 652
	4.	-	-	4	17 200		4.	-	-	1	4 633

Table 3. Stock of First-owner ships. In tons gross.

Ships built in the year	Age of the ships at the beginning of the year					6	7	8	9	10
	0	1	2	3	4					
1883.	14 406	14 406	13 730	13 730	13 730	13 730	13 730	13 227	12 844	10 568
1884.	17 496	17 496	17 496	14 961	12 852	12 392	11 481	11 481	11 011	10 002
1885.	6 034	6 034	6 034	6 034	6 034	6 034	5 501	5 039	4 485	2 941
1886.	646	646	646	646	646	646	498	498	498	498
1887.	419	419	419	-	-	-	-	-	-	-
1888.	15 640	15 640	14 718	12 629	12 626	12 629	12 629	12 629	10 329	10 329
1889.	23 128	23 128	22 529	21 608	19 357	18 360	16 499	16 499	15 434	12 808
1890.	36 435	36 435	36 435	35 480	34 563	34 196	33 725	33 140	31 467	28 160
1891.	30 421	30 421	29 662	26 921	25 923	25 633	22 510	20 998	20 998	19 434
1892.	20 559	20 559	16 162	16 162	15 245	15 012	15 012	14 446	14 446	12 606
1893.	19 333	19 333	19 333	19 333	19 071	16 341	16 341	16 341	16 341	16 341
1894.	22 993	22 933	22 993	19 613	19 613	15 877	15 622	12 628	12 628	8 946
1895.	51 791	49 738	49 738	49 188	46 702	46 702	46 702	46 702	42 434	42 434
1896.	40 384	37 959	37 959	33 996	32 743	32 743	32 743	32 743	30 717	26 617
1897.	27 995	27 995	27 367	25 322	25 322	25 322	23 386	22 746	22 607	21 000
1898.	50 343	46 202	46 202	46 202	46 202	45 654	45 654	45 654	45 654	42 750
1899.	68 853	67 153	67 153	67 153	63 584	63 584	63 584	58 518	58 518	56 831
1900.	42 776	41 399	41 399	39 760	39 115	39 115	37 946	37 946	37 845	36 186
1901.	40 139	40 139	36 989	35 620	35 354	35 354	30 760	30 093	30 093	30 093
1902.	67 995	67 357	65 945	64 557	63 040	61 658	61 014	59 408	59 408	59 408
1903.	67 079	67 079	66 632	66 632	64 989	63 369	62 586	60 428	60 428	59 679
1904.	92 486	91 322	82 484	80 194	77 520	73 266	70 261	67 484	65 422	59 681
1905.	91 577	89 198	88 079	84 470	83 891	82 870	82 870	80 578	74 008	72 897
1906.	126 517	125 297	125 297	125 297	125 297	117 772	108 604	95 855	94 370	94 370
1907.	114 136	110 145	110 145	110 145	104 649	101 260	94 685	89 700	87 169	56 336
1908.	74 053	74 053	74 053	73 329	67 742	67 742	65 318	60 982	38 441	22 311
1909.	42 437	37 500	36 584	35 055	35 055	35 055	21 604	16 557	14 698	11 139
1910.	49 767	49 767	47 866	46 478	44 996	37 126	32 767	25 186	14 642	13 053
1911.	115 274	115 274	115 274	110 598	105 465	93 410	76 148	52 625	52 625	52 625
1912.	99 351	99 351	97 916	85 083	75 019	59 157	49 920	48 764	48 764	48 764
1913.	116 312	116 312	108 278	94 815	78 886	56 256	51 287	51 287	49 525	49 525
1914.	103 136	96 089	81 181	66 063	54 931	53 744	53 744	53 744	50 547	43 187
1915.	54 232	54 232	40 030	32 397	29 803	28 673	28 673	21 010	21 010	18 885
1916.	136 595	117 693	83 564	80 911	78 814	74 986	70 790	67 668	64 388	64 388
1917.	118 313	112 220	105 152	98 010	94 472	93 533	84 432	82 380	80 574	75 812
1918.	72 035	72 035	71 411	70 667	66 495	62 144	60 517	59 605	53 413	44 153
1919.	60 149	56 617	51 329	47 304	41 723	39 619	38 492	36 016	32 486	28 393
1920.	283 897	260 771	221 409	193 682	173 975	158 650	149 811	138 790	127 409	108 479
1921.	285 808	251 143	236 781	211 441	203 141	192 511	187 211	171 498	153 292	131 019
1922.	102 124	96 733	88 295	86 698	86 698	86 698	86 698	85 708	82 866	82 866
1923.	67 812	64 153	64 153	63 288	62 165	62 165	53 977	49 196	46 836	46 836
1924.	71 607	67 698	67 698	66 663	62 047	62 047	59 319	59 319	59 319	-
1925.	182 254	179 777	168 515	168 515	168 515	167 516	160 200	160 200	-	-
1926.	164 788	164 788	161 882	161 882	161 882	161 882	161 822	-	-	-
1927.	132 175	132 175	132 175	131 305	131 305	131 305	-	-	-	-

Table 6.

Life Characteristics for Firstownerships 1883—1927.

The period of the War excluded.

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x	L_x	D_x	C_x	$D_x^{(s)}$	$C_x^{(s)}$	$D_x^{(w)}$	$C_x^{(w)}$
0	2 937 389	102 784	10 936	89 118	0	13 666	10 936
1	2 790 328	109 441	17 770	83 533	1 414	25 908	16 356
2	2 688 123	107 555	21 845	86 651	10 949	20 904	10 896
3	2 550 881	83 785	29 155	65 188	19 809	18 597	9 346
4	2 451 903	67 858	14 496	57 021	9 219	10 837	5 277
5	2 402 734	86 022	29 402	63 298	13 093	22 724	16 309
6	2 171 376	87 789	17 836	71 460	10 106	16 329	7 730
7	1 880 769	76 848	27 172	55 743	12 859	21 105	14 313
8	1 603 352	103 920	57 219	94 284	52 424	9 636	4 795
9	1 380 269	84 735	46 974	73 517	42 161	11 218	4 813
10	1 206 060	76 548	27 224	65 392	22 465	11 156	4 759
11	1 002 652	21 573	11 661	14 470	8 686	7 103	2 975
12	824 375	26 600	11 715	21 915	9 532	4 685	2 183
13	722 113	19 411	11 163	14 962	7 820	4 449	3 343
14	695 431	25 114	20 474	25 114	20 474	0	0
15	599 243	38 871	27 498	33 819	22 446	5 052	5 052
16	508 057	25 793	15 660	21 014	10 881	4 779	4 479
17	453 646	21 734	10 524	13 761	5 523	7 973	5 001
18	405 575	32 786	20 482	29 830	18 370	2 956	2 112
19	334 310	36 971	32 349	35 812	31 671	1 159	678
20	279 052	42 331	22 915	38 884	21 745	3 447	1 170
21	205 582	12 963	7 243	11 322	7 243	1 641	0
22	154 371	6 656	1 347	1 755	0	4 901	1 347
23	132 105	9 749	4 504	9 749	4 504	0	0
24	120 335	10 381	4 375	8 550	4 375	1 831	0
25	104 421	4 922	4 432	4 922	4 432	0	0
26	86 563	8 077	6 688	8 077	6 688	0	0
27	63 813	6 571	1 339	6 221	989	350	350
28	43 003	3 984	2 524	3 984	2 524	0	0
29	30 594	386	386	386	386	0	0
30	28 767	2 263	1 129	2 263	1 129	0	0
31	22 900	0	0	0	0	0	0
32	20 774	0	0	0	0	0	0
33	19 787	825	0	825	0	0	0

Reinvestment Cycles

Table 7.

Life Characteristics for Firstownerships 1883—1927.

The period of the War excluded.

x	$q_x = \frac{D_x}{L_x}$	$q_x^{(s)} = \frac{D_x^{(s)}}{L_x}$	$q_x^{(w)} = \frac{D_x^{(w)}}{L_x}$	$m_x = \frac{C_x}{D_x}$	$m_x^{(s)} = \frac{C_x^{(s)}}{D_x^{(s)}}$	$m_x^{(w)} = \frac{C_x^{(w)}}{D_x^{(w)}}$	$\frac{C_x}{L_x}$	$\frac{C_x^{(s)}}{L_x^{(s)}}$	$\frac{C_x^{(w)}}{L_x^{(w)}}$
0.....	0.03499	0.03034	0.00465	0.10640	0.00000	0.80023	0.00372	0.00000	0.00372
1.....	0.03922	0.02994	0.00928	0.16237	0.01693	0.63131	0.00637	0.00051	0.00586
2.....	0.04001	0.03223	0.00778	0.20311	0.12636	0.52124	0.00813	0.00407	0.00406
3.....	0.03285	0.02556	0.00729	0.34797	0.30387	0.50255	0.01143	0.00777	0.00366
4.....	0.02768	0.02326	0.00442	0.21362	0.16168	0.48694	0.00591	0.00376	0.00215
5.....	0.03580	0.02634	0.00946	0.34180	0.20685	0.71770	0.01224	0.00545	0.00679
6.....	0.04043	0.03291	0.00752	0.20317	0.14142	0.47339	0.00821	0.00465	0.00356
7.....	0.04086	0.02964	0.01122	0.35358	0.23068	0.67818	0.01445	0.00684	0.00761
8.....	0.06481	0.05880	0.00601	0.55061	0.55602	0.49761	0.03569	0.03270	0.00299
9.....	0.06139	0.05326	0.00813	0.55436	0.57349	0.42904	0.03403	0.03054	0.00349
10.....	0.06347	0.05422	0.00925	0.35565	0.34354	0.42659	0.02257	0.01863	0.00394
11.....	0.02152	0.01443	0.00709	0.54054	0.60028	0.41884	0.01163	0.00866	0.00297
12.....	0.03227	0.02659	0.00568	0.44041	0.43495	0.46596	0.01421	0.01156	0.00265
13.....	0.02688	0.02072	0.00616	0.57509	0.52266	0.75140	0.01546	0.01083	0.00463
14.....	0.03611	0.03611	0.00000	0.81524	0.81524	0.00000	0.02944	0.02944	0.00000
15.....	0.06487	0.05644	0.00843	0.70742	0.66371	1.00000	0.04589	0.03746	0.00843
16.....	0.05077	0.04136	0.00941	0.60714	0.51780	1.00000	0.03082	0.02141	0.00940
17.....	0.04791	0.03033	0.01758	0.48422	0.40135	0.62724	0.02320	0.01217	0.01103
18.....	0.08080	0.07352	0.00728	0.62472	0.61582	0.71448	0.05048	0.04527	0.00521
19.....	0.11059	0.10712	0.00347	0.87498	0.88437	0.58499	0.09676	0.09473	0.00203
20.....	0.15170	0.13935	0.01235	0.54133	0.55923	0.33943	0.08212	0.07793	0.00419
21.....	0.06306	0.05508	0.00798	0.55874	0.63973	0.00000	0.03523	0.03523	0.00000
22.....	0.04312	0.01137	0.03175	0.20237	0.00000	0.27484	0.00873	0.00000	0.00873
23.....	0.07380	0.07380	0.00000	0.46200	0.46200	0.00000	0.03409	0.03409	0.00000
24.....	0.08627	0.07105	0.01522	0.42144	0.51170	0.00000	0.03636	0.03636	0.00000
25.....	0.04714	0.04714	0.00000	0.90045	0.90045	0.00000	0.04244	0.04244	0.00000
26.....	0.09331	0.09331	0.00000	0.82803	0.82803	0.00000	0.07726	0.07726	0.00000
27.....	0.10297	0.09749	0.00548	0.20377	0.15898	1.00000	0.02098	0.01550	0.00548
28.....	0.09264	0.09264	0.00000	0.63353	0.63353	0.00000	0.05869	0.05869	0.00000
29.....	0.01262	0.01262	0.00000	1.00000	1.00000	0.00000	0.01262	0.01262	0.00000
30.....	0.07867	0.07867	0.00000	0.49890	0.49890	0.00000	0.03925	0.03925	0.00000
31.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
32.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
33.....	0.04169	0.04169	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 8.

Life Characteristics for Firstownerships 1883—1927.

The period of the War excluded. Calculated Tables.

x	l_x	$d_x = l_x q_x$	$d_x^{(s)} = l_x q_x^{(s)}$	$d_x^{(w)} = l_x q_x^{(w)}$	$d_x \frac{C_x}{D_x}$	$d_x^{(s)} \frac{C_x^{(s)}}{D_x^{(s)}}$	$d_x^{(w)} \frac{C_x^{(w)}}{D_x^{(w)}}$
0	100 000	3 499	3 034	465	372	0	372
1	96 501	3 785	2 889	896	615	49	566
2	92 716	3 710	2 988	722	754	378	376
3	89 006	2 924	2 275	649	1 017	691	326
4	86 082	2 383	2 002	381	509	324	185
5	83 699	2 996	2 205	791	1 024	456	568
6	80 703	3 263	2 656	607	663	376	287
7	77 440	3 164	2 295	869	1 119	529	590
8	74 276	4 814	4 367	447	2 651	2 428	223
9	69 462	4 264	3 700	564	2 364	2 122	242
10	65 198	4 138	3 535	603	1 472	1 241	258
11	61 060	1 314	881	433	710	529	181
12	59 746	1 928	1 589	339	849	691	158
13	57 818	1 554	1 198	356	894	626	268
14	56 264	2 032	2 032	0	1 657	1 657	0
15	54 232	3 518	3 061	457	2 489	2 032	457
16	50 714	2 575	2 098	477	1 563	1 086	477
17	48 139	2 306	1 460	846	1 117	586	531
18	45 833	3 703	3 370	333	2 313	2 075	238
19	42 130	4 659	4 513	146	4 077	3 991	86
20	37 471	5 684	5 222	462	3 077	2 920	157
21	31 787	2 004	1 751	253	1 120	1 120	0
22	29 783	1 284	339	945	260	0	260
23	28 499	2 103	2 103	0	972	972	0
24	26 396	2 277	1 875	402	960	960	0
25	24 119	1 137	1 137	0	1 024	1 024	0
26	22 982	2 144	2 144	0	1 776	1 776	0
27	20 838	2 146	2 031	115	437	322	115
28	18 691	1 732	1 732	0	1 097	1 097	0
29	16 959	214	214	0	214	214	0
30	16 745	1 317	1 317	0	657	657	0
31	15 428	0	0	0	0	0	0
32	15 428	0	0	0	0	0	0
33	15 428	644	644	0	0	0	0
34	14 785	-	-	-	-	-	-

Table 9.

Life Characteristics for Firstownerships 1883—1927.

The period of the War included. Calculated tables.

x	l_x	$d_x = l_x q_x$	$d_x^{(s)} = l_x q_x^{(s)}$	$d_x^{(w)} = l_x q_x^{(w)}$	$d_x \frac{C_x}{D_x}$	$d_x^{(s)} \frac{C_x^{(s)}}{D_x^{(s)}}$	$d_x^{(w)} \frac{C_x^{(w)}}{D_x^{(w)}}$
0	100 000	3 940	2 637	1 303	539	0	539
1	96 060	5 488	3 488	2 000	886	156	730
2	90 572	4 654	3 487	1 167	1 139	450	689
3	85 918	3 760	2 399	1 361	1 403	729	674
4	82 158	3 725	2 478	1 247	1 196	290	906
5	78 433	3 954	2 450	1 504	1 480	564	916
6	74 479	3 988	2 409	1 579	1 365	408	957
7	70 491	3 791	2 605	1 186	1 329	497	832
8	66 700	5 617	4 676	941	2 380	1 956	424
9	61 083	5 228	3 932	1 298	2 089	1 650	439
10	55 855	4 622	3 423	1 199	1 644	969	675
11	51 233	2 375	1 556	819	710	467	243
12	48 858	2 841	1 751	1 090	1 236	493	743
13	46 017	2 045	1 084	961	1 144	398	746
14	43 972	2 802	2 057	745	1 551	1 074	477
15	41 170	3 746	2 524	1 222	2 174	1 640	534
16	37 424	3 144	2 258	886	1 381	966	415
17	34 280	2 647	1 400	1 247	1 132	411	721
18	31 633	3 421	2 586	835	1 851	1 567	284
19	28 212	3 561	3 005	556	2 743	2 397	346
20	24 651	3 972	3 221	751	2 133	1 900	233
21	20 679	1 640	1 258	382	987	902	85
22	19 039	1 682	182	1 500	1 133	0	1 133
23	17 357	1 712	1 406	306	493	493	0
24	15 645	2 034	1 776	258	496	496	0
25	13 611	836	836	0	520	520	0
26	12 775	1 970	1 307	663	860	860	0
27	10 805	1 043	987	56	213	157	56
28	9 762	860	860	0	545	545	0
29	8 902	148	148	0	148	148	0
30	8 754	1 046	1 046	0	424	424	0
31	7 708	0	0	0	0	0	0
32	7 708	0	0	0	0	0	0
33	7 708	302	302	0	0	0	0
34	7 406	-	-	-	-	-	-

Table 10.

Life Characteristics for Firstownerships 1888—1902.

The period of War excluded. Calculated tables.

x	l_x	$d_x = l_x q_x$	$d_x^{(s)} = l_x q_x^{(s)}$	$d_x^{(w)} = l_x q_x^{(w)}$	$d_x \frac{C_x}{D_x}$	$D_x^{(s)} \frac{C_x^{(s)}}{D_x^{(s)}}$	$d_x^{(w)} \frac{C_x^{(w)}}{D_x^{(w)}}$
0	100 000	2 063	1 205	858	858	0	858
1	97 937	2 098	835	1 263	995	0	995
2	95 839	4 014	2 490	1 524	1 180	743	437
3	91 825	2 876	1 610	1 266	1 244	443	801
4	88 949	1 797	1 132	665	1 078	644	434
5	87 152	2 617	1 482	1 135	1 014	95	919
6	84 535	2 359	940	1 419	1 610	598	1 012
7	82 176	1 806	1 196	610	567	483	84
8	80 370	4 603	3 412	1 191	2 077	1 696	381
9	75 767	4 977	3 493	1 484	3 093	2 288	805
10	70 790	6 228	5 243	985	2 618	2 169	449
11	64 562	2 566	1 499	1 067	1 023	646	377
12	61 996	3 489	2 884	605	1 064	951	113
13	58 507	2 182	1 381	801	1 235	670	565
14	56 325	1 722	1 722	0	1 020	1 020	0
15	54 603	5 503	4 736	767	2 605	1 838	767
16	49 100	3 505	3 043	462	2 372	1 910	462
17	45 595	3 519	767	2 752	2 237	511	1 726
18	42 076	2 751	1 645	1 106	1 743	953	790
19	39 325	2 927	2 720	207	2 720	2 720	0
20	36 398	8 942	8 321	621	5 795	5 795	0
21	27 456	3 402	2 830	572	1 408	1 408	0
22	24 054	651	651	0	0	0	0
23	23 403	563	563	0	263	263	0
24	22 840	3 484	2 767	717	1 711	1 711	0
25	19 356	1 427	1 427	0	1 229	1 229	0
26	17 929	2 482	2 482	0	2 482	2 482	0
27	15 447	2 353	2 206	147	147	0	147
28	13 094	1 575	1 575	0	998	998	0
29	11 519	151	151	0	151	151	0
30	11 368	894	894	0	446	446	0
31	10 474	0	0	0	0	0	0
32	10 474	0	0	0	0	0	0
33	10 474	437	437	0	0	0	0
34	10 037						

Table 11.

Life Characteristics for Firstownerships 1903—1927.

The period of War excluded. Calculated tables.

x	l_x	$d_x = l_x q_x$	$d_x^{(s)} = l_x q_x^{(s)}$	$d_x^{(w)} = l_x q_x^{(w)}$	$d_x \frac{C_x}{D_x}$	$d_x^{(s)} \frac{C_x^{(s)}}{D_x^{(s)}}$	$d_x^{(w)} \frac{C_x^{(w)}}{D_x^{(w)}}$
0	100 000	3 866	3 501	365	248	0	248
1	96 134	4 225	3 424	801	515	61	454
2	91 909	3 630	3 118	512	642	283	359
3	88 279	2 936	2 450	486	957	756	201
4	85 343	2 538	2 233	305	358	239	119
5	82 805	3 097	2 396	701	1 027	551	476
6	79 708	3 525	3 150	375	393	312	81
7	76 183	3 621	2 664	957	1 304	547	757
8	72 562	4 937	4 775	162	2 895	2 733	162
9	67 625	4 009	3 838	171	2 077	2 077	0
10	63 616	3 195	2 767	428	940	772	168
11	60 421	611	540	71	544	473	71
12	59 810	1 042	853	189	741	552	189
13	58 768	1 207	1 114	93	707	614	93
14	57 561	2 247	2 247	0	2 038	2 038	0
15	55 314	2 719	2 389	330	2 495	2 165	330
16	52 595	2 287	1 793	494	1 296	802	494
17	50 308	1 806	1 806	0	633	633	0
18	48 502	4 206	4 206	0	2 617	2 617	0
19	44 296	5 498	5 375	123	4 744	4 621	123
20	38 798	3 973	3 590	383	1 617	1 369	248
21	34 825	879	879	0	879	879	0
22	33 946	1 858	0	1 858	511	0	511
23	32 088	3 579	3 579	0	1 650	1 650	0
24	28 509	679	679	0	0	0	0
25	27 830	682	682	0	682	682	0
26	27 148	1 424	1 424	0	594	594	0
27	25 724	936	936	0	936	936	0
28	24 788	0	0	0	0	0	0
29	24 788	0	0	0	0	0	0
30	24 788	0	0	0	—	—	—
31	—	—	—	—	—	—	—
32	—	—	—	—	—	—	—
33	—	—	—	—	—	—	—

Table 12.

Life Characteristics for Firstownerships 1883—1927.

The period of the War excluded. *Revival.*

x	$q_x = \frac{D_x}{L_x}$	$q_x^{(s)} = \frac{D_x^{(s)}}{L_x}$	$q_x^{(w)} = \frac{D_x^{(w)}}{L_x}$	$m_x = \frac{C_x}{D_x}$	$m_x = \frac{C_x^{(s)}}{D_x^{(s)}}$	$m_x^{(w)} = \frac{C_x^{(w)}}{D_x^{(w)}}$	$\frac{C_x}{L_x}$	$\frac{C_x^{(s)}}{L_x}$	$\frac{C_x^{(w)}}{L_x}$
0.....	0.02382	0.02264	0.00118	0.04937	0.00000	1.00000	0.00118	0.00000	0.00118
1.....	0.03886	0.02002	0.01884	0.43878	0.09792	0.80100	0.01705	0.00196	0.01509
2.....	0.02827	0.00921	0.01906	0.44607	0.00000	0.66165	0.01261	0.00000	0.01261
3.....	0.02951	0.02194	0.00757	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4.....	0.01883	0.01883	0.00000	0.15034	0.15034	0.00000	0.00283	0.00283	0.00000
5.....	0.03079	0.00812	0.02267	0.90356	0.90209	0.90409	0.02782	0.00732	0.02050
6.....	0.01565	0.01353	0.00212	0.20726	0.08321	1.00000	0.00324	0.00112	0.00212
7.....	0.03182	0.01667	0.01515	0.36895	0.08702	0.67918	0.01174	0.00145	0.01029
8.....	0.05676	0.04708	0.00968	0.41749	0.47772	0.12454	0.02370	0.02249	0.00121
9.....	0.06717	0.05106	0.01610	0.49895	0.44231	0.67857	0.03351	0.02259	0.01092
10.....	0.04350	0.03194	0.01156	0.47934	0.65286	0.00000	0.02085	0.02085	0.00000
11.....	0.02711	0.00000	0.02711	0.52261	1.00000	0.52261	0.01417	0.00000	0.01417
12.....	0.03452	0.02042	0.01410	0.89294	1.00000	0.73798	0.03083	0.02042	0.01042
13.....	0.05492	0.04510	0.00982	0.87291	0.84525	1.00000	0.04794	0.03812	0.00982
14.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15.....	0.06930	0.05713	0.01217	0.60960	0.52642	1.00000	0.04225	0.03008	0.01217
16.....	0.03765	0.03765	0.00000	1.00000	0.00000	0.00000	0.03765	0.03765	0.00000
17.....	0.06469	0.03797	0.02772	0.56703	0.56966	0.56352	0.03668	0.02106	0.01562
18.....	0.11625	0.10911	0.00714	0.70892	0.75531	0.00000	0.08241	0.08241	0.00000
19.....	0.08056	0.07596	0.00460	0.64092	0.67977	0.00000	0.05163	0.05163	0.00000
20.....	0.11238	0.10805	0.00433	0.38373	0.39911	0.00000	0.04312	0.04312	0.00000
21.....	0.05450	0.03742	0.01708	0.37930	0.55243	0.00000	0.02067	0.02067	0.00000
22.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
23.....	0.13066	0.13066	0.00000	0.52069	0.52069	0.00000	0.06803	0.06803	0.00000
24.....	0.15290	0.12677	0.02613	0.62004	0.74786	0.00000	0.09480	0.09480	0.00000
25.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
26.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
27.....	0.03169	0.03169	0.00000	1.00000	1.00000	0.00000	0.03169	0.03169	0.00000
28.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 13.

Life Characteristics for Firstownerships 1883—1927.

The period of the War excluded. Prosperity.

x	$q_x = \frac{D_x}{L_x}$	$q_x^{(s)} = \frac{D_x^{(s)}}{L_x}$	$q_x^{(w)} = \frac{D_x^{(w)}}{L_x}$	$m_x = \frac{C_x}{D_x}$	$m_x^{(s)} = \frac{C_x^{(s)}}{D_x^{(s)}}$	$m_x^{(w)} = \frac{C_x^{(w)}}{D_x^{(w)}}$	$\frac{C_x}{L_x}$	$\frac{C_x^{(s)}}{L_x}$	$\frac{C_x^{(w)}}{L_x}$
0.....	0.04859	0.04387	0.00472	0.05622	0.00000	0.57890	0.00273	0.00000	0.00273
1.....	0.04987	0.04627	0.00370	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2.....	0.05700	0.05321	0.00379	0.06870	0.07359	0.00000	0.00392	0.00392	0.00000
3.....	0.04379	0.03346	0.01033	0.46021	0.44660	0.50432	0.02015	0.01494	0.00521
4.....	0.04038	0.03373	0.00665	0.10232	0.05845	0.32504	0.00413	0.00197	0.00216
5.....	0.03793	0.03307	0.00487	0.18926	0.12911	0.59802	0.00718	0.00427	0.00291
6.....	0.05600	0.04309	0.01291	0.17071	0.09394	0.42696	0.00956	0.00405	0.00551
7.....	0.05790	0.04295	0.01495	0.37468	0.26826	0.68029	0.02169	0.01152	0.01017
8.....	0.08216	0.07664	0.00552	0.57611	0.54560	1.00000	0.04733	0.04182	0.00551
9.....	0.06012	0.05112	0.00900	0.56423	0.63470	0.16390	0.03392	0.03245	0.00147
10.....	0.03388	0.03269	0.00119	0.55036	0.57043	0.00000	0.01865	0.01865	0.00000
11.....	0.01783	0.01553	0.00230	0.29287	0.33613	0.00000	0.00522	0.00522	0.00000
12.....	0.01082	0.00900	0.00182	0.37363	0.44929	0.00000	0.00404	0.00404	0.00000
13.....	0.02595	0.01760	0.00835	0.46542	0.44183	0.51512	0.01208	0.00778	0.00430
14.....	0.03195	0.03195	0.00000	1.00000	1.00000	0.00000	0.03195	0.03195	0.00000
15.....	0.07904	0.07694	0.00210	0.88706	0.88398	1.00000	0.07012	0.06802	0.00210
16.....	0.06854	0.04353	0.02501	0.67621	0.49014	1.00000	0.04635	0.02134	0.02501
17.....	0.03494	0.03494	0.00000	0.30170	0.30170	0.00000	0.01054	0.01054	0.00000
18.....	0.09480	0.09024	0.00456	0.49788	0.47251	1.00000	0.04720	0.04264	0.00456
19.....	0.07785	0.07785	0.00000	1.00000	1.00000	0.00000	0.07785	0.07785	0.00000
20.....	0.11627	0.08750	0.02877	0.60753	0.68037	0.38601	0.07064	0.05953	0.01111
21.....	0.03809	0.03809	0.00000	1.00000	1.00000	0.00000	0.03809	0.03809	0.00000
22.....	0.09187	0.00000	0.09187	0.27484	0.00000	0.27484	0.02520	0.00000	0.02520
23.....	0.01588	0.01588	0.00000	1.00000	1.00000	0.00000	0.01588	0.01588	0.00000
24.....	0.01065	0.01065	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
25.....	0.01084	0.01084	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
26.....	0.09218	0.09218	0.00000	1.00000	1.00000	0.00000	0.09218	0.09218	0.00000
27.....	0.22476	0.20291	0.02185	0.09722	0.00000	1.00000	0.02185	0.00000	0.02185
28.....	0.21695	0.21695	0.00000	0.66858	0.66858	0.00000	0.14505	0.14505	0.00000
29.....	0.03405	0.03405	0.00000	1.00000	1.00000	0.00000	0.03405	0.03405	0.00000
30.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Tables

Table 14.

Life Characteristics for Firstownerships 1883—1927.

The period of the War excluded. *Recession.*

x	$q_x = \frac{D_x}{L_x}$	$q_x^{(s)} = \frac{D_x^{(s)}}{L_x}$	$q_x^{(w)} = \frac{D_x^{(w)}}{L_x}$	$m_x = \frac{C_x}{D_x}$	$m_x^{(s)} = \frac{C_x^{(s)}}{D_x^{(s)}}$	$m_x^{(w)} = \frac{C_x^{(w)}}{D_x^{(w)}}$	$\frac{C_x}{L_x}$	$\frac{C_x^{(s)}}{L_x}$	$\frac{C_x^{(w)}}{L_x}$
0.....	0.02082	0.02082	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1.....	0.03492	0.02296	0.01196	0.34258	0.00000	1.00000	0.01196	0.00000	0.01196
2.....	0.02017	0.02017	0.00000	0.20366	0.20366	0.00000	0.00411	0.00411	0.00000
3.....	0.02232	0.02232	0.00000	0.57767	0.57767	0.00000	0.01289	0.01289	0.00000
4.....	0.00069	0.00069	0.00000	1.00000	1.00000	0.00000	0.00069	0.00069	0.00000
5.....	0.00752	0.00575	0.00177	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6.....	0.01042	0.00803	0.00239	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7.....	0.04497	0.04497	0.00000	0.28112	0.28112	0.00000	0.01264	0.01264	0.00000
8.....	0.08109	0.07265	0.00844	0.69914	0.78030	0.00000	0.05669	0.05669	0.00000
9.....	0.02019	0.02019	0.00000	1.00000	1.00000	0.00090	0.02019	0.02019	0.00000
10.....	0.05274	0.05274	0.00000	0.38709	0.38709	0.00000	0.02042	0.02042	0.00000
11.....	0.03905	0.03713	0.00192	0.82227	0.86475	0.00000	0.03211	0.03211	0.00000
12.....	0.04818	0.04818	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13.....	0.00769	0.00769	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14.....	0.12652	0.12652	0.00000	1.00000	1.00000	0.00000	0.12652	0.12652	0.00000
15.....	0.12240	0.08591	0.03694	0.66655	0.52492	1.00000	0.08158	0.04509	0.03649
16.....	0.04813	0.04813	0.00000	0.64618	0.64618	0.00000	0.03110	0.03110	0.00000
17.....	0.00256	0.00256	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18.....	0.01249	0.01249	0.00000	1.00000	1.00000	0.00000	0.01249	0.01249	0.00000
19.....	0.04649	0.00000	0.04649	1.00000	0.00000	1.00000	0.04649	0.00000	0.04649
20.....	0.03149	0.03149	0.00000	1.00000	1.00000	0.00000	0.03149	0.03149	0.00000
21.....	0.20425	0.20425	0.00000	0.47510	0.47510	0.00000	0.09704	0.09704	0.00000
22.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
23.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
24.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
25.....	0.69146	0.69146	0.00000	1.00000	1.00000	0.00000	0.69146	0.69146	0.00000
26.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
27.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
28.....	0.41162	0.41162	0.00000	0.50297	0.50297	0.00000	0.20703	0.20703	0.00000
29.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 15.

Life Characteristics for Firstownerships 1883—1927.

The period of the War excluded Depression.

x	$q_x = \frac{D_x}{L_x}$	$q_x^{(s)} = \frac{D_x^{(s)}}{L_x}$	$q_x^{(w)} = \frac{D_x^{(w)}}{L_x}$	$m_x = \frac{C_x}{D_x}$	$m_x^{(s)} = \frac{C_x^{(s)}}{D_x^{(s)}}$	$m_x^{(w)} = \frac{C_x^{(w)}}{D_x^{(w)}}$	$\frac{C_x}{L_x}$	$\frac{C_x^{(s)}}{L_x}$	$\frac{C_x^{(w)}}{L_x}$
0.....	0.03715	0.01581	0.02134	0.57434	0.00000	1.00000	0.02134	0.00000	0.02134
1.....	0.01546	0.00614	0.00932	0.18229	0.00000	0.30250	0.00282	0.00000	0.00282
2.....	0.04388	0.04197	0.00191	0.51132	0.48908	1.00000	0.02244	0.02053	0.00191
3.....	0.01367	0.01367	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4.....	0.03995	0.02676	0.01319	0.80498	0.70884	1.00000	0.03216	0.01897	0.01319
5.....	0.08747	0.07431	0.01316	0.27795	0.17858	0.83902	0.02431	0.01327	0.01104
6.....	0.07662	0.07079	0.00583	0.69293	0.74997	0.00000	0.05309	0.05309	0.00000
7.....	0.02464	0.00137	0.02327	0.94438	0.00000	1.00000	0.02327	0.00000	0.02327
8.....	0.05347	0.04488	0.00859	0.41293	0.30052	1.00000	0.02208	0.01349	0.00859
9.....	0.01558	0.01558	0.00000	1.00000	1.00000	0.00000	0.01558	0.01558	0.00000
10.....	0.16582	0.10725	0.05867	0.53847	0.28644	1.00000	0.08929	0.03072	0.05867
11.....	0.00341	0.00000	0.00341	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12.....	0.02275	0.01266	0.01009	0.44341	0.00000	1.00000	0.01009	0.00000	0.01009
13.....	0.01265	0.00000	0.01265	1.00000	0.00000	1.00000	0.01265	0.00000	0.01265
14.....	0.09844	0.09844	0.00000	0.38960	0.38960	0.00000	0.03835	0.03835	0.00000
15.....	0.03254	0.03254	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16.....	0.06413	0.06413	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17.....	0.05712	0.05712	0.00000	0.62342	0.62342	0.00000	0.03561	0.03561	0.00000
18.....	0.03098	0.03098	0.00000	1.00000	1.00000	0.00000	0.03098	0.03098	0.00000
19.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20.....	0.19317	0.19317	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
21.....	0.02078	0.02078	0.00000	1.00000	1.00000	0.00000	0.02078	0.02780	0.00000
22.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
23.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
24.....	0.58396	0.58396	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
25.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
26.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
27.....	0.22150	0.22150	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
28.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
29.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
30.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
31.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
32.....	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
33.....	0.27583	0.07583	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 16.

Life Characteristics for Total (Firstownerships and others) 1883—1927.

The period of War excluded.

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x	$q_x = \frac{D_x}{L_x}$	$q_x^{(s)} = \frac{D_x^{(s)}}{L_x}$	$q_x^{(w)} = \frac{D_x^{(w)}}{L_x}$	$\frac{C_x}{L_x}$	$\frac{C_x^{(s)}}{L_x}$	$\frac{C_x^{(w)}}{L_x}$
0.....	0.02066	0.01563	0.00503	0.00372	0.00000	0.00372
1.....	0.02634	0.01719	0.00915	0.00649	0.00050	0.00599
2.....	0.01611	0.00855	0.00756	0.00888	0.00476	0.00412
3.....	0.01638	0.00950	0.00689	0.01080	0.00734	0.00346
4.....	0.01047	0.00594	0.00453	0.00591	0.00349	0.00242
5.....	0.01910	0.00942	0.00968	0.01181	0.00554	0.00627
6.....	0.02602	0.01878	0.00724	0.00822	0.00411	0.00411
7.....	0.02908	0.01609	0.01299	0.02132	0.01175	0.00975
8.....	0.03126	0.02114	0.01012	0.03916	0.03417	0.00499
9.....	0.03675	0.02980	0.00695	0.02950	0.02621	0.00329
10.....	0.03303	0.02371	0.00932	0.02486	0.02066	0.00420
11.....	0.01950	0.01190	0.00760	0.01597	0.01124	0.00473
12.....	0.01735	0.01102	0.00633	0.01226	0.00917	0.00309
13.....	0.03049	0.02306	0.00743	0.01887	0.01552	0.00335
14.....	0.02858	0.02858	0.00000	0.02396	0.02396	0.00000
15.....	0.02840	0.02167	0.00673	0.03915	0.03307	0.00608
16.....	0.03596	0.02376	0.01220	0.02446	0.01690	0.00756
17.....	0.05364	0.02224	0.03140	0.03388	0.00948	0.02440
18.....	0.02068	0.01494	0.00574	0.03817	0.03474	0.00343
19.....	0.08006	0.06998	0.01008	0.09082	0.08259	0.00823
20.....	0.09511	0.06870	0.02641	0.08864	0.06392	0.00472
21.....	0.05058	0.04627	0.00431	0.04778	0.04778	0.00000
22.....	0.06909	0.04689	0.02220	0.01224	0.00772	0.00452
23.....	0.04172	0.03880	0.00292	0.01804	0.01804	0.00000
24.....	0.09004	0.06654	0.02350	0.03826	0.03826	0.00000
25.....	0.03144	0.03144	0.00000	0.02836	0.02836	0.00000
26.....	0.04361	0.04361	0.00000	0.04230	0.04230	0.00000
27.....	0.02545	0.02277	0.00268	0.01026	0.00758	0.00268
28.....	0.05276	0.01493	0.03783	0.02316	0.02316	0.00000
29.....	0.01152	0.00556	0.00596	0.05224	0.05224	0.00000
30.....	0.03392	0.01453	0.01939	0.02729	0.02729	0.00000
31.....	0.03143	0.02144	0.00999	0.02144	0.02144	0.00000
32.....	0.00537	0.00000	0.00537	0.00000	0.00000	0.00000
33.....	0.02489	0.02489	0.00000	0.00000	0.00000	0.00000

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