business cycles and steel markets

Studies in demand variations and firms' short-terms behaviour in the Swedish steel market

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BECKMANS

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Preface

The main part of this book was written during my time as economist at Jernkontoret, the Swedish Ironmasters' Association. I devoted a great deal of that time to studies of cycles in different steel markets as they appear in order- and delivery data, revenue-, cost- and profitability figures, labour statistics etc. The aim of these studies was to provide a framework for short-term forecasting; later on the field of study was extended to include different kinds of long run problems of the Swedish steel industry.

In order to avoid drowning in all the material from many different studies over specified products I have let this book deal either with steel as *one* product or steel divided into ordinary and special steels. Furthermore I have with the exception of an analysis of the determination of steel consumption restricted the study to Swedish steel markets. These two limitations may seem discouraging at least from the point of view of marketing men. And it certainly looks as if I have overdone the sales promotion of the book by giving it the very promising title of Business Cycles and Steel Markets. It is, however, in the first place my experience that general phrases like "steel demand is picking up" and "merchants' price quotations are still moving upwards", are of interest (if they are true) to almost all steelworks in Sweden, in spite of the fact that some of them are very specialized as far as product lines are concerned. Secondly, though small in size Sweden has a highly developed structure of steel consuming sectors. The Swedish steel market (or steel-markets) can therefore serve as a "model" for other steel-markets, i.e. the conclusions drawn might be of much more general validity than a first glance at the problem would leave one to believe.

The study consists of three analytical parts, surrounded by a descriptive survey of postwar developments in the Swedish steel market and a general conclusion. The analytical parts, which deal with the determination of steel consumption, inventory cycles and subdivision of steel demand in imported and Swedish steel respectively, can be read as separate essays. They were originally written as single studies. Although they have been combined to give a coherent general survey of the Swedish steel market, I have let their original status as independent studies remain. I have therefore to ask the reader to be indulgent with the fact that some sections overlap, that principles of notation will vary somewhat between different parts and that the choice of "statistical unit period" varies from one year in Part II to a quarter in Part III.

Parts II, III and IV were originally written in Swedish and have been translated into English by Roger Tanner. He has also read and corrected Part I, Epilogue and the appendices, which have been written directly in English.

This book would never have been completed without the stimulating support given to me by many persons.

Starting with my friends at Jernkontoret, I owe a great debt to Ragnar Sundén, its managing director, who showed an inspiring personal interest in my work and who in many ways has been of great help not least by introducing me to firms, institutes and persons of interest for this study. I have also gained very much from discussions with Hans von Delwig, who generously has shared with me his broad and deep knowledge of the Swedish and international steel industries. I also wish to thank the staff of the statistical department, the basic work of which has been a necessary prerequisite to this study, and especially Jan Beckeman, its present head, and Alf Abrahamsson, who has prepared much of the statistical material to Part I. In this context I would also like to thank Lennart Fridén, with whom I had the pleasure of collabarating and exchanging ideas for several years.

During my different studies of steel markets I have had the great opportunity of consulting Erik Ruist, formerly at Jernkontoret, now Professor at the Stockholm School of Economics. He has not only guided me in these studies but also educated me in scientific research. Being himself devoted to empirical research, he has changed my attitude towards empirical econometrics from a slight but perhaps not outspoken scepticism to enthusiasm. I have also derived advantage from our common work with practical forecasting in Swedish and international organizations. His personal interest in this work has been a great encouragement to me.

During my time at Jernkontoret I also had the pleasure of discussing my problems with many helpful friends at Konjunkturinstitutet, the National Institute of Econonic Research. I thank all of them but cannot avoid mentioning especially Stig Cronwall who not only kindly introduced me to the institute's computer programs but also spent much of his time on informative discussions of problems of regression analysis, seasonal adjustment etc, and Lars Jacobsson, now at Svenska Handelsbanken, who carefully read and gave me valuable comments upon early drafts of the essay about inventory cycles (Part III).

I had the opportunity of having some early versions penetrated at the seminar of Economics of Handelshögskolan in Stockholm, the Stockholm School of Economics. At these times Erik Lundberg, who represents a very important link between the old Stockholm school and modern theoretical and empirical economic dynamics, provided me with many interesting and appealing points of view.

He also inspired Jernkontoret to start business cycles research by a brilliant and penetrating address at the Hindermässan (a yearly event in Örebro for the past hundred years) in 1962.

At the same time I would also like to thank my inspiring teachers Bertil Ohlin who aroused my interest in economics as a science as well as an important ingredient in modern society, and Erik Dahmén who opened my eyes for the necessity of taking institutional factors into account in relevant economic analyses.

Apart from Jernkontoret I have also had financial support from the Svenska Handelsbanken Foundation for Social Science Research, Stockholm and the Torsten and Ragnar Söderberg Foundations, Stockholm, which I gratefully acknowledge.

Finally I would like to express my appreciation of the skillful assistance Mrs Linnea Rudolf gave me in managing an overwhelming quantity of statistical material and to Mrs Marianne Fröberg, who typed several versions of the manuscript.

To Kristina, Erik, Sverker and Henrik, my wife and our children, who have been the injured party in this affair I would like to render my thanks for their encouragement and my admiration of their patience.

Stockholm, November 1972

Lars Vinell

Part I

A survey of postwar trends and cycles in the Swedish steel market

0. The general economic background

There is little doubt that the western economies have followed different patterns of development than was generally expected after the end of the second world war. Having the experiences from the interwar period in mind, forecasters in many countries waited for the first crises to come.[1]) Instead of recurrent depressions, however, most western countries have experienced an almost uninterrupted economic growth. The average rates of growth have in general been much above those of the 1920s and 1930s. As a consequence of this rapid growth problems of unemployment have been much less severe in the later period than in the former.

The difference as regards the path of development between the postwar and the interwar periods is obvious in the accompanying figures—1a and 1b—which show GNP 1920—40 and 1950—1970 for USA and Sweden respectively. Looking on the two postwar GNP curves one naturally asks oneself if the business cycle has disappeared. Or as the question was put on an international conference in London organized by the Social Science Research Council: "Is the Business Cycle Obsolete?"[2])

If we associate the term "business cycles" with regular non seasonal upswings and downturns in the level of aggregate production, the answer is of course in the affirmative. This restriction in the definition of a business or a trade cycle,

1) Cf. Erik Lundberg, Business Cycles and Economic Policy, London 1957.

2) The lectures and summaries of the following discussions are published in Bronfenbrenner (ed.), Is the Business Cycle Obsolete? New York 1969.

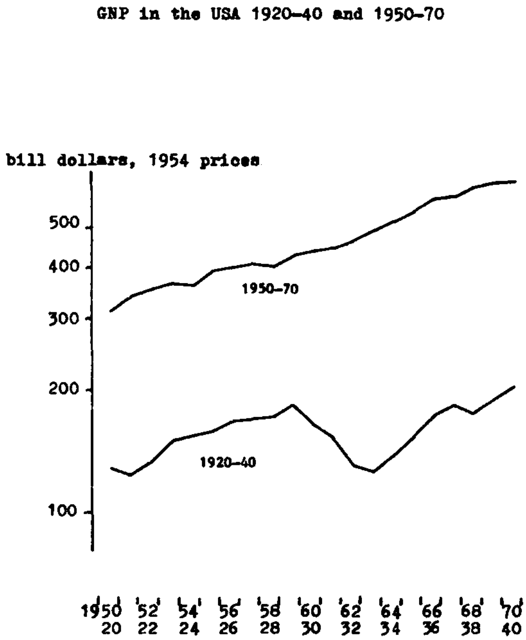

Fig. 1a

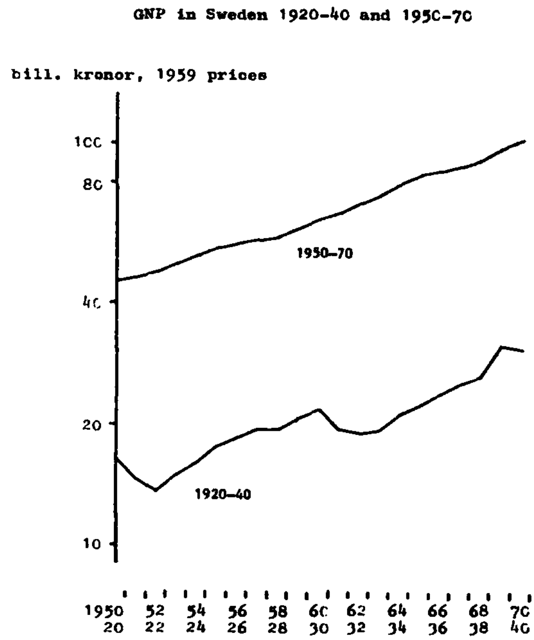

Fig. 1b

however, is neither convenient nor relevant. Instead economists have turned their interest to the cyclical behaviour of the rates of change or of trend deviations in aggregate production and in other macrovariables. Those cycles may be of interest per se but most attention should be and is paid to the fact that they are timed with cycles in primary target variables of economic policy like the rate of unemployment.[3])

Even if GNP in a country grows without interruption the development in many of its various industries can show cycles of the "classic" type. In the steel industries of the USA, Japan and Europe people certainly do not agree with the view that the business cycle is obsolete. Not only have they experienced regular and sharp ups and downs in the yearly figures for steel consumption, steel production, steel prices etc., but attentive observers have also been able to see that these changes are well phased with those in the growth rate of GNP and in other indicators of the general business situation. To those people an expected increase in the growth rate of GNP from 2 to 4 percent per year can be associated with a fundamental improvement in business prospects.

[3]) Cf. Erik Lundberg, Instability and Economic Growth, Stocholm 1969, cap. 2.

In order to get an idea of the relation between the mode of behaviour of the steel cycle and that of the general cycle we can compare trend deviations in steel consumption with those in total production. In figure 2 this is done for the USA, EEC and Japan. The trend adjusted series for steel consumption, industrial production and GNP have fairly similar waves as regards timing but the amplitude of the steel cycle is much bigger in all three cases than those for the other two cycles. The great trend deviations in steel consumption are corresponded by big fluctuations in the yearly rates of change. In Japan they have ranged from − 11 percent to + 47 per cent. Though GNP has had a growth rate which in the yearly statistics has always been positive there have still been great absolute decreases in the input of the most important material in the Japanese economy. Similar but less drastic experiences can be found for countries in the West. So we can conclude that even if the post war period shows very few examples of absolute drops in GNP, which has behaved quite differently than in the interwar period, there is no reason to kill the concept of business cycles. The existence of cycles in the rates of change in GNP are associated with among other things classic cycles in the steel sectors. In later sections we shall show that the common properties of the two kinds of cycles are no matter of mere hazard but to a high degree of causal relationships.

Most of the analysis in the subsequent parts concerns the Swedish steel market. In the rest of this introductory essay we shall therefore give a brief description of cyclical and long term patterns of development on this market during the 1950s and 1960s. Because of lack of relevant data for the early part of this period we shall in most cases confine ourselves to the period 1954—1970.

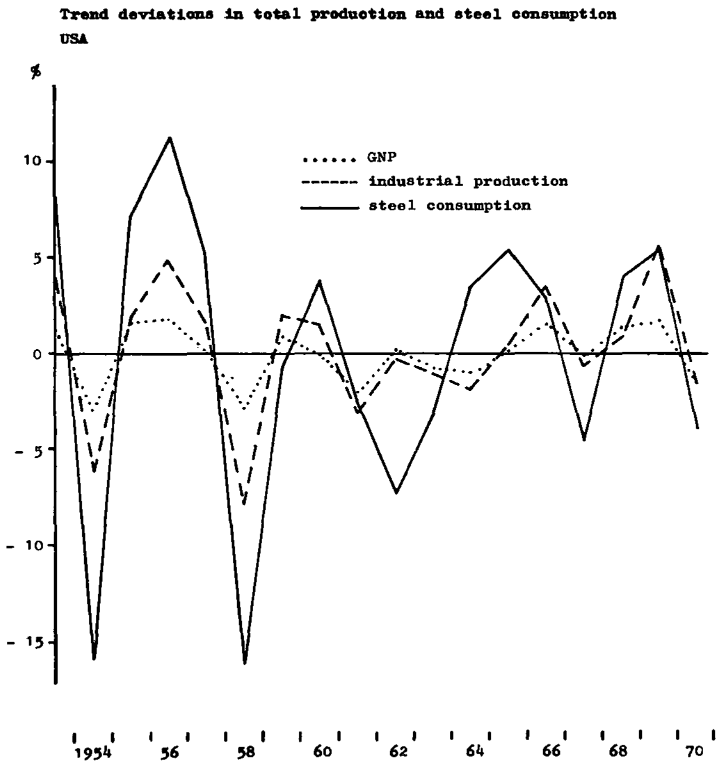
Trend deviations in total production and steel consumption
USA
%
10
5
0
- 5
- 10
- 15
GNP
industrial production
steel consumption
1954
56
58
60
62
64
66
68
70

Fig. 2a

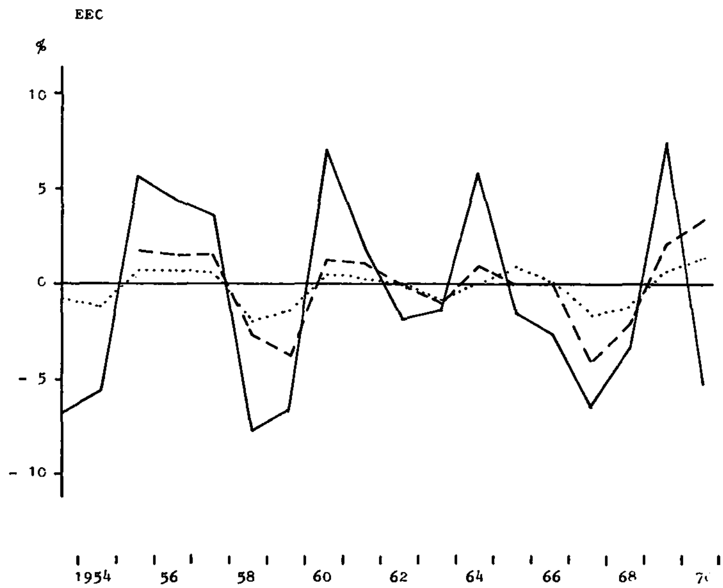
EEC
%
10
5
0
- 5
- 10
1954
56
58
60
62
64
66

Fig. 2b

Japan

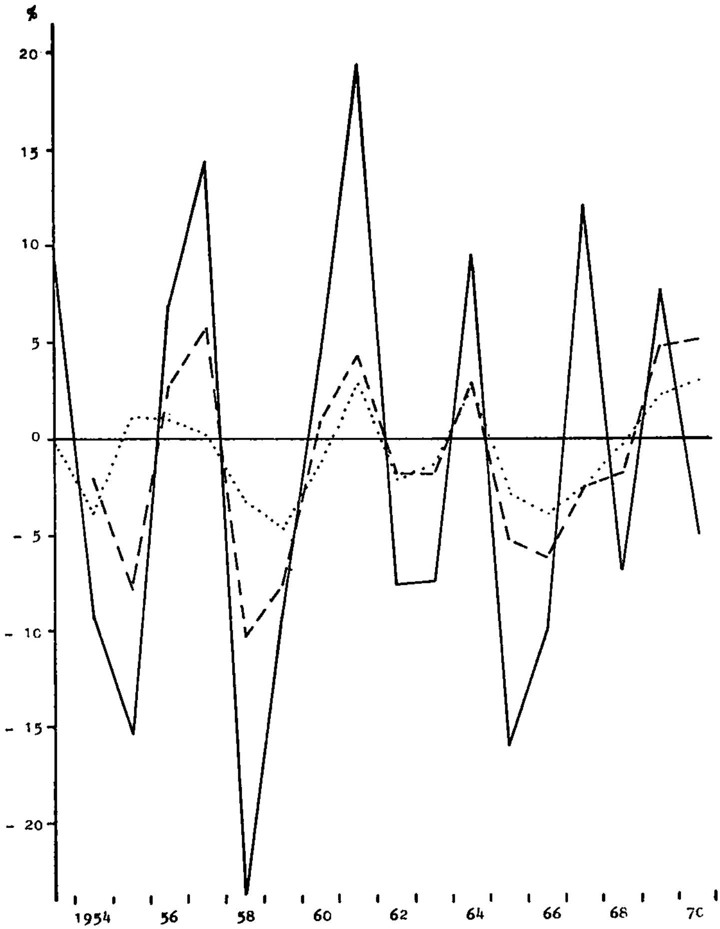

Fig. 2c

1. Production, trade and market supply

Looking back on the GNP curve for Sweden (figure 1b) we must agree with Lundberg when he states that "The general appearance of Swedish postwar cycles does not look especially interesting".[1]) Looking closer at economic data we can, however, distinguish "growth cycles" which, though comparatively small, coincide with cycles in the rate of unemployment and in the degree of capacity utilization. Of course the fluctuations in the unemployment rate have been milder than during the interwar period. Not even during the most pronounced recession year after the second world war, i.e. 1972, has unemployment reached levels comparable to those in the 1930s. There are, however, as Lundberg remarks, good reasons to believe that "the variation of growth of the production indices and employment rate tend to underestimate the true instability on the demand side".[2]) Firms have for several natural reasons not been able to adjust their output quickly at an upswing in the demand for goods. This inertia has led to recurrent periods of increasing excess demand, the sign of which is growing order backlogs. During downturn periods in demand those backlogs have acted as shock absorbers and thus stabilizing the rate of output and the rate of unemployment.[3])

For some commodity sectors, primarily raw material and intermediate goods, demand fluctuations have caused obvious

1) Instability and Economic growth, page 192.

2) Ibidem, page 198.

3) Businessmen and business paper journalists have been very sensitive to those fluctuations. Their sensitivity seems to have created psychological cycles the effect of which has been most apparent in the stock market.

upswings and downswings in deliveries and production. In the following pages some evidence of the postwar instability on the Swedish steel market will be shown and in the subsequent parts we shall on several occasions return to the relation between the growth cycles in the general economy and the classical cycles in the steel market.

The pattern of development on the steel market stands at least superficially in stark contrast to that of the Swedish economy as a whole. We recognize very much of the cyclical pattern of development from elementary textbooks on business cycles when we are looking at historical curves for production, trade, prices etc. in this market.

According to figures 3a and 3b steel consumption (here apparent steel consumption, i.e. production + imports − exports) shows a rapid and markedly cyclical growth with sharp upswings 1954—55, 1959—60, 1963—64, 1968—70 and downturns 1955, 1957—58, 1962, 1966—67 and 1971.[1]) Imports of steel behave in very much the same way as apparent consumption, the only remarkable difference being that the trend deviations of the former are in relative terms bigger than those of the latter. Exports and production have less marked cycles than imports and consumption. Since exports and imports have been very different as regards long-term growth rates and phase of cycle, the balance of trade has undergone remarkably strong changes. The balance of current payments starts with an import surplus in 1954 of 117 mill. kronor but after 1959 it turns to an export surplus which grows rapidly to a high in 1968 of 1136 mill. kronor. During some periods like 1955—56 and 1967 exports have expanded at an increasing rate while imports have decreased thus causing drastic increases in net exports. The export surplus rose from 757 mill. kronor in 1966 to 1030 mill. kronor in 1967.

	1	2
Prod	7.4	3.6
Imp	5.4	8.7
Exp	11.9	5.0
Appc	5.1	5.9

1 Average growth rate in per cent per year

2. Average distance from trend in per cent

In figure 3a steel consumption, production of steel and steel trade are measured in tons of finished steel. This change in measurement does not change the trend and cycles of each separate curve very much as compared with the corresponding curves in figure 3b, but it changes their levels. When counted

[1]) The dating of upswing and downturns relates to the non trend adjusted curve. In detrended series downturns will come earlier and upturns later and different detrending rules will in general give different turning points. The latter would here also be affected by our applying a 5 quarter moving average to the original series. To speak about leads and lags is because of these operations no clear-cut matter. We shall however return to the problem in part II.

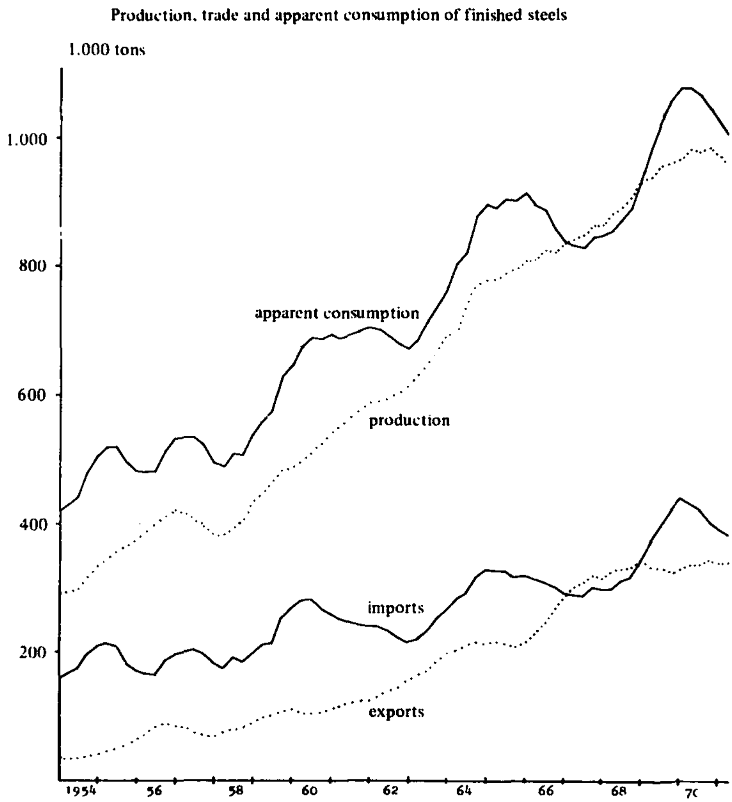

Fig. 3a

in tons steel consumption has been bigger than steel production and steel imports bigger than steel exports except for the years 1967 and 1968, while the position of the curves in question is the opposite when consumption etc. are measured in kronor (1959 prices).

Behind these shifts lies a peculiar attribute of the Swedish steel industry, namely its heavy concentration on special steel. More than 25 per cent of its crude steel production and more than 50 per cent of the sales value of its production consists of special steels which have much higher average prices than ordinary steels.[1]) Most of the special steels are exported and the special steel content of Swedish steel consumption in tons of crude steel lies in the interval 10 to 15 percent. Hence the two consumption curves are very similar as are the import curves, while the export and production curves are more affec-

[1]) See Part IV for further and more detailed information.

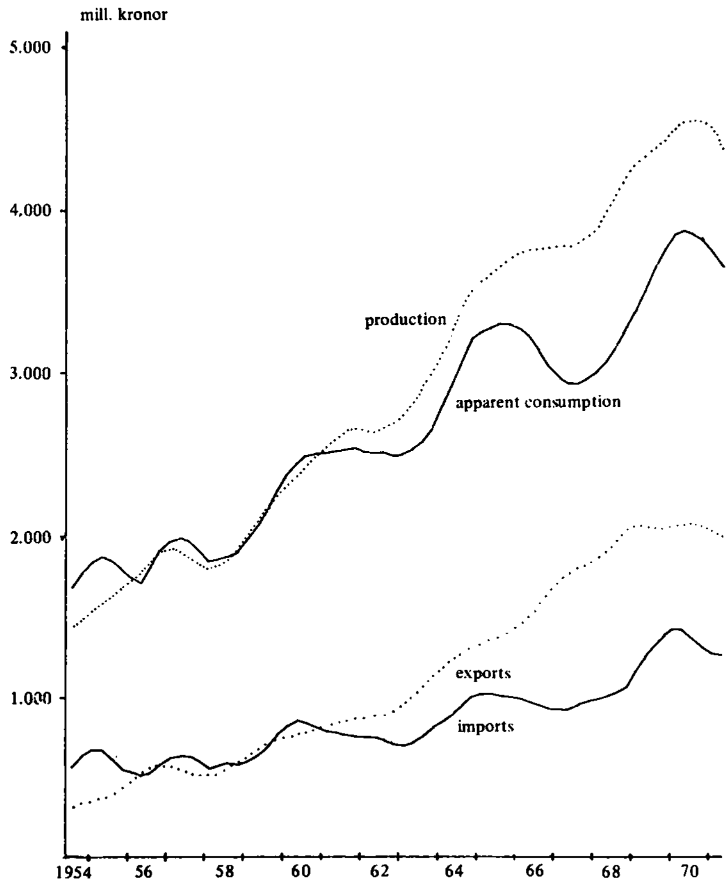

Fig. 3b

ted by the way of measurement.[2]) In Part IV we shall return to analyse the differences in the dynamic properties between the product of special steel and that of ordinary steels.

Apparent consumption can be divided into two components, input of steel into the steel consuming industries (or actual steel consumption) and steel inventory investments. As compared to the output of steel consumers, actual consumption has shown big fluctuations, the growth rate varying from — 1.5 percent to + 14 per cent per annum. The apparent consumption cycles have furthermore been accentuated by the cyclical

[2]) For an economist the tonnage measurement may seem meaningless but as will be shown in Part II a ton of steel has acceptable attributes to be treated as a composite good. It is furthermore not possible to get fixed price measurements of inventories etc.

changes in steel inventory investments. In some periods this component has dominated the changes in apparent steel consumption completely. Such was the case with the 7 percent decrease in the latter variable from 3.56 mill. ton of finished steel in 1966 to 3.32 mill. ton in 1967. A noticable feature of steel inventory investments is their lack of a rising long term trend. Since steel consumption and steel production have increased at rapid rates this must mean that the speed of turnover of steel inventories has been raised. As will be pointed out more clearly in Part III there is a great difference in this respect between different categories of firms. Thus the speed of turnover among steel consumers increased from 1.6 times a year in 1953 to 4.4 in 1970, while at the same time it decreased from 13 to 6 in the case of steelproducers.

The long-term trends reflect a change of the property of the steel market from the sellers' to the buyers' market. The same impression is given by the price trends in the 1960s. In figure 4 four price curves are drawn, of which the first (from above) is a wholesale price index covering a broad range of steels, from precious special steels to the common ordinary qualities, the second is the merchants' price quotations for a common bar quality, the third is an index of the Belgian export price quotations and the fourth, finally, is a Swedish import price index.

Let us first state that they show roughly coinciding cycles with four peaks (1957.3., 1960.1., 1964.3. and 1970.2.) and three troughs (1959.1., 1963.1. and 1968.2.).[1])

Secondly the peaks are successively lower until the "great market disturbance" in 1969, while the troughs of the two first curves are slowly increasing.

Thirdly the relative price of steel (steel price divided by an index of the general price level) has decreased sharply. This decrease reflects a growing excess capacity in the European steel industry in the 1960s, which pressed steel prices towards the marginal costs of production in the less efficient steel works. During this time pessimism grew in the European steel industry and affected the long term forecasts. According to a hypothesis put forward by Ruist this pessimism effectuated a rapid rise in the scrapping of old capacity. So, when a demand upswing started in 1969 the excess capacity "vanished" and the situation

[1]) The dating applies to the first curve.

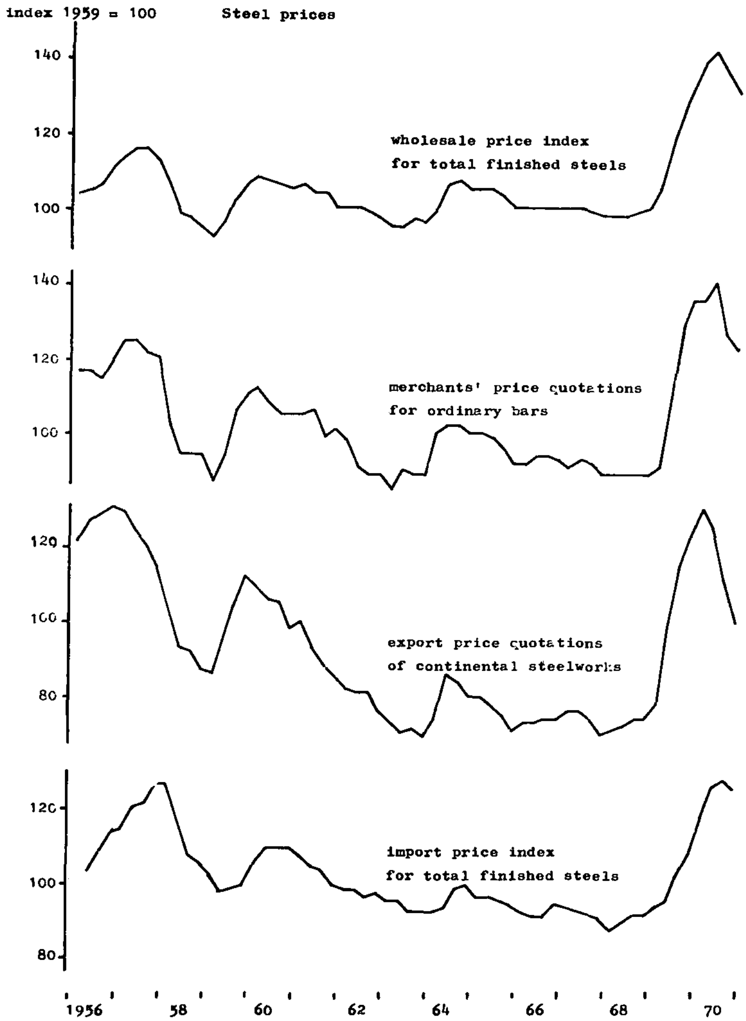

Fig. 4

turned quickly towards a pronounced excess demand, the result of which is clearly reflected in the curves.[1])

The continental export prices seem to have dictated the prices of ordinary steels in Sweden. A closer look at short-term price quotations show that the Swedish quotations neatly follow those of the continental exporters. A certain lag between the export quotations of the Belgian steelproducers and those of the Swedish merchants can be traced even in quarterly data.

[1]) Erik Ruist, The Case of the Vanishing Excess Capacity, Jernkontorets forskning, Stockholm 1971. For a broad treatment of fluctuations in the "world market prices" see Lennart Fridén, Instability in the International Steel Market Stockholm 1972.

2. Business cycles and the steel industry

We have observed in figures 3a and 3b that production has been more stable than apparent consumption, the stabilizer by necessity being net-exports. Since however demand for steel, measured as orders received by the producers, has still bigger fluctuations than realized purchases one further important stabilizer has to be mentioned, i.e. order backlogs. These have increased considerably during all observed upswings in demand thus making it possible for steel producers to let their output decrease at a slower rate (or not at all) during the subsequent downswings.

Production has however been unstable enough, together with price changes, to create fluctuations in the revenues and profits of firms. At least during the period 1957—63 the total revenues of steel producers have had approximately the same cyclical properties as apparent consumption. Thus we can observe two typical peak years—1957 and 1961—and two trough periods—1958 and 1962/63. Then we should expect a peak year in 1965 and a trough year in 1967, but by a remarkably strong increase in exports the steel works were able to match the drop in home market demand. In this way a whole potential cycle in revenues has almost been smoothed out.

Contrary to revenues, profits have kept their cyclical behaviour throughout the whole period. Four full cycles can be distinguished, the peak years of which being 1957, 1960, 1964 and 1970. The trough years are 1958, 1962, 1967/68 and 1971. Though yearly data, which in this case are the short-term statistics available, provide very limited information to the analysis of such things as the dating of turns in cycles and lag

Orders and deliveries

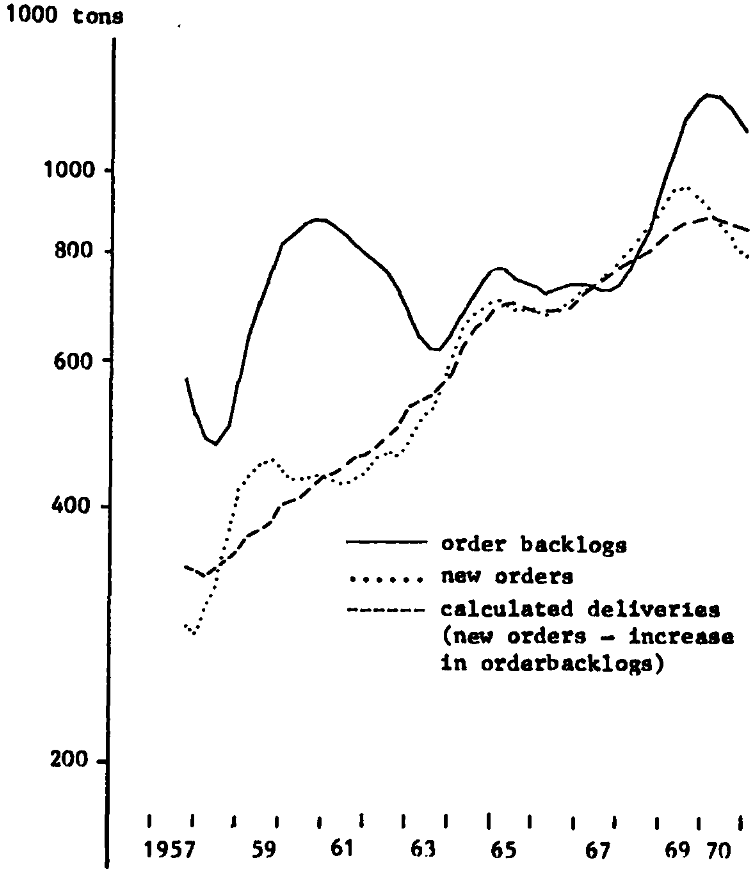

Fig. 5

structures, it can still be worthwhile to look a little closer at the revenue and cost components.

We have seen that price and "quantity" cycles in the Swedish steel market coincide. This will of course accentuate the cyclical swings in revenues. If we divide the period into "good" years (1956—57, 1959—61, 1964—65 and 1969—70) and "bad" years (1958, 1962—63, 1966—67 and 1971), this division refers equally well to prices and to the quantity demanded.

During the good years the average increases in production and in prices are 10.2 and 7.2 per cent while corresponding

Revenues and costs in the Swedish steel industry

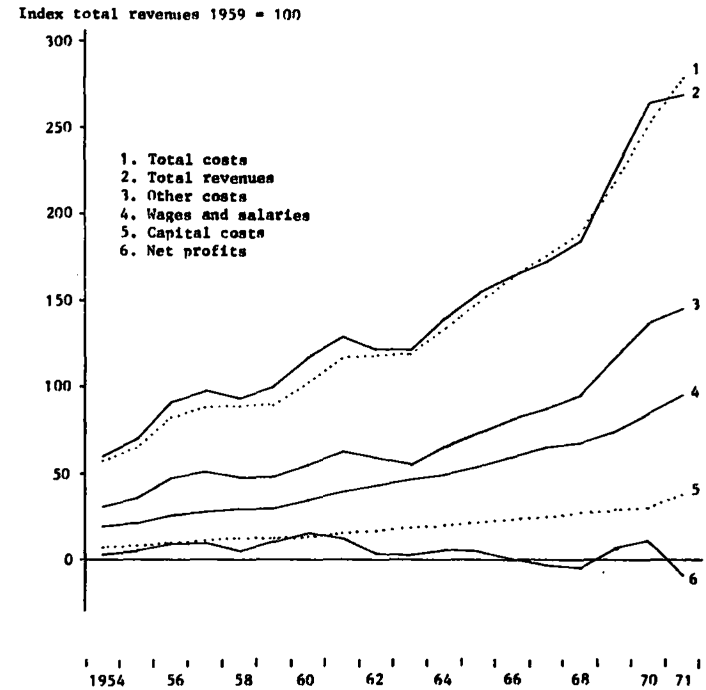

Fig. 6

values for the bad years are + 1.9 and — 4.2 per cent respectively.[1])

As regards costs the raw material costs are highly correlated with revenues, a fact which reflects a certain stability in input coefficients as well as a covariation between the steel prices and the relevant raw material prices; an increase in excess demand for steel is in general followed by an increase in the

[1]) The change in total revenues can be divided into a price, a quantity and a combination effect. Let R, p and q denote revenues, price and quantity produced respectively. Then the change in revenues during year t over the preceeding year is

$$R - R_{-1} = \Delta R = \Delta(p \cdot q) = \Delta p \cdot q_{-1} + \Delta q \cdot p_{-1} + \Delta p \cdot \Delta q$$

The relative change is

$$\Delta R/R_{-1} = \Delta p/p_{-1} + \Delta q/q_{-1} + \Delta p \cdot \Delta q/R_{-1}$$

The average values of the last term are here 0.6 % and ±0 %. The last term should be positive if the Δp and Δq are positively correlated even in bad years. Here the difference in trends have counteracted the cyclical covariation.

excess demand for coke and other raw materials thus causing a rise in their prices.

Wages and salaries are less dependent on revenues than are raw material costs. As a matter of fact they seem to move quite differently from revenues in the short run. If we look at the curve for wage cost per unit of product we can observe "contra—cyclical" movements. During recession years like 1958, 1962 and 1966 this unit cost increases, while it decreases during the early phases of upswings, the year 1969 being a striking exception. From figure 7 we can see that this property is mainly due to the development of hours worked per unit of output (which is the inverse of the common productivity measure), the second factor of the unit wage cost, i.e. wages per hour worked, having had a rather stable growth. In weak years like 1958, 1962 and 1966 the productivity increase has been relatively small. This reflects what was probably a concious labour hoarding by the producers. Because of this kind of under-utilization of labour, firms have been able to increase their production rapidly during the early upswing without increasing their employment, the result of which is big productivity increases or large reductions in the labour input per unit of output. It is interesting (even if discouraging from the point of view of the Swedish steel industry) to see that the average productivity increase beetween 1964 and 1970 has been clearly less than the average for 1954—64. At the same time the average rate of wage increases has been raised. The consequence of

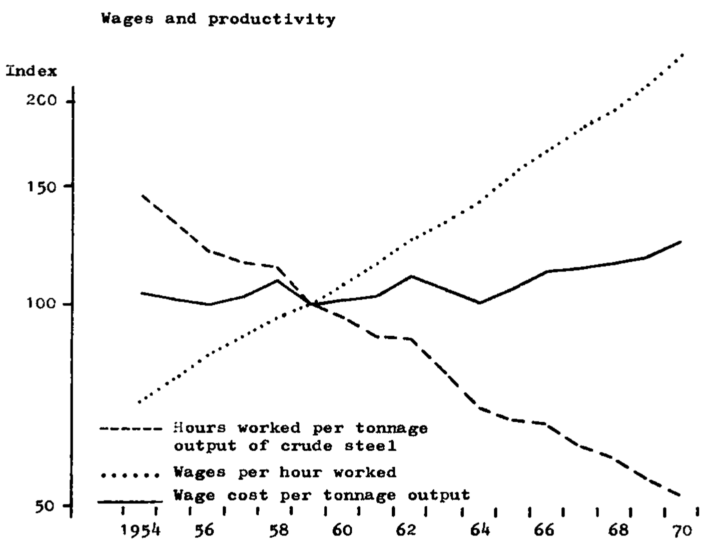

Fig. 7

this coincidence has been an increase in unit cost of more than 20 percent in five years.

The explanation to the declining rate of productivity increase may be found in the development of gross fixed investments. Those were very sluggish in the middle years of the 1950s most likely due to prevailing quantitative restrictions on industrial investments. When these were released the level of gross investment doubled and reached a top in 1961 (in fixed prices). Since then the trend has been decreasing, which with respect to increasing replacement needs indicates a sharp drop in net investments.

The capital cost, which in this case is based on the fire insurance values of fixed assets, has been growing at a fairly stable

Fixed investments of the Swedish steel industry

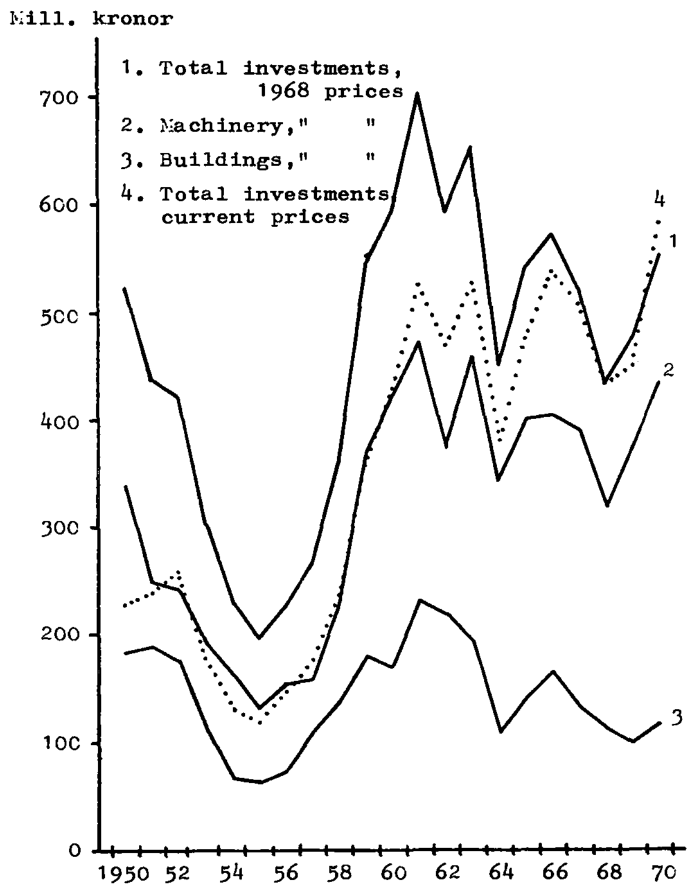

Fig. 8

rate. Since this growth by the very way of accounting is uninterrupted during downswings in demand and revenues, it accentuates the induced downturns in net profits. Neither capital nor labour costs have, however, played any significant role for the cyclical swings of profits, which have instead been dominated by fluctuations in prices, quantity produced and raw material costs.

Let us drop the capital costs out of the discussion and concentrate our interest to gross earnings (total revenues minus labour and raw material costs) and especially gross earnings per unit of output. As can be observed in figure 9 (page 22) the changes in the two variables are very well correlated with price changes; the correlation between the percentage change in price and the percentage change in gross earnings per unit of output is as high as 0.95. In the first place it is not astonishing in the light of the preceding discussion that price and gross earnings per unit of output covary. The last variable can very broadly be defined as price minus labour and raw material costs per unit of output. Even if the first of those costcomponents has varied systematically, the variations have been of little importance to fluctuations in total unit cost. Since changes in raw material prices, the most volatile part of raw materials cost per unit of output, have been positively correlated with steel prices, fluctuations in unit earnings can almost completely be assigned to price fluctuations.

Secondly, the fact that price increases have tended to occur at periods of upswings in demand for steel in Western Europe, where most of the Swedish steel is sold, and vice versa, has also created a high correlation between changes in gross earnings and price changes.[1])

[1]) By definition given in the text gross earnings per unit of output (g) is

$$g = p - w - r$$

where p is price for steel, w is labour costs per unit of output and r is raw material costs per unit of output. If w and r are independent of p, the elasticity of g with respect to p is

$$(dg/dp)\,(p/g) = p/g$$

Since p/g in the case of the Swedish steel industry has been of the magnitude 5—6 in the last decade, the cyclical swings in g should be 5 to 6 times as big as those in p. Now we obtain by regression analysis the following numerical relationship

$$\Delta\%\, g = -8.08 + 2.308 \cdot \Delta\%\, p; \;\; R = 0.95$$

where the symbol $\Delta\%$ denotes "percentage change of". R is the coefficient of correlation (see part III chapt. 7). According to this relation

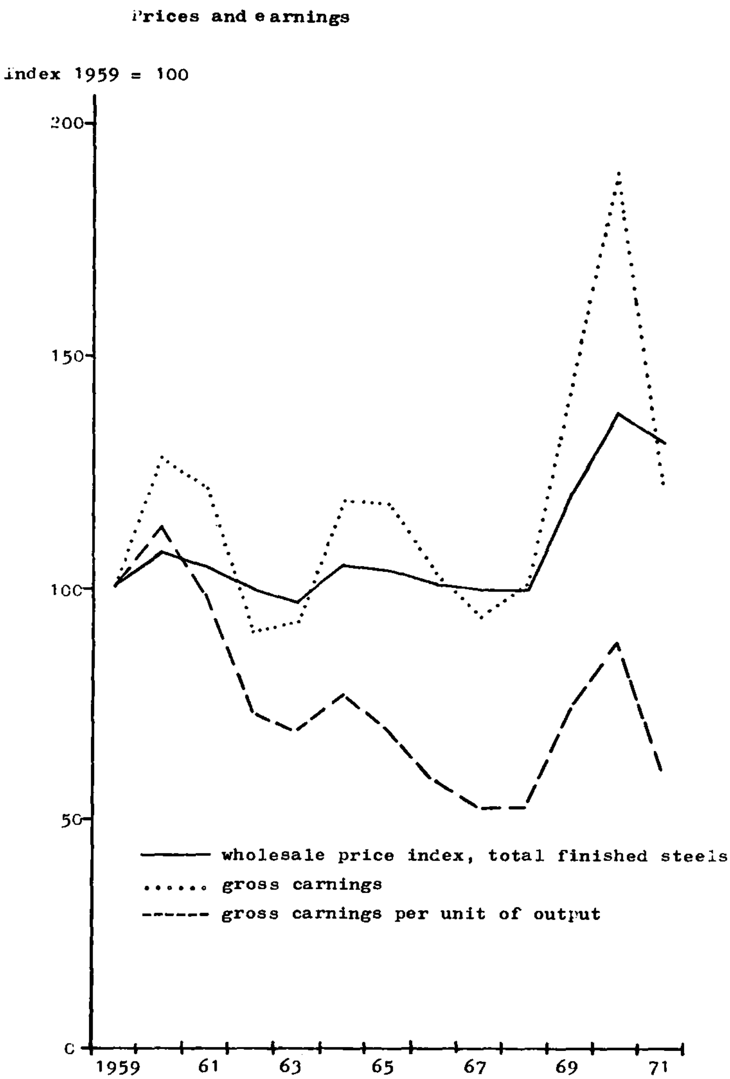

Fig. 9

the price elasticity of g (which varies with $\Delta\% p$) is on average clearly less than "expected". Since there are many reasons to believe that the price indicator used does not exaggerate the real price fluctuation, the result should be a consequence of the dependence between prices and costs. It has earlier been said that the raw material prices are positively correlated with steel prices. If this is also true for r, the elasticity of g with respect to p will be

$$(1 - \partial r/\partial p)(p/g)$$

which if $0 < \partial r/\partial p < 1$ is less than p/g.

3. Problems to be studied in subsequent sections

The preceding survey on developments in the Swedish steel market should have given sufficient evidence for the existence of business cycles in industrial sectors. Sweden is no exception in this respect. The mode of behaviour can be found in any country where the role of the steel sector is significant. In most of these countries cycles in steel demand, steel production, profits of steel industry etc have occured in an era of history the most obvious sign of which is a rapid, uninterrupted growth in total production. How is this possible?

What are the main causes of the instability of steel demand? Do firms in the steel sector act so as to stabilize the "external" cyclical disturbances or do they add fuel to the flames? These and other more specific questions will be studied in the subsequent essays.

In the first one we will try to get a picture of the determination of steel consumption, not only of the factors determining consumption but mainly of its dynamic properties, e.g. its inherent tendency to fluctuate. The following essay goes deeper into the short-term instability of steel demand. Here the emphasis is on steel inventory investments by steel consumers but at the same time a more detailed analysis of the short term behaviour of steel consumption will be given. The last essay is a study of the marketing policy of steel producers and its consequences for such things as the instability of steel output and foreign trade in steel. Because of the above-mentioned special properties of the Swedish steel industry it has here been necessary to make a distinction between producers of special steels and producers of ordinary steels.

Part II. The determination of steel consumption

0. The properties of steel from the point of view of demand. Definition of the concept of consumption

The term finished steel covers a variety of products differing both in appearance and—as regards quality—in both chemical composition and type of processing. This diversity is matched by a wide range of requirements from consumers regarding the tensile strength and toughness of the steel, its corrosion resistance, welding properties etc. These requirements in turn are due to the fact that steel is used in a host of different sectors and figures as a raw material in a large number of products. One quality common to all these products is their durability, which is generally a matter of several years. The steel incorporated in them is thus used or consumed for a considerable period of time by motorists, house-dwellers, manufacturers etc. Steel consumption thus defined, i.e. as the consumption of capital, which is the normal sense in which the term is used, is very difficult to measure. However, this concept of consumption is not of prime interest when analysing how much steel is being sold or will be sold in future. For present purposes the consumption of steel during a particular period will therefore be taken to mean the quantity of steel used during this period for the production of goods in which steel is incorporated as a raw material.

1. The theoretical framework

1.1. A general model

As we have already seen, steel is a raw material or an input which has to be processed further before it reaches the ultimate user. In analysing the determinants of steel consumption it is natural therefore to begin with the level of production in the steel-consuming sectors (X) and steel consumption per unit of production within these sectors (A). The steel consumers' output can in turn be regarded as determined by the demand for their products for consumption, investment or export (Y). Steel consumption per unit of production, steel intensity (A) can depend on such quantities as the price of steel in relation to the price of rival materials. Steel intensity influences and is influenced by investments in the steel-consuming industries. Thus we can work our way backwards through a chain of causes to discover factors determining private consumption, industrial investments etc.

Such a general model for the analysis of steel demand or steel consumption is illustrated in the figure below.

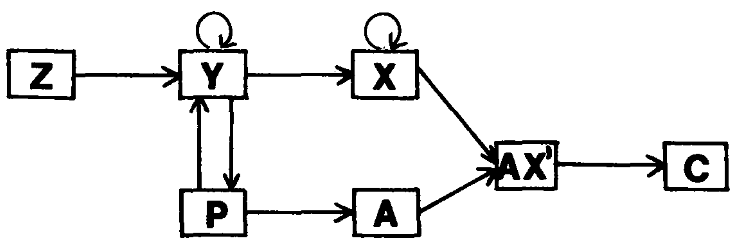

Fig. 1

Denotations:

C	steel consumption
$X = [X_1, X_2 \ldots X_n]$	production in different sectors
$A = [A_1, A_2 \ldots A_n]$	steel consumption per unit of output (steel intensity) in the different sectors of production
$P = [P_1, P_2 \ldots P_k]$	the price of steel, the prices of substitutes for steel and other factors affecting steel intensity
$Y = [Y_1, Y_2 \ldots Y_m]$	private consumption, private investments and other final demand categories
$Z = [Z_1, Z_2 \ldots Z_1]$	variables determining final demand.

All these relations will be studied in the present essay, but the main emphasis will be on the analysis of $Y \rightarrow X \rightarrow C$ relations, somewhat at the expense of the $Z \rightarrow Y$ and $P \rightarrow A$ relations. $P \rightleftarrows Y$ relations will only be dealt with incidentally.

The disposition of the essay is as follows. First attention will be devoted to the primary relation $X \rightarrow C$. Basic assumptions concerning the nature of the production function will be presented and discussed in this connection. The analysis will then proceed to a macro model, from which the $Y \rightarrow X$ and $X \rightarrow C$ relations will be simultaneously derived. We will be concerned here with the input-output model. A statistical picture of the division of steel consumption into different X and Y categories will then be given on the basis of an input-output model for Sweden. The stability of the relations will be investigated, a specific model being used to explain short-term variations in the A coefficients; the long-term variations will be treated in a more speculative vein in this section.

Next comes a short presentation of the determination of certain Y categories relevant to this context. This is followed by a comparatively lengthy analysis of steel consumption as a function of total activity in an economy. Various models will be tested on data from several industrial nations, the more long-term relations being analysed from cross-section data. Finally the question of the price sensitivity of steel consumption will be considered. Hypotheses concerning price effects will be tested on data for the steel markets in the USA and Sweden.

1.2. The X → C relation: the production function of the steel consumers

Let us consider an economy which can be divided into homogenous sectors of production, each producing one good. For each period (t) we can then form the following identity:

$$C_t = \Sigma C_{jt} = \Sigma a_{jt} \chi_{jt};\ j = 1, 2 \ldots s \tag{1}$$

Denotations:

C_{jt} steel consumption in sector j
χ_{jt} output of good j
a_{jt} steel input per unit of good j produced

In every period, consumption within a sector is exactly equal to the quantity produced times steel input per unit of production. Clearly the formation of a theory of the relation between steel consumption and output in different sectors is equivalent to formulating a set of hypotheses regarding variations in steel intensity in the different sectors. Referring to fig. 1 we can say that the theory of the $X \rightarrow C$ relation will apply to the $P \rightarrow A$ relation.

1.2.1. Short term and long term relations. In static economic theory, a firm's use of factors of production for a given quantity of output is determined by the production function and relative prices. The production function can generally be written as

$$q = f(x_1 \ldots x_k;\ x_{k+1} \ldots x_m;\ x_{m+1} \ldots x_n) \tag{2.}$$

Denotations:

q quantity produced
x_i quantity of factor of production i used

Let $(x_1 \ldots x_k)$ be a set of variables denoting the levels of use of different types of real capital. Similarly, let $(x_{k+1} \ldots x_m)$ and $(x_{m+1} \ldots x_n)$ denote the use of labour and raw materials. As regards substitution between these groups we shall assume here that there are no possibilities of substitution as between capital and raw materials or labour and raw materials. Consequently the combination of labour and capital with which a given level of output is attained will be immaterial to the consumption of raw materials. The choice of raw materials is determined by their ability to replace one another and by their prices. With no change in production functions, consumption of a particular raw material, such as steel, will therefore be a function of the output level and raw material prices, i.e.

$$x_{m+i} = g(q, r_{m+i} \ldots r_n); \qquad 3.$$
$$g'_q > 0; \quad g'_{r_j} \geqslant 0 \quad j \neq i; \quad g'_{r_i} \leqslant 0$$

According to this function, a rise in steel prices will lead to a fall in steel intensity and, consequently, in steel consumption as well. So much for the statical analysis. Empirically, equilibrium is often hard to identify because the statistical picture is obscured by lags in adjustment. There are a host of a priori reasons for supposing that substitution between steel and other materials is a slow process. Generally a change of materials will mean that steel consumers have to acquire new processing machinery as well as replacing or retraining their labour, i.e. they will try to alter their production functions. In many cases too, substitution would call for heavy capital investments. Steel consumers are therefore unlikely to make far-reaching alterations to their combinations of materials as a result of what they judge to be short-term fluctuations in prices. Thus in the short run, i.e. with a given capital structure, steel consumption per unit of output will remain constant. It is worth noting that this constancy of input coefficients is a dynamic property which reflects the lag in adjustment. Even in the long run, i.e. when all factors of production are variable, substitution between steel and other materials however will probably not be important. In many sectors interchangeability is very small for technical reasons. We shall therefore assume here that steel forms part of a fixed combination with other raw materials at any point in time. Projected on a two dimensional surface, the relation between raw material inputs and output can be illustrated by the collection of curves in the figure on page 30, where each curve (isoquant) denotes a particular output level. Profit-maximizing firms will choose a combination corresponding to one of the corners, regardless of price relations.[1])

The first hypothesis concerning the $X \rightarrow C$ relation will therefore be

$$C_t = \Sigma a_j \chi_{jt} \qquad 4.$$

[1]) The question of substitution will be discussed more thoroughly in chapter 4.

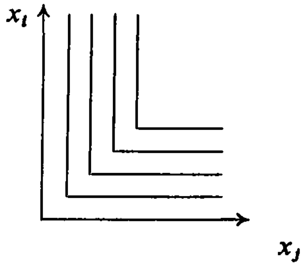

Fig. 2

This relation is thus assumed to apply both in the long run and the short run. The hypothesis will be considerably modified later on, but in the meantime we shall extend the assumption of constancy so as to obtain a simplified but manageable picture of the determination of steel consumption in an economy.

1.2.2. The input-output model. Equation 4 is less informative than it might appear at first sight. We can estimate steel consumption if we know the output of every sector for a given period, but we can hardly ever use the equation to calculate the total effects on steel consumption of a given rise in output within a sector. This is only possible if the output levels in different sectors (χ_j) are mutually independent. This is a patently unrealistic assumption, for it would mean that no one sector would need any output from any other sector (apart from the steel sector). A cursory glance at reality is enough to show that the interdependence of different sectors of production is a fundamental characteristic of industrial economies. A primary increase in output equal to $\Delta\chi_j$ ($j = 1, 2 \ldots n$) will therefore in the majority of sectors result in a steel consumption greater than $a_j \Delta\chi_j$, for a rise in the output of a branch causes output to rise in many other branches, which in turn have to increase their steel consumption in order to achieve this rise in their output. These increases in turn call for greater inputs from various industries etc. Thus we have to take into account, not only the direct effect of a rise in output on steel consumption, $a_j \chi_j$, but also a series of indirect effects.

In order to obtain a picture and an estimate of these indirect effects we need a larger system, e.g. a system of equations, in which the relations between the output levels of different sectors (χ_j) are exactly defined. One such system is the input-output model, which among other things describes the flow of goods between sectors of production in a system of linear equations. After W. Leontief's pioneering work in this field, especially after the appearance of his important book, The Structure of the American Economy, input-output analysis has been the subject of innumerable theoretical and empirical studies.[1]) Its theoretical foundations and economic implications are no doubt reasonably familiar to economists, but since the model in question constitutes the basis of subsequent argument, a brief description of its salient features will be given here to enable any non-economists with an interest in steel consumption to follow the rest of the argument. We shall also devote special attention to those properties of the input-output model which are relevant to its use in the kind of empirical analysis we are concerned with here.

The system can be schematically described in the following table:

$$
\begin{array}{c|cccc|c}
 & \multicolumn{3}{c}{\xrightarrow{\text{output}}} & & \\
 & X_1 & X_2 & \ldots X_n & & \\
\hline
\uparrow & X_{11} & X_{12} & \ldots X_{1n} & y_1 & X_1 \\
 & X_{21} & X_{22} & \ldots X_{2n} & y_2 & X_2 \\
 & \cdot & \cdot & \cdot & & \\
 & \cdot & \cdot & \cdot & & \\
\text{input} & \cdot & \cdot & \cdot & & \\
 & X_{n1} & X_{n2} & \ldots X_{nn} & y_n & X_n \\
 & M_1 & M_2 & \ldots M_n & M_f & \\
 & K_1 & K_2 & \ldots K_n & K_f & \\
 & L_1 & L_2 & \ldots L_n & L_f &
\end{array}
$$

Table 1

Denotations:

X_{ij}	deliveries from sector i to sector j (of good i for production of good j)
X_j	total production in sector j (of good j)
y_i	sector i's deliveries to final demand
M_j	sector j's consumption of imported goods
K_j	sector j's consumption of capital
L_j	sector j's consumption of labour
M_f, K_f, L_f	"deliveries" of primary factors for final demand

All variables are measured in Swedish kronor. Traditionally the input-output theory assumes that the input of good i per output unit of good j is constant. This means that

$$X_{ij}/X_j = a_{ij}$$

where the factor a_{ij} is a constant showing how large a fraction of a unit of good i is required for the production of one unit of good j.

[1]) W. Leontief, The Structure of the American Industry, New York 1951.

The unit is defined for all goods as "the quantity of the good having a market value of 1 krona".

Disregarding primary commodities, the system, which in table 1 has been described as a pure accounting system, can be specified as a system of linear equations which gives us an explicit theory of the network of relations existing between the sectors of production Thus the upper part of the table can be rewritten as n equations:

$$\begin{array}{lllllll} 0 & + a_{12}X_2 & + \ldots & + a_{1n}X_n & + y_1 & = X_1 \\ a_{21}X_1 & + 0 & + \ldots & + a_{2n}X_n & + y_2 & = X_2 \\ \vdots & \vdots & & \vdots & \vdots & \vdots \\ a_{n1}X_1 & + a_{n2}X_2 & + \ldots & + 0 & + y_n & = X_n \end{array} \qquad 5.$$

In matrix form the system can be written

$$AX + y = X \qquad 5.a.$$

or

$$I - AX = y \qquad 5.b.$$

$A = [a_{ij}]$ is an $n \cdot n$ matrix. I is the unit matrix while X and y are the vectors of total output and of final demand respectively.

Thus fixed factor proportions are here assumed to apply universally as regards produced inputs. Note that $a_{ii} = 0$ for all i. In this respect our presentation differs from traditional descriptions of the input-output model. This is reasonable in view of our definition of the sectors of the production system. It is also thoroughly in keeping with our practical use of the input-output model; henceforth we have no reason to concern ourselves with internal deliveries. Let subindex s be the steel sector. According to our definition, steel consumption (in the absence of imports) is:

$$X_s - y_s = \Sigma a_{sj}X_j$$

Clearly this expression is equivalent to equation 4. However, we are now in a position to study the effect on steel consumption of an autonomous change in output within one of the other sectors, say sector v. A change of this kind is equivalent to a change in the final product of the sector, i.e. deliveries to final demand. Thus by studying production as a function of final demand we can obtain the information we require. If the determinant of the matrix $(I - A)$ is different from zero (non-singular) we obtain from 5 .b.

$$X = [I - A]^{-1}y \qquad 6.$$

From this we find that

ΔX_v (autonomous) $\rightarrow \Delta X_s = b_{sv} \cdot \Delta y_v$

The coefficient b_{sv} is the v'th element in the s'th row of the inverted matrix. This coefficient is $> a_{sv}$ and $b_{sv} - a_{sv}$ is the indirect steel input in the production of one unit of product v. The total steel consumption of sector v is the direct and indirect steel consumption of the sectors supplying sector v. The indirect steel consumption of these sectors will in turn depend on direct and indirect steel consumption by their suppliers etc. Thus there are obvious advantages to beginning with the input-output model's assumption of constancy when dealing with a system of production that is characterized by an intricate network of internal relations.[1])

1.3. The Y → X → C relations

The input-output model provided us with a frame of reference for studying the relation between production in different sectors. Starting from this model we shall form hypotheses concerning the relation between the Y and X variables so as to obtain specified hypotheses regarding the $Y \rightarrow C$ relation.

Let final demand be divided into m categories: consumption of durables, consumption of non-durables, machinery investments etc. Deliveries by the sectors for final demand can be written:[2])

$$\begin{array}{l} y_{11} + y_{12} + \ldots + y_{1m} = y_1 \\ y_{21} + y_{22} + \ldots + y_{2m} = y_2 \\ \vdots \qquad \vdots \qquad\quad \vdots \\ y_{n1} + y_{n2} + \ldots + y_{nm} = y_n \\ \hline Y_1 + Y_2 + \ldots + Y_m = \sum Y_k = \sum y_i \end{array}$$

[1]) A small model may help to concretize the content of the b_{sv} coefficient. Put n in equation 5) = 2. We then obtain

$$\begin{array}{l} 0 \qquad + a_{12}X_2 + y_1 = X_1 \\ a_{21}X_1 + 0 \qquad + y_2 = X_2 \end{array}$$

An autonomous rise in the output of sector 2, which means a rise in its final product, will lead to a rise in the output of sector 1 of

$$\frac{a_{12}}{1 - a_{12} \cdot a_{21}} \cdot \Delta y_2$$

We find now that $(a_{12}/1 - a_{12} \cdot a_{21}) > a_{12}$, when a_{12} and a_{21} are in the open interval]0,1[

[2]) We shall assume for the time being that no direct deliveries of primary commodities are made for final demand, i.e. $M_f = K_f = L_f = 0$.

Denotations:

y_{ik} deliveries by sector i for final demand category k
y_i totaldeliveries from sector i
Y_k total deliveries for final demand category k

A second assumption will now be introduced concerning the nature of the relations within the input-output system, namely that all ratios

$$y_{ik}/Y_k = d_{ik}; \quad i = 1, 2, \ldots n; \quad k = 1, 2, \ldots m$$

are constant over time. This means that each category has a fixed distribution between sectors of production. On the other hand the distribution of deliveries by the sectors of production between categories of final demand, i.e. y_{ik}/y_i, can vary.

If a matrix in the order of $n \cdot m$

$$D = [d_{ik}]$$

and a column vector in the order of $m \cdot 1$

$$Y = [Y_k]$$

$X = [1 - A]^{-1} y$ 6. are defined, equation system 6. can be written

$$X = [I - A]^{-1} \cdot D \cdot Y \qquad 7.$$

In this system output in different sectors is expressed as a linear function of the final demand variables (Y_k). If $y_s = 0$ so that steel output is equal to the total input of steel in other sectors, i.e. steel consumption, we obtain the following expression for the latter quantity:

$$X_s = (\Sigma b_{sj} d_{j1}) \cdot Y_1 + (\Sigma b_{sj} d_{j2})\, Y_2 + \ldots + (\Sigma b_{sj} d_{jm})\, Y_m \qquad 8.$$

Since both b_{sj}, the coefficients in the inverted matrix, and d_{jk} are constants, the expressions in parentheses, which comprise sums of products of these constants, are also constants. This definition of the relation between final demand quantities and steel consumption has thus been obtained via a formulation of the relation between steel consumption and production in different sectors. The relations thus determined can be expressed in the following way

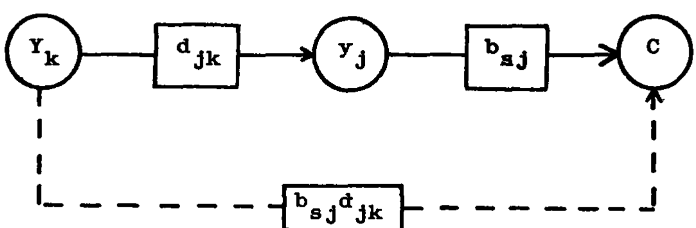

Fig. 3

The relations can be denoted both by the continuous arrows and by the broken ones, the latter relation being derived from the first two.

The input-output model we have used is open, all final demand categories being exogenous. In reality, however, they are not independent. Consequently, when we estimate the rise in consumption induced by an autonomous rise in final demand category k at $(\Sigma b_{sj} d_{jk}) \Delta Y_k$, we are guilty of the same kind of underestimate as when, on the basis of equation 4, we estimate the effect of an autonomous rise in output in sector j on X_j at $a_j \Delta \chi_j$. If this rise leads to rises in other categories, the total effect will be greater than the direct effect. This can be illustrated in a simple Keynesian model for an economy with two categories of demand, consumption (Y_1) and investments (Y_2):

$$C_t = \Sigma a_j \chi_{jt} \qquad 4.$$

$$y = Y_1 + Y_2$$
$$Y_1 = c_1 y + c_0;\; 0 < c_1 < 1$$
$$Y_2 = Y_2$$

c_1 and c_0 are constants. A rise in autonomous investments leads to a total rise in income of $[1/(1-c_1)]\Delta Y_2$. Consequently the rise in steel consumption will be

$$x_s = [h_1 \cdot c_1/(1-c_1) + h_2]\, \Delta Y_2 \qquad 9.$$

where $h_1 = \Sigma b_{sj}\, d_{jk}$. If $h_1 > 0$ the total rise in consumption will be greater than the direct rise, due to the so-called multiplier effect.[1])

Although this total model is too simplified to provide the basis for an empirical study, it does indicate that an extension of the explanatory scheme for steel consumption to include the Z quantities can easily lead us into a total model with many variables in which the various Y quantities are determined. It is beyond the scope of the present study to go to such lengths. Nonetheless we shall return to the $Z \rightarrow Y$ relation to give a short empirical account of it. We shall also consider what from the forecasting point of view are a set of simple and convenient models for steel consumption entailing certain hypotheses regarding the covariation of the Y categories.

[1]) The determination of steel consumption in dynamic macro models is discussed in Vinell, "A theory of steel consumption", 1972, (mineographed). The paper will a appear in Ruist ed., The future for steel; cross-section and time series approaches to steel demand forecasting.

1.4. Assumptions concerning imports

The input-output model with which we have been working so far has only included a system for produced goods. Henceforth however one type of primary commodities is bound to come into the picture, namely imports. These can relate to input in the production system or direct delivery for final demand. Let us divide imports up into the same number of commodity groups as production and call imports of good i to sector j M_{ij} and imports of the same good for final demand category k MF_{ik}. Steel consumption will now be $\Sigma_j (X_{sj} + M_{sj})$. In order for the pronouncements made concerning X_{sj} to be equally valid for the new concept of consumption, the following conditions must apply.

$$M_{ij}/X_j = m_{ij} \text{ and } MF_{ij}/Y_k = mf_{ik}$$

where m_{ij} and mf_{ik} are constant in time. This means that input in each sector consists of a fixed relation for that sector between Swedish and imported materials and that the division of each final demand category between the n domestic *and* the n imported products is also fixed. In order to be able to build realistic import models for steel in a subsequent context, we shall make one exception from the very outset. We shall not let X_{sj}/X_j and M_{sj}/X_j be constants instead we shall for the steel sector limit our assumption of constancy to the ratio

$$(X_{sj} + M_{sj}) \,/\, X_j$$

Thus neither a_{sj} nor m_{sj} are regarded as constants. The sum $(a_{sj} + m_{sj})$ on the other hand is a constant. In principle of course there is nothing to prevent us from applying this assumption to the entire system. In order however to analyse steel consumption we would then be forced to define functions determining the proportion of Swedish and foreign goods in each input.[1])

1.5. The implications and tenability of the model

1.5.1. **Sector division and stability in the coefficient structure.** In the previous section the division into sectors of production was assumed to be identical to the product breakdown, in such a way that each sector produced *one* commodity. As a result of this assumption, the first assumption of constancy

[1]) To prevent our assumption becoming illogical, we shall assume that no input in steel production contains steel.

in the input-output theory, $a_{ij} = \text{constant}$, was a perfectly natural one. Even if we assume a division of this kind to be a practical proposition, the utility of the model would still be confined to economies not undergoing any changes of production technique or product content.[1]) In economies where changes of this kind are legion, the model in its theoretical guise will be of little or no help for purposes of economic analysis. One of the main criteria of a useful model is that it must be possible to define variables that can be identified at different points in time. Here however the x vector successively changes character. Among other things, its order is a function of time; new products appear, others are knocked out and disappear from the economy.

In practical applications of the input-output model this problem is solved automatically. The sectors of production then defined consist of a host of products which however have important common qualities as regards input structure. Since product changes and the appearance and elimination of products are a regular occurrence in these sectors, their properties will also change in the course of time. Obviously this means that input coefficients will normally be constant when each product in a sector uses the same quantity of each input commodity. This however would mean that the products were identical and that the sectors of production had the same properties as previously. Thus the use of aggregated sectors of production means that the input coefficients in a sector generally change when the product mix varies. In order to carry out a meaningful study of intermediate demand, one must modify the assumption of constancy in the functions of production.

Let us consider the production system presented on pages 31—32. Moreover let the n sectors of production refer to the type of aggregated sectors or branches used in current statistical accounts. Finally let the coefficient matrix A change character so that its elements are no longer constant in time. The input of goods from sector i for the production of one unit in sector j is now written

$$(a_{oij} + w_{tij})$$

where a_{oij} is the input coefficient for a given base period.

The second component in the input coefficient will be

[1]) Thus the model would be most applicable to underdeveloped economies.

regarded for all sectors except the steel sector as a non-autocorrelated stochastic variable with a mean value of zero, i.e.

$$\mathscr{E}(w_{tij}) = \mathscr{E}(w_{(t-1)ij} \cdot w_{tij}) = 0; \; i \neq s$$

$\mathscr{E}$ is the symbol for mathematical expectation. We may add that w_{ij} for the base period is by definition zero.

In the case of the steel sector we shall assume that systematic variations exist in the input coefficients, a_{sj}. We shall divide these variations into long-term, short-term (cyclical) and stochastic variations. The variable part of the input coefficient can be correspondingly divided into components:

$$w_{tsj} = w_{ltsj} + w_{ctsj} + w_{stsj}; \; j = 1, 2 \ldots n$$

where the variables in the right-hand side are long-term, short-term and stochastic components respectively.

1.5.2. **Two factors of instability.** Attention must be drawn here to two groups of factors affecting the stability of steel intensity, i.e. a_{sj}. One of them has a cyclical effect while the other exerts a more long-term influence. The former concerns the length of production time in steelconsuming industries together with the definitions and measurements of steel consumption and production respectively. The latter concerns changes in the production functions due, among other things, to inventions and product innovations.

1.5.2.1. *Short term instability.* In the static input-output model, input and output are by definition synchronized. In real life input and output are two links in a chain of causes, so that there is bound to be a certain interval of time between them. In other words, production (processing) takes time. Let us define processing time as the time elapsing from the point when production of a commodity begins until it is finished, i.e. ready for delivery to the purchaser. In this study, processing time is important for two reasons. Firstly, it is often extremely protracted in the case of some steel-consuming products—more than six months in a few significant instances. Secondly, the process we observe as steel consumption, i.e. the input of steel, is mostly confined to the early stages of the production process: see accompanying figure.

The steel put into the production process during a particular period and registered by us as consumption may either leave the process during that same period or remain in it. Let us

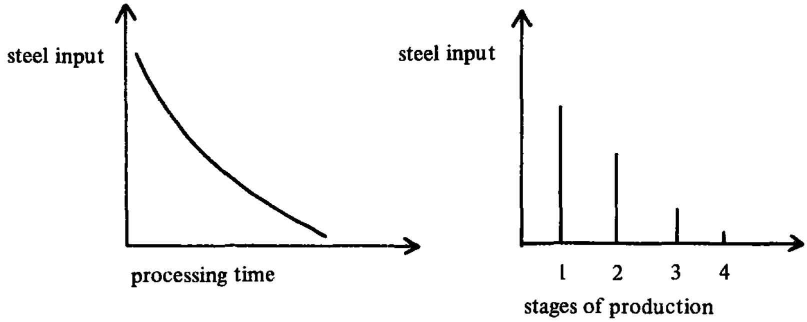

Fig. 4

assume for a moment that the steelconsumers' combinations on factors of production remain unaltered. If during the period the same amount of steel leaves the process in sector j as is taken into it, steel consumption in the sector will be $a_{sj}X_{jt}$, which quantity here will be denoted by ${}_0C_{jt}$ and we will observe a steel intensity of a_{sj}. If on the other hand more steel had been put into the production process than left it, steel consumption would have been greater than ${}_0C_j$. The difference between C_j and ${}_0C_j$ consists of the increase in the quantity of steel in process $(\Delta_{sp}L)$. In this case the observed steel intensity $(C/X)_j$ would have been $a_{sj} + (\Delta_{sp}L/X)_j$. Referring back to the terminology introduced previously, the cyclical part of the variable component in the steel input coefficients in this case is[1]

$$w_{cj} = \Delta_{sp}L_j/X_j$$

This component is very likely to prove important if we study annual or quarterly data. During an upswing the rise in activity can be reflected more in the input level (and in investments in goods in process) than in the output level. A recession will probably have less effect on the increase in output to begin with than on input. This in turn means that steel intensity, measured as *steel input/output*, will in this case exhibit cyclical fluctuations even without changes in production techniques.

In practice, observations of the rate of production in different sectors need not necessarily refer to output. The output figures given in Swedish industrial statistics are a species of value added figures, more exactly sales value in fixed prices multiplied by a constant value added ratio. Whereas output observations are made at the end of the production process, value added is

[1]) In order to simplify the denotations we can drop subindices which are not necessary in the context.

a measure of the average level of activity throughout the entire production process. Even with a value-added measure of production, however, we would in a time series study observe fluctuations in steel intensity, this time registreed as *steel input/value added.* If on the other hand we had a gauge of production which registered activity in the first stages of the production process, then—assuming that our idea of the distribution of steel input in the production process was accurate—we could obtain a stable series for steel intensity.

Now we cannot observe directly the quantity "increase in steel-consumers' steel in process", i.e. $\Delta_{sp} L$. On the other hand there are data on total investments by these firms in goods in process $\Delta_p L$. We shall assume here by way of an initial approximation that the rise in the quantity of steel in process is proportional to total investments in goods in process i.e.

$$\Delta_{sp} L_t = h \cdot \Delta_p L_t + \epsilon_t$$

where h is a constant and ϵ_t a stochastic variable with a mean value of zero.

However, there is reason to believe that the variable ϵ_t has systematic variations, i.e. that it is autocorrelated. At the beginning of an upswing the accompanying rise in investments in goods in process is concentrated on the early stages of the production process. Similarly reductions in these investments at the beginning of a recession are also concerned with the initial stages of production. In both cases we imagine a chain of causes: changes in steel-consumers' order inflow → changes in their raw material input → changes in investments in goods in process in the early stages of the production process → changes in investments in goods in process in later stages of production → changes in output.[1]) It is therefore possible that the equation

$$\Delta_{sp} L_t = h_1 \Delta_p L_t + h_2 \Delta^2{}_p L_t + \epsilon_{1t}$$

is a better description of investments in steel in process than the preceding equation.

1.5.2.3. *Long-term instability.* So far our discussion of the determination of steel consumption has proceeded on the assumption that the combinations of factors of production remain unaltered and more particularly that the quantity

[1]) Owing to lags in the system, which may be prompted by considerations of profitability, changes in the volume of orders received need not have a fully proportional effect on output, order backlogs *and* inventories of goods in process acting as buffers. Therefore we cannot obtain stability in the input coefficients by giving production a lead in relation to steel consumption, i.e. by studying the relation $C_{jt} = a_{sj} X_{j(t+k)}$.

of steel used for the production of a given commodity does not vary. This assumption of constancy becomes highly unrealistic when we study steel consumption as a function of production in different sectors by a time series analysis covering a period of 10—20 years.

There are many reasons to suppose that factor combinations are subject to systematic variations:

- Consumers may learn to make better use of their steel, thus reducing steel consumption per unit of output. Here we can speak in terms of the effect of a *learning process.*
- The quality of steel (tensile strength etc.) may rise, making it possible to use lighter constructions. This reduces the quantity of steel consumed per unit of output. How it affects input coefficients in kronor is harder to say. This kind of variation in input coefficients can be regarded as *substitution between different steel qualities.*
- Steel can eliminate or be eliminated by other materials: this is *substitution in the conventional sense.*

The latter form of substitution can be prompted by

1. changes in the price relation between existing substitutes (the classical case)
2. the appearance of new substitutes or major improvements to old ones.
3. changes in the steel-consumers' techniques
   a) change in the finished product
   b) a change in production technique making it possible to use alternative inputs.

We have already observed that substitution in the classical sense (point 1) is hardly likely to be of major consequence to steel consumption. There are product sectors where e.g. substitution between certain types of steel and aluminium occurs even on a short-term basis, but these account for a very small proportion of total steel consumption.[1]) The dominant role is in all probability played by the dynamic factors in the substitution process. If we consider a specific product or a defined product sector, this process will probably appear as a markedly discrete function of time. In the present context, however, where we are studying highly aggregated sectors of production, it is probably not unrealistic to treat substitution as a continuous process. We shall also regard it as a one-way process, for we shall assume that the input coefficients decrease in time.

[1]) Cf. chapter 4.

Referring back to the terminology introduced previously, we shall assume that

$$w_{ltsj} = f(t);\ df/dt < 0$$

Our analysis of the long-term development of the input coefficients will also be mainly confined to the determination of a long-term rate of change. Later on, however, the problem will be briefly considered in a more speculative and casuistic analysis than is to be found elsewhere in this essay.

2. A statistical study of the determination of steel consumption

2.1. Measures of steel consumption

In the preceding section the steel consumption of an economy was defined as the input of steel in its various sectors of production. The firms accounting for steel consumption were termed steel-consumers. Accordingly the quantity of steel consumed during a period is that quantity put into the steel-consumers' production processes during that period. The consumers may have purchased the steel they consume during the period in question and/or during an earlier period. In the latter case, consumption is brought about partly or wholly through the reduction of inventories. Consequently steel consumption during a given period is equal to purchases plus the reduction of steel inventories held by steel consumers. This means that we can determine steel consumption statistically either directly, i.e. by observing the input of steel, or indirectly, i.e. by observering purchases and inventory reductions. As a rule one of the quantities purchases, consumption or inventory reductions will be estimated from measurements of the other two quantities, so that the equation *purchases* = *consumption* + *increase in inventories* always applies exactly.

The consumption statistics used here are based on production and trade statistics. Since we shall be using different concepts of consumption in the statistical analysis, it will be advisable for us to carry out our definition in three stages:

Production + Imports — Exports = Apparent consumption
Apparent consumption — inventory increases by producers and wholesalers[1]) = Total deliveries (to consumers)

[1]) Wholesalers and stockholding merchants will in this study be regarded as synonyms.

Total deliveries — inventory increases by consumers =
= (actual) consumption

To each of these three concepts of consumption, apparent consumption, total deliveries and (actual) consumption, three units of measurement will be applied: the first two of these are tonnage measurements, one of which concerns consumption in finished weight and the other consumption in crude steel weight. The third unit of measurement concerns values in fixed prices. All these items can be obtained, albeit in varying qualities, from the Swedish statistics. In the case of other countries, lack of inventory data is a major obstacle to the calculation of actual consumption. This is why international studies almost without exception have dealt with apparent consumption (in crude steel weight).

When calculating consumption in crude steel weight production is measured at the crude steel stage while import and export tonnages, which are registered in finished weight, are converted to crude steel weight by means of so-called conversion factors. Thus apparent consumption in crude steel weight (ACc) is defined

$$ACc = Qc + \Sigma_i k_i (M_i - E_i)$$

Denotations:

Qc output in crude steel weight
M_i imports of commodity i in finished weight
E_i exports of commodity i in finished weight
k_i conversion factor for commodity i

The conversion factor k_i is the inverted value of the yield in the production of commodity i. This yield, which is the result of the rolling loss incurred, is generally expressed by the ratio *output of finished steel/input of crude steel.*

One reason for using this type of data is that crude steel is a more homogeneous product than finished steel. It is also interesting to express demand for steel in crude steel weight because crude steel capacity is generally the bottleneck in the production process of the steel industry. One might add that the OECD, among others, provides relatively good statistics illuminating the development of crude steel capacity in its member countries. This means that steel demand or steel consumption expressed in crude steel weight can be compared with relevant measures of capacity. One necessary condition for the use of such a measure of consumption is the availability of proper values for the conversion factors. These can be regarded as technical coefficients dependent on the structure of the plant, so that they can also differ from one country to another. In using them for estimates of apparent steel consumption in the publications of the ECE and EEC, among others, a set of conversion factors has been chosen for all countries. However the difference between steel consumption for a particular country calculated using the ECE coefficients and steel consumption estimated on the basis of a coefficient structure obtained by studying the special production conditions of the country in question has proved negligible as regards the majority of countries.[1]

The main series for steel consumption in Sweden which will be used here refers to actual consumption in finished weight. This series has been computed in the manner described above, i.e. via data on production, foreign trade and inventory increases. One of the weaknesses of the series is that output is measured in hot rolled weight while foreign trade comprises both hot and cold rolled steel. Since it is only during the last few years that cold rolling has attained any notable proportions in Sweden, this does not pose any problems as regards the greater part of the period under consideration. Moreover we can to a very great extent avoid the curious consequences of having separate accounting principles for production and foreign trade if we go by available delivery data for the Swedish steelworks. Steel consumption will then be defined as

> deliveries by steelworks to consumers (including their own steel transforming factories) and wholesalers + imports + reductions in the inventories of wholesalers and consumers.

Theoretically this is identical to the definition given previously, but the two series will differ somewhat because deliveries are measured differently from production.

One fundamental precondition of the use of tonnage measurements in economic studies is for the product or groups of products to satisfy the requirements of homogeneity. We observed by way of introduction that, superficially at least, finished steel is a heteregeneous group of products. For purposes of aggregation, however, it has two important properties:

1. There is good covariation of demand between the various sub-groups.

[1]) As witness e.g. the ECE's Steel Committee document STEEL/WP.3/ Working Paper No. 14, 1968.

2. The prices of different steel products have a high intercorrelation.

We can express this in such a way that $\Sigma p_{i0} q_{it} = \text{constant} \cdot q_t + \epsilon_t$ where p_{i0} is the price of commodity i at a base period, q_t the quantity of the composite product consumed at period t and where ϵ_t is a random variable with a mean value of zero. Moreover, as we saw in Part I, variations in apparent consumption had an obvious effect on such quantities as employment and profitability, which is reason enough in itself for making the quantity in question a relevant economic measure.

Although there is a great deal to suggest that the tonnage-based consumption series will not differ significantly from corresponding series expressed in fixed prices, the statistical picture will be augmented here with an indicator of this kind. The main difficulty in constructing such an indicator lies in the evaluation of inventory variations, because there is no explicit division of these into ordinary and special steels to be had: these two categories differ considerably in price.

Summing up we can say that our main indicator of steel consumption will be that of actual steel consumption in thousands of tons finished weight. For international comparisons we shall also employ another tonnage measure, namely apparent consumption in crude steel weight. Finally, in our analysis of the Swedish market we shall also make use of steel consumption in fixed prices.

The accompanying table shows the average growth rate[1]) of five indicators of steel consumption. First of all we find that the difference between the indicators as regards the rate of growth; the value of steel consumtion in constant prices increases slightly more rapidly than steel consumption measured in tons. There is a clear difference between the *C* indicators however when we compare their trend deviations. Thus apparent consumption measured in crude steel weight has a trend deviation practically twice those of the corresponding values for the two gauges of actual steel consumption. The table

Table 2

		Trend %	Trend deviation %
C	tons	5.3	4.2
C	kronor	5.4	4.1
S	tons	5.3	5.3
AC	kronor	5.5	6.5
ACc	tons	5.1	7.9

Legend: C actual consumption
S total deliveries
AC apparent consumption
ACc " " in crude steel weight

[1]) In this study average growth is measured (subject to a few exceptions) as an exponential trend, i.e. $y^T = ae^{B \cdot t}$ where B is calculated by the least square method and is generally stated as a percentage. The average deviation (trend deviation) is estimated as

$$[\Sigma(\log y_t - \log y_t^T)^2/n]^{1/2}$$

y_t and y_t^T are the observed values and the trend values respectively for the variable in question.

shows that the smaller the inventory changes contained by the indicator, the smaller the trend deviation. As we have already seen, *ACc* contains inventory changes by producers, merchants and consumers, including changes in crude steel inventories. In *AC*, changes in crude steel inventories have been eliminated and *J* contains no inventory changes by producers and merchants. In *C* (1.000 tons and millions of kronor) all inventory changes have been eliminated. This difference in inventory contents and, consequently, in cyclical properties between the various indicators is important when studying the determination of steel consumption.

2.2. The structure of steel consumption

2.2.1. Höglund's and Werin's input-output study. One practical prerequisite of an analysis of variations in steel consumption from the total model described in the previous section is the availability of at least one input-output study. For Sweden there is an input-output study by Professors Bengt Höglund and Lars Werin, "The Production System of the Swedish Economy", Uppsala 1964, which has been of great consequence to empirical economic research in Sweden. This study which refers to the year 1957, is particularly interesting for present purposes. Of the 127 sectors of the production system, over 50 are engineering sectors. The study of the complex network of the engineering industry included in Höglund's and Werin's work probably has few if any counterparts in the international input-output literature.[1]) A full description of source materials and practical procedure is given in a supplementary mimeographed volume in Swedish, Input-output tabeller för Sverige år 1957. This volume also contains more exhaustive tabular material which has been used for the present study.

2.2.2. Deviations from Höglund's and Werin's assumptions and presentation.

2.2.2.1. *Constancies.* The special purposes for which the figures from the Swedish input-output study are used in this study have led me to make certain alterations as regards assumptions and presentation. We have seen in preceeding sections that the assumption of constancy in the production function which is

[1]) The concept of engineering industry is used here in its broadest sense.

interesting for studies of steel consumption concerns the input of the sum of domestic and imported steel per unit of output. Höglund's and Werin's study employs the more extreme assumption that both components (a_{sj} and m_{sj}) are constant over time.

2.1.2.2. *Level of aggregation.* For the sake of clarity, I have chosen to aggregate the original 127-sector model to a 45 and 15-sector model.[1]) The different levels of aggregation will be termed *M* 127, *M* 45 and *M* 15 respectively. In *M* 45 and *M* 15 the steel sector (2) consists of sectors 8 plus 13 in *M* 127. This means that in the latter versions the steel sector also include cold rolled products. In the majority of definitions of the steel industry, this cold rolling is included as a sub-sector. The aggregation of sectors whereby *M* 127 has been transformed to *M* 45 has mainly concerned sectors outside the engineering industry. Thus *M* 45 includes no less than 35 engineering sectors. On the other hand a considerable aggregation of engineering sectors has been made in the transformation *M* 127 $\rightarrow$ *M* 15. The latter includes only 5 engineering sectors, the object being to come up to the system level employed by Swedish short-term statistics.

Following Malinvaud, we can describe the aggregation of the input-output tables in the following tableau.[2])

$$\begin{tikzcd} x \arrow[d, "G"'] & y \arrow[l, "{[I-A]^{-1}}"'] \arrow[d, "G"] \\ x^* & y^* \arrow[l, dotted, "{[I-A^*]^{-1}}"] \end{tikzcd}$$

Here x^* and y^* denote vectors of the order of $m \cdot 1$; $m < n$. G is a grouping matrix describing the grouping of sectors. We shall assume that a functional relation exists between x and y. It is only in special cases that aggregation gives such a relation between x^* and y^*, because the new coefficient matrix A^* is determined by the values of the x elements for the period to which the aggregation refers. In order for the aggregation to be regarded as satisfactory, a certain minimum stability is required in the A^* matrix. Now we are not

[1]) My thanks are due to Bengt Höglund and Lars Werin for their kindness in putting the basic material at my disposal and to Mr. S. Silverstein, who programmed the calculations.

[2]) Edmund Malinvaud, Aggregation problems in Input-Output Models, in The Structural Interdependence of the Economy, Barna, Tibor (Ed), Milan 1955; cf. Bengt Höglund's study, Modell och observationer, particularly cap. V.

interested in the whole system, only in the part which is relevant to the demand for steel. What we are aiming at is stability in a row, namely that referring to the steel sector, in the new inverted matrix $(I^* - A^*)^{-1}$, where I^* is the unit matrix of the order of m. Stability in the corresponding row in the A^* matrix is not sufficient here, but we can add freely over sectors which are neither directly nor indirectly connected with the consumption of steel. Thus all input coefficients, i.e. the aggregated sectors, need not be equal, nor need the composition of the aggregated sectors be stable, in order for an aggregation to be of use, e.g. in forecasting demand for steel.

As regards the relation between output and final demand categories, aggregation is often worth while. Premultiplying equation

$x = [1 - A]^{-1} \cdot D \cdot Y$ 7.

7 by G we obtain

$$x^* = G(I - A)^{-1} DY$$

Here we can say immediately that the probability of the D matrix being stable increases with the level of aggregation. But this is a chimerical advantage, for it is counterbalanced by a reduction in the stability of the total input coefficients. The real advantage is that we can aggregate the $(I - A)^{-1}$ matrix in a simple way to a level which facilitates a statistical identification of the sectors, e.g. in foreign trade statistics. Thus we do not have to go the long way round by first calculating A^* and then inverting the matrix $(I - A^*)$.

Practical considerations have also predominated in the aggregations in question. In the transformation M 127 $\rightarrow$ M 45 I have above all tried to keep to aggregates which seem natural with regard to current statistical accounts. However, this procedure has also enabled me to obtain sectors which have exhibited satisfactory properties as regards the product mix. In this way the loss of information which nearly always results from aggregation has been small.

The difference between M 15 and M 45 concerns as have been mentioned the level of aggregation in the engineering sector. In this context the practical principle of obtaining sectors corresponding to the branch division of the short-term statistics has not left any scope for any other principle.[1])

2.1.2.3. *Gross and net accounts.* In Höglund's and Werin's book, the coefficient matrix and the inverted matrix are accounted gross. This means that in certain sectors internal deliveries have been included in the estimates of the value of the output of the sector. Consequently these sectors account deliveries to themselves, so that the diagonal elements of the coefficient matrix (a_{ii}) are generally greater than zero. However it is not only these elements that are affected by this accounting principle: both the A and $(1 - A)^{-1}$ matrices entirely differ

[1]) The aggregation was undertaken in 1967. Since then the Swedish short-term statistics have been made more specific, so that the aggregation is unnecessarily severe with regard to the analysis of subsequent years.

from corresponding matrices in which the net principle has been applied, i.e. where only output for external deliveries has been taken into account in calculating the input coefficients.

As a rule input-output tables are presented in gross terms. This form of accounting is considered to have a higher informative value and it offers advantages from the point of view of aggregation.[1]) For the application of the input-output theory used in this connection, however, a net account is unquestionably to be preferred. Thus the differences between gross and net calculations are particularly large as regards the steel sector. This sector comprises 4 distinct stages of production (pig iron crude steel, hot rolled and cold rolled products) and the gross account includes the value of inputs of pig iron for crude steel production, crude steel for hot rolling and corresponding products for cold rolling in the value of the output of the steel sector. Consequently in the gross account the direct input of steel per unit of steel produced is as big as 0.61 and the indirect output more than 3. Naturally these figures are of no interest. Comparisons between direct input coefficients are uninteresting for the same reason if the sectors differ with regard to the relative amount of internal transactions; the value of the ratio input of steel/output depends on how output is calculated.

Fortunately it is relatively simple to convert gross matrices to net ones. Let the elements of the coefficient matrices in gross and net accounts be γ_{ij} and a_{ij} respectively. It is easy to show that the relation between these quantities can be expressed by the formula[2])

$$a_{ij} = \gamma_{ij}\delta_{ij}/1 - \gamma_{jj};\ \delta_{ij} = \begin{cases} 0 \text{ if } i = j \\ 1 \text{ if } i \neq j \end{cases}$$

Consequently the net coefficients—if we disregard the diagonal elements a_{jj}, which are always zero—are never less than the gross coefficients and are generally greater, i.e. when $\gamma_{jj} > 0$.

The relation between the total input coefficients in gross and net form respectively is

$$\alpha_{ij} = \beta_{ij} \cdot (1 - \gamma_{jj})$$

where $[\alpha_{ij}] = [1 - A]^{-1}$ and $[\beta_{ij}] = [1 - \Gamma]^{-1}$, where A and Γ are two coefficient matrices $[a_{ij}]$ and $[\gamma_{ij}]$ respectively. Here

1) Cf. Evans W. Duane; Input-Output Computations, in The Structural Interdependence of the Economy, Barna, Tibor (Ed), Milan 1955.

2) See Evans, W. Duane op.cit., pp. 97—98.

the net coefficients are always less than or equal to the gross coefficients.

2.2.3. Steel in the production system and in final demand. The input-output tables describe the consumer structure as it appeared in 1957. Table 3, which is an extract from the most aggregated matrix (*M* 15), shows that virtually 95 % of steel consumption occurs in the engineering, shipbuilding and building industries.[1]) As one might expect, these industries also have the highest input coefficients.

Engineering works account for 2/3 of the total steel con-

Table 3

Steel consumption by sectors of production in 1957

	1 m.kr.	2 kr/kr	3 kr/kr	4 kr/kr
1. Ores	14.9	0.0120	0.0156	0.0036
3. Metals	26.5	0.0238	0.0394	0.0156
4. Manufactures of metals and steel	365.8	0.1942	0.2003	0.0061
5. Products from engineering works	628.0	0.0939	0.1065	0.0126
6. Ships	239.7	0.1530	0.1754	0.0224
7. Electrical products	74.3	0.0415	0.0530	0.0115
8. Products of stone,clay etc.	13.8	0.0114	0.0150	0.0036
9. Wood and products thereof	5.1	0.0017	0.0078	0.0061
10. Pulp, paper and products thereof	10.2	0.0022	0.0082	0.0060
11. Agricultural products, food, beverages	1.1	0.0002	0.0047	0.0045
12. Textiles, furs, rubber, leather and products thereof	0.0	0.0000	0.0039	0.0039
13. Chemical products	6.0	0.0026	0.0072	0.0046
14. Buildings	169.2	0.0188	0.0370	0.0182
15. Services	12.3	0.0008	0.0069	0.0061

1. Deliveries from the steel sector to other sectors
2. Direct steel consumption (of Swedish steel) per unit of output
3. Total steel consumption per unit of output
4. Indirect steel consumption per unit of output

[1]) The reported input coefficients comprise the sum of domestic and imported steel, i.e. $m_{sj} + a_{sj}$. In their estimate of a_{sj}, Höglund and Werin have taken total consumption and divided it into consumption of domestic and imported steel respectively. In doing so they have with a few minor exceptions assumed the proportion of imports to be the same for all sectors. See Input-output tabeller för Sverige 1957. IUI 1964: 1.

sumption of the engineering sector, but the greatest relative consumption is to be found in the subsector "manufacture of hardware".[2]) A closer study of the engineering sector in the more disaggregated models reveals considerable variations between the input coefficients of the sub-sectors which together make up one sector in *M* 15. Cars and machinery exhibit input coefficients far above the average for commodity groups in the engineering industry and electric motors incorporate more steel per unit of output than do other electro-technical products. Steel input per krona of output varies considerably even between sub-sectors of steel manufacture.

The difference between the total and direct input coefficients denotes the magnitude of the indirect effect. Within the building sector, to quote one example, it raises the total steel input coefficient *c.* 100 % over the direct input coefficient. This means that the quantity of steel included in various goods delivered from engineering works and elsewhere to the building industry together with the expendable steel materials used by these suppliers are equal in value to the directly consumed steel (reinforcement steel, girders etc.). The indirect effects also make steel consumption more dependent on other industries besides the big steel consumers than the direct input coefficients would suggest. It should however be borne in mind that the total effects referred to here are only total in the context of the input-output model, which, as we have already seen, does not allow for the fact that increased output can lead to a rise in investments and, consequently, in steel consumption as well; the final deliveries are determined outside the system we are studying.

We can also use the input-output tables to study the distribution of steel consumption between different final demand categories. The procedure has been indicated in equation 8,

$$X_s = (\Sigma b_{sj}\, d_{j1}) \cdot y_1 + (\Sigma b_{sj}\, d_{j2}) \cdot y_2 + \ldots + (\Sigma b_{sj}\, d_{jm}) \cdot y_m \qquad 8.$$

according to which we can use the inverted matrix $(1 - A)^{-1}$ and a matrix for the division of each final demand category into sectors of production (*D*) to ascertain the final use of steel consumption. Table 4 shows four principal groups of final demand categories. Of these fixed investments account for more than half the consumption of steel, though a considerable proportion also went on exports, mostly engineering products

Table 4

Steel consumption by final demand sectors in 1957

	m.kronor[1]	%
Private consumption	330.6	13.5
Fixed investments	1249.0	51.0
private	869.4	35.5
government	379.6	15.5
Exports	769.0	31.4
Inventory investment	100.4	4.1
	2449.0	100.0

1) Steel imports included

[2]) The term engineering works covers here producers of transport equipment (excl. ships), machinery and other mechanical products.

and ships. It should be noted that this figure only refers to indirect exports of steel. Direct exports were considerable, but according to our definition they are of no consequence to steel consumption. As regards private consumption it is perhaps surprising to find that foodstuffs and other groups not counted as durables play such an important part in the consumption of steel.[1]) The inventory investment figure reflects the fact that 1957 was a boom year. Unlike the presentation given in Höglund's and Werin's book, this inventory investment figure includes the rise in the quantity of goods in process. We shall return to this item later.

2.3. A time series study based on the input-output model

2.3.1. Test of the X → C and Y → C relations.

2.3.1.1. *Hypotheses.* Using the input-output model we were able earlier on to specify the $X \rightarrow C$ and $Y \rightarrow C$ relations in two linear equations:[1])

$$C = \Sigma a_j X_j \qquad 10.$$

and

$$C = \Sigma b_k Y_k \qquad 11.$$

With the aid of Höglund's and Werin's study we have been able to obtain numerical values for the input coefficients a_{sj} and b_{sj} respectively.

How well then can the input-output model explain actual consumption trends? In other words: how realistic has our assumption of constant input coefficients in the production system been? A complete test of the input-output model, i.e. a study of the stability of every a_j, cannot be undertaken owing to the lack of data, but a statistical test of certain necessary and—from the point of view of forecasting—important conditions of stability is perfectly feasible:

[1]) Travel is the predominant group here. This item has been made to include the steel required for current maintenance of our railways and tramways. The steel in our foodstuffs refers not so much to the Fe content of what we eat as to the tinplate from which tins are made.

[1]) Henceforth the direct and total input coefficients will include the sum of domestic and imported steel. In view of the construction of the Swedish input-output tables regarding the steel sector, we could instead have written $C = \beta \Sigma_j a_j X_j = \beta \Sigma_k b_k Y_k$ where $\beta = (M_{sj} + X_{sj})/X_j$ is a coefficient which is the same for all steel-consuming sectors.

1. If the assumption of constancy in the model is confined to the constancy of steel input per unit of output in different sectors, only equation 10 need apply, i.e. consumption is equal to the total production of different sectors weighted with the a_{sj} coefficients.
2. If we extend this assumption to apply to all input coefficients indirectly influencing total steel consumption and the coefficients denoting the composition of the various categories of final demand with respect to sectors of production, equation 11 is also correct. This means that consumption is equal to a weighted sum of exports, private consumption etc.

One of the preconditions of stability in relevant subsets of the entire coefficient structure, i.e. the A, M and D matrices, is that

$$C_t = \Sigma a_j X_{jt} = \Sigma b_k Y_{kt}$$

or in the statistical context that the differences between the three quantities can be explained by a stochastic variable the variance of which is small.

If we are mainly concerned with the short-term stability of the coefficient structure, we can dictate less rigorous conditions of stability, namely that

$$C_t - \Sigma a_j X_{jt} = \epsilon_{1t} + c_1 \cdot t;\ E(\epsilon_{1t}) = 0;\ \sigma^2(\epsilon_{1t}) < \Theta$$

and that

$$C_t - \Sigma b_k Y_{kt} = \epsilon_{2t} + c_2 \cdot t;\ E(\epsilon_{2t}) = 0;\ \sigma^2(\epsilon_{2t}) < \Theta$$

Thus in the latter case we allow deviations between observed steel consumption and that calculated according to the input-output structure: these deviations can be described by a linear trend.

2.3.1.2. *Results.* It is evident from figures 5a and 5b together with table 5 that the first of our conditions of stability has not applied throughout the period observed. Although the correlation matrix shows a high covariation between observed and estimated values for steel consumption, the figures show that the deviations are not random but are to a great extent trend-dominated.[1]) By taking the first and second difference

Table 5

	C_1	C_2	AX	BY
C_1	1	.9982	.9903	.9966
C_2		1	.9873	.9967
AX			1	.9935
BY				1
	ΔC_1	ΔC_2	ΔAX	ΔBY
ΔC_1	1	.9350	.7782	.8271
ΔC_2		1	.7538	.8647
ΔAX			1	.8109
ΔBY				1
	$\Delta^2 C_1$	$\Delta^2 C_2$	Δ^2AX	Δ^2BY
$\Delta^2 C_1$	1	.8987	.7342	.7150
$\Delta^2 C_2$		1	.7430	.7880
Δ^2Ax			1	.7306
Δ^2BY				1

C_1 actual steel consumption in kronor
C_2 " " " " tons
$AX = \Sigma a_j X_j$
$BY = \Sigma b_k Y_k$

[1]) The simple correlation between C and $\Sigma a_j X_j$ and between C and $\Sigma b_k Y_k$ is really of little interest in this context. The regression equation corresponding to the correlation figures contains an intercept which is

with respect to time of the variable in question, we successively reduce the influence of a trend. The table shows that there is a definite short-term relation between observed and calculated values. The strength of this relation may seem surprising, in spite of its obvious theoretical basis, bearing in mind that we have had to work with what from the point of view of the input-output theory are exceedingly large aggregates.

Both table and figures show that steel consumption is better explained by the final demand index, i.e. $\Sigma b_k Y_k$ than by the weighted production index, i.e. $\Sigma a_j X_j$. This may seem curious in view of the fact that the stability requirements for the coefficient vector $[b_k]$ are stronger than those for the vector $[a_j]$. It should at once be pointed out that the final demand index with its 18 categories is somewhat more refined than the production sector index, apart from which the division into categories has been made in such a way that each sub-category is directly referable to a particular sector of production in *M* 15; thus the stability of the distribution matrix (*D*) is a natural consequence of the division into categories. (The distribution of exports of ships and car consumption respectively into sectors of production is after all quite unequivocal.)

2.3.1.3. *Investments in goods in process.* The main reason for the difference in explanatory value between the two indices is in all likelihood to be found in the degree to which they take account of changes in the inventories of the engineering industry, particularly goods in process; it is above all these changes that have set the pattern of the short-term variations of steel consumption calculated from the final demand structure.

In applying the production sector method, one is forced for statistical reasons to employ a highly aggregated model (*M* 15). Judging by the results, the effect of these inventory fluctuations on steel consumption has to a certain extent been eliminated in the aggregation of sectors of production; sectors which are small in terms of output but important for direct steel consumption have been mixed with large sectors with a definitely smaller "specific steel input". It is also evident that

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greater than zero and a regression coefficient that is less than unity. This helps to explain the trend in $C - \Sigma a_j X_j$. The hypothesis in which we are interested is that C is proportional to $\Sigma a_j X_j$. If instead we define the correlation coefficient as $(1 - \hat{\sigma}^2/\bar{\sigma}^2)^{1/2}$, where $\hat{\sigma}^2$ is $\Sigma_t(C - \Sigma a_j X_j)_t^2$ and $\bar{\sigma}^2$ is $\Sigma(C_t - \bar{C})^2$, we obtain an R value of 0.94.

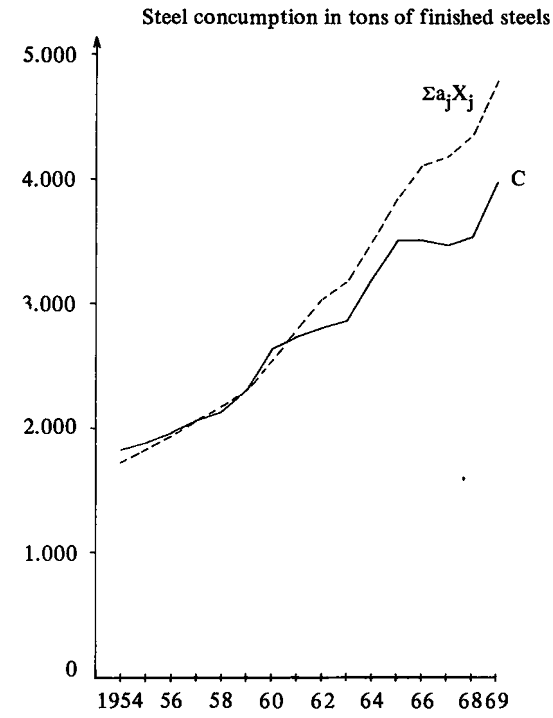


Fig. 5 a

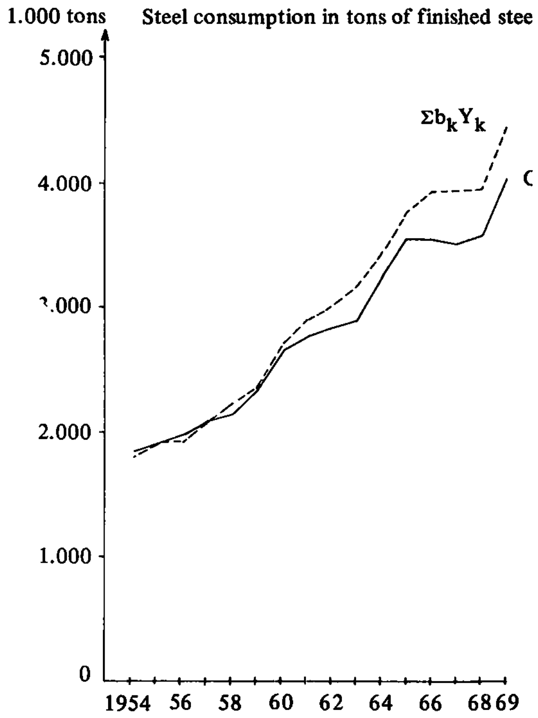


Fig. 5 b

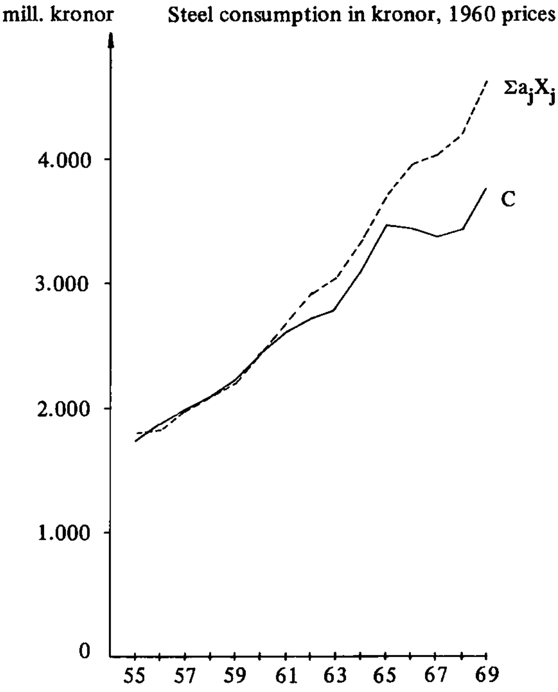


Fig. 5 c

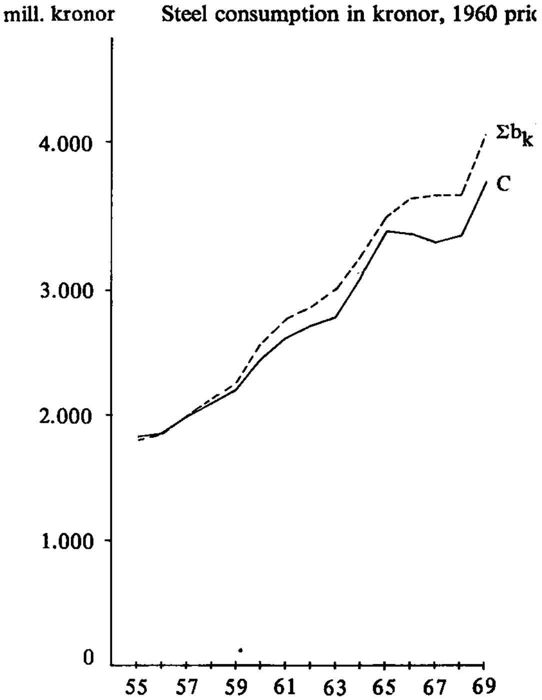


Fig. 5 d

the changes in the difference between observed steel consumption and steel consumption calculated by the production sector method $\Delta(C - \Sigma a_j X_j)$ are positively correlated with the changes in investements in goods in process in the engineering industry. Obviously a certain short-term instability has arisen in the input coefficients due to variations in investments in goods in process in relation to total production, although the measure of production in this case contains the value of such inventory fluctuations.

The effect of fluctuations in investments in goods in process within the engineering industry on the short-term instability of the input coefficients is clearly apparent if we use an output gauge. One such gauge is a final demand index from which investments in goods in process are excluded $(\Sigma b_k Y_k)'$.[1] If we study the difference between observed steel consumption and this quantity as a linear function of investments in goods in process and time, which are intended to explain the short-term and long-term instability of the input coefficients, we obtain the following numerical relations (the first in millions of kronor in 1960 prices and the second in thousands of tons of finished steel)

$$C_t - (\Sigma b_k Y_k)'_t = 64.266 + \underset{(0.07704)}{0.36290}\, \Delta_p L_t - \underset{(3.498)}{25.147} \cdot t$$

$$R^2 = 0.834 \quad DW = 2.34$$

$$C_t - (\Sigma b_k Y_k)'_t = 91.29 + \underset{(0.1241)}{0.5705}\, \Delta_p L_t - \underset{(3.05)}{32.75} \cdot t$$

$$R^2 = 0.927 \quad DW = 2.23$$

Whether we measure steel consumption in fixed prices or thousands of tons, the coefficients for $\Delta_p L$ are highly significant. The corresponding β coefficients are *c.* 0.50, which suggests that during the period observed (1954—1969) considerable fluctuations of steel consumption were caused by variations in investments in goods in process.

Earlier we advanced the hypothesis that the second differences of these inventory investments $(\Delta^2{}_p L)$ also have a positive effect on steel consumption. Now however the trend has been such that

[1]) In calculating the final demand index given in the figures, the steel content of investments in goods in process has been calculated as the average of the proportion of steel costs in the raw materials of the engineering firms and the proportion of steel costs in their finished products.

$\Delta_p L$ and $\Delta^2{}_p L$ have been strongly correlated with each other ($R = 0.70$) so that it is impossible to identify their individual effects on steel consumption. The coefficient estimates are uncertain. This can be seen from the following regression equation, which refers to finished steel in thousands of tons

$$C_t - (\Sigma b_k Y_k)_t' = \underset{}{120.73} + \underset{(0.1649)}{0.3798\Delta_p L_t} + \underset{(0.1299)}{0.2095\Delta^2{}_p L_t} - \underset{(3.31)}{33.14 \cdot t}$$

$R^2 = 0.938 \quad DW = 2.47$

The insertion of $\Delta^2{}_p L$ heightens the uncertainty of the coefficient estimate and if we take into account the loss of degree of freedom, the explanatory value declines in correlation terms compared with the previous specification. This is still more apparent if we use the other gauge of steel consumption, i.e. C in millions of kronor. From this last experiment we may conclude that the material has not permitted a closer analysis of the hypothesis put forward.

2.3.1.4. *The significance of indirect imports of steel.* As we have already seen, in order to be able to estimate steel consumption from final demand, the proportions of imports in the purchases of steel-consuming products must be constant; the occurrence of variations in indirect imports of steel in relation to total steel input means that the total input coefficients are variable. As is evident from figure 6 the weighted sum of these shares has not been subject to any significant variations, which may seem surprising in view of our earlier discussion, since a great deal of the large volume of imports of engineering products concerns items competing with Swedish brands, in addition to which the engineering sector has been a market for innovations during the period under consideration. Admittedly, if we regard the trend from one year to another, there do occur

The share of indirect steel imports in the total steel use

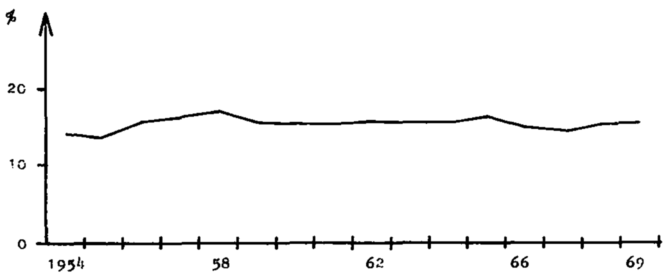


Fig. 6

Note: By indirect steel imports is here meant the imputed steel value of imports of manufactures of metals, cars and machinery.
The total steel use is the sum of direct and indirect steel consumption.

variations in this proportion which are of interest in that they have the effect of evening out the differences in absolute increase between estimated and observed steel consumption, but not even these short-term changes can be said to have had any very tangible effect on steel consumption. This assertion is however subject to the reservation that a more detailed analysis might give another picture of the influence of indirect imports of steel on variations in steel consumption.

During 1969 and 1970, however, the rise in indirect imports of steel seems to have had a more palpable effect on the rise in steel consumption in Sweden. This extraordinary rise in imports has in turn been the result of a pronounced labour shortage in Sweden. However attempts to introduce the labour shortage, measured as the difference between the number of vacancies and the number of unemployed as an independent variable in the above equations have not produced any significant results.[1])

2.3.2. The contribution of the sectors to the growth and cyclical fluctuations of steel consumption. As we have already seen, steel consumption during the period 1954—69 rose somewhat more slowly than the index for final demand, $\Sigma b_k Y_k$. Let us distribute this long-term decline in specific steel consumption on the various final demand categories according to their share of total steel consumption in 1957 and with this assumption in mind investigate their influence on trend and cyclic fluctuations in steel consumption.

According to figure 7, exports have been decidedly more expansive than domestic demand for investment and consumer goods. Consequently, as can be seen from table 6, exports, calculated in tons, have on average contributed almost 30 thousand tons more to steel consumption each year than investments, although the latter were *c.* 2.5 times as great as exports in terms of steel consumption at the beginning of the period. As table 7 shows, this trend has led to a distinct shift in the final demand category distribution of steel consumption, so that in 1969 exports and investments accounted for roughly equal proportions of steel consumption. The rise in the share of the export sector can be attributed in its entirety to products from the engineering industry (excluding shipbuilding) while the proportion accounted for by ships and other products declined. If we turn to domestic demand, the shares of all

[1]) Perhaps this is because the variable in question can have two effects, the negative effect mentioned here and a positive effect due to the fact that labour shortage is correlated with the ratio $\Delta_p L / \Sigma a_j X_j$. Cf. section 2.5.3.

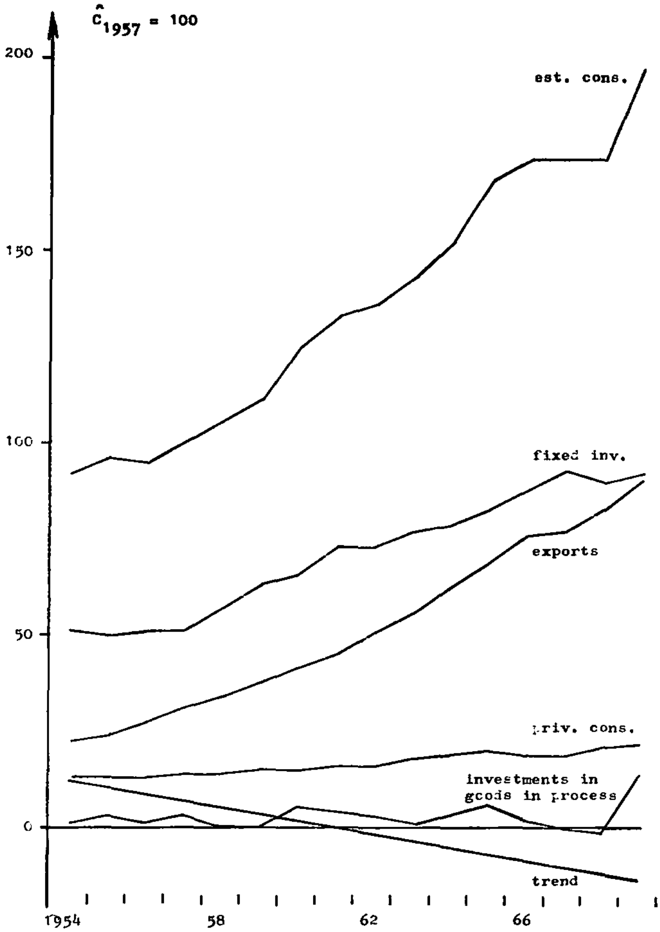


Fig. 7

Table 6

	1 %	2 %	3 1000 tons	4 1000 tons	5 %
Exports	10.1	4.2	95.9	52.4	48.6
Fixed investments	4.9	4.6	68.0	54.5	50.5
Private consumption	4.0	2.6	13.2	10.6	9.9
Inventory investments			4.1	75.4	69.9

1. Trend in procent per year
2. Standard deviation from the trend in per cent of trend value
3. Trend in 1000 tons of steel
4. Standard deviation from the trend in 1000 tons of steel
5. Standard trend deviation of the Y-values divided by the standard trend deviation of actual steel consumption

Table 7

Steel consumption by final demand sectors in 1957 and in 1969

	1957	1969
Private consumption	13.46	10.21
of which:		
transport equipment	4.09	4.49
other durables	3.27	2.04
food	2.09	1.30
other nondurables and services	4.01	2.38
Fixed investments	51.10	42.41
of which:		
buildings	29.03	23.81
machinery	22.07	18.60
Exports	31.34	41.35
of which:		
engineering products, excl. ships	19.30	30.82
ships	9.97	8.70
other products	2.07	1.83
Inventory investments	4.10	6.03
	100.00	100.00

accounted categories declined except for car purchases, whose share rose by c. 1/2 unit in spite of the stagnation and recession of the second half of 1960s. The exceptional upturn in 1969 also resulted that year in a higher figure for inventory investments by consumers than in 1957: in other words this increase is not the result of a long-term trend.

Even if inventory investments, of which investments in goods in process are the predominant element in this connection, have had little effect on the long-term growth of steel consumption, they have influenced cyclical fluctuations a great deal. If we measure their cyclical effect on steel consumption by the standard deviation from the trend, we find that inventory investments show a deviation which expressed in tons is over 2/3 of the total trend deviation in steel consumption. Fixed investments have a somewhat more pronounced trend deviation than exports, which in turn deviate more from their trend than private consumption. Figures 8 a—c show that the fluctuations in the subgroups accounted are not particularly synchronized but often cancel one another out. This also applies to the larger aggregates. Thus trend deviations in fixed investments and consumption cancel each other out to a very great extent, so that domestic cyclical discruptions, disregarding variations in inventories, have been surprisingly small.

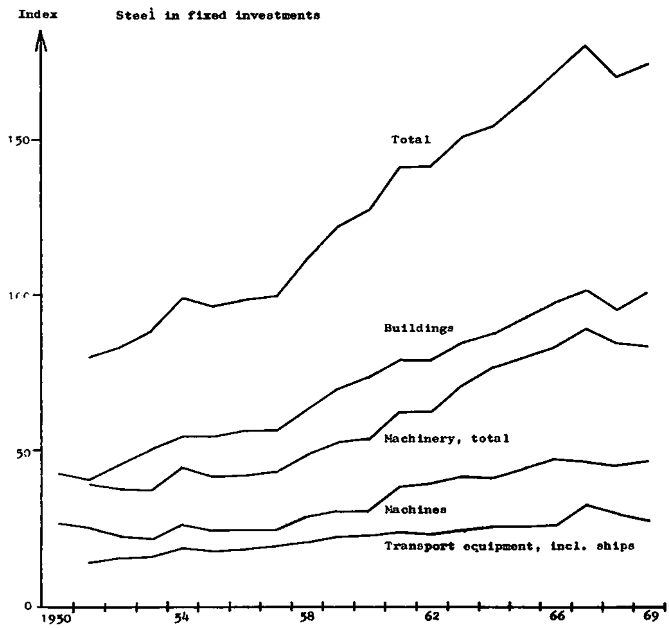

Index
Steel in fixed investments
150
100
50
0
Total
Buildings
Machinery, total
Machines
Transport equipment, incl. ships
1950
54
58
62
66
69

Fig. 8a

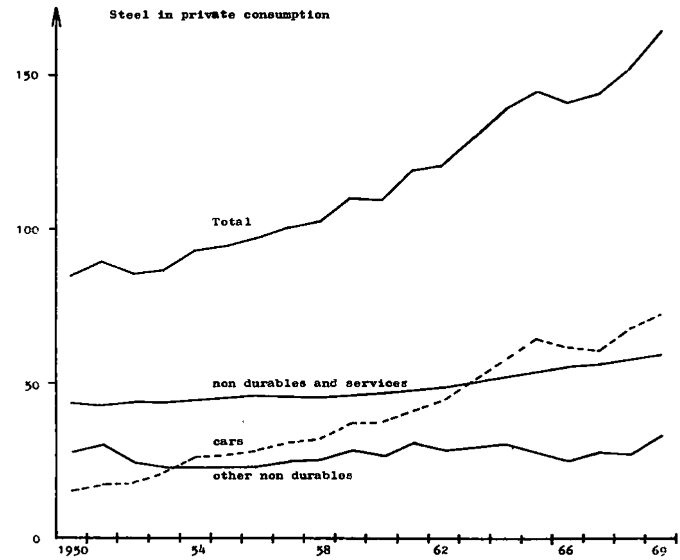

Steel in private consumption
150
100
50
0
Total
non durables and services
cars
other non durables
1950
54
58
62
66
69

Fig. 8b

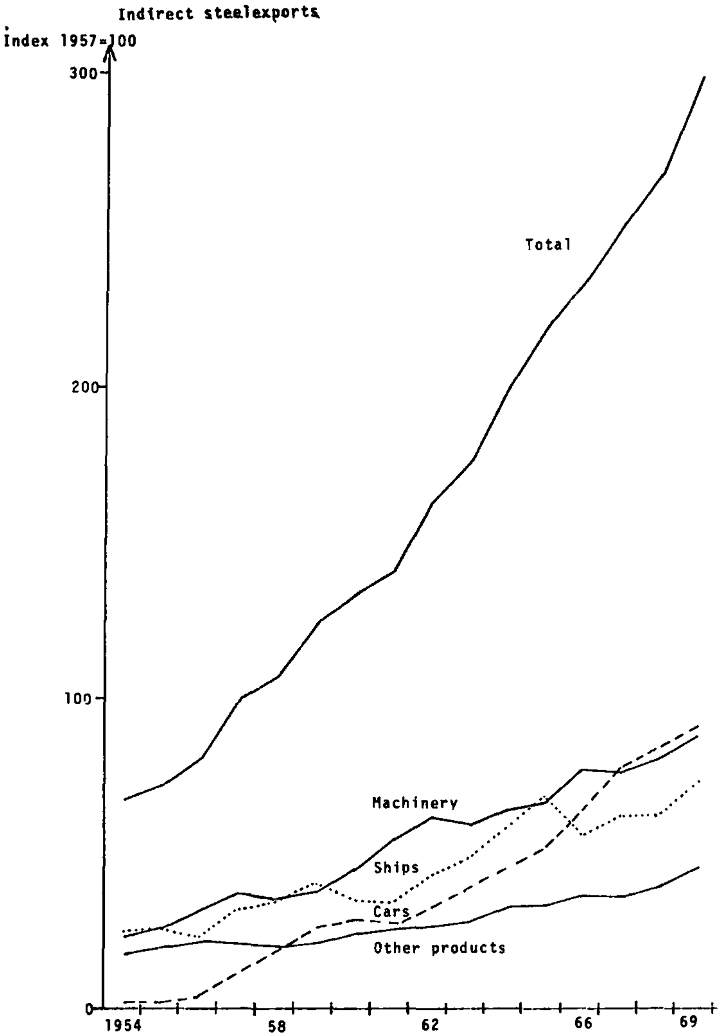


Fig. 8c

2.4. The fall in steel intensity

Between 1954—69 steel intensity fell by almost two per cent p.a. in terms of the ratio $C/\Sigma a_j X_j$ and by c. one per cent if we consider the ratio $C/\Sigma b_k Y_k$.[1]) It is hard to attribute this trend specifically to the various factors which (according to

[1]) These values have been derived from the estimates

a) $^{10}\log(C/\Sigma a_j X_j) = 0.05599 - \underset{(0.000905)}{0.007930} \cdot t$; $R = 0.93$; $DW = 1.19$

$^{10}\log(C/\Sigma b_k Y_k) = 0.030405 - \underset{(0.000522)}{0.004185} \cdot t$; $R = 0.92$; $DW = 2.01$

previous sections) influence the long-term stability of input coefficients. On the one hand we can say in the light of market research that steel input has declined in a host of products within the commodity aggregates comprising the sectors of production in our analysis. But meantime new steel-consuming products have appeared, so that the decline in the specific steel consumption of the sectors of production has been a moderate one. An analysis of the production trend for more specific groups of products suggests that the steel-intensive products in the engineering sectors accounted here have grown faster than other products, which of course has helped to sustain steel intensity within these sectors.[2])

It is of course extremely hazardous to attempt to describe in quantitative terms the reasons for the decline in steel input per unit of output for old products and the choice of input combination for new products. Generally speaking, plastic and aluminium have to a very great extent supplanted steel in sectors where its technical properties have not been fully utilized. Steel can also be said to "compete against itself", i.e. improved qualities have reduced the quantity of steel in kg per unit of output. As a rule the fall in steel intensity, measured in tons, has been relatively greater than the increase in steel prices caused by improvements in the quality of steel, so that steel intensity expressed in kronor has also declined. The rise in steel quality per krona has of course been due among other things to potential competition by other materials. We shall return to a brief consideration of substitution effects in a later section in which we consider the price-sensitivity of the demand for steel.

2.5. Z → Y relations

So far we have studied steel consumption as a function of output in different sectors and of final demand. In the latter case Y_k are exogenous variables. If we know these we can estimate steel consumption. In a forecasting situation it is therefore necessary to have some kind of forecast model for these exogenous quantities. It is not intended here to go into detail regarding the 18 final demand categories. Instead we shall confine ourselves to a rhapsodic summary of econometric studies of the determination of engineering exports, the consumption of durables and especially investments in goods in

[2]) See Vinell, L., Prognoser för stålförbrukningen i Sverige.

process.[1]) We shall then insert *estimated* values instead of *observed* values of these quantities into the expression $\Sigma b_k Y_k$ and see how much the explanatory value is affected.

Thus it should be emphasized that we are not proposing here to construct a total economic model for Sweden in which the interdependence of the Y variables relevant to steel consumption is completely elucidated. An analysis of this kind is desirable although it falls outside the scope of this study, for the projection of reality which a good model of this kind would offer would probably be quite distinct e.g. as regards variable content and the specification of dynamic relations from the total models compiled by various institutes for separate countries as an instrument of analysis for policies of stabilization, macro forecasts and other purposes. The various purposes to which total models are applied often call for different projections of reality even though the object to be studied, the functioning of the general economy, is the same in all cases. This is not to say that the traditional macro models are of no interest in the study of steel consumption. On the contrary, the input-output tables have shown us that the distribution of steel over sectors of production is very wide and that it has its principal uses in the production of investment goods and consumer durables, demand for which seems to have been a major determinant of general cyclic fluctuations during the post-war period. In the next chapter we shall also study steel consumption as a function of the total activity of an economy.

2.5.1. Exports[2]). A great deal of Sweden's production is exported.

Exports in 1969 were in current prices 21 and in 1959 prices 30 per cent of GNP. We saw earlier that exports have also had considerable influence on the growth and fluctuations of steel consumption. It is therefore natural for us to attempt to "explain" this variable.

We shall use a simple approach in which exports are mainly determined by export demand. Let us consider the system

$$E^d = f(I_1\ I_1, \ldots I_n)$$
$$E^s = E^d + g\,(EXCAP) + h\,(p^h/p^w)$$

[1]) It would of course have been interesting to take the determination of total fixed investments into account. There are however considerable difficulties involved in construction simple functioning investment models for the Swedish economy. Gunnar Eliasson has however tried to explain the difference between planned and actual investment by using so called realization functions. See his interesting book The Credit Market, Investment Planning and Monetary Policy, Stockholm 1969.

[2]) This part is to a great extent based on an unpublished study by Hans Lindblom and Lars Nyberg. Export-Import, Stockholm 1971 (mimeographed).

A detailed and informative account of Sweden's foreign trade is given in Export och Import 1971—1975, SOU 1971: 40, to which the main contributor is Björn Magnusson, The National Institute of Economic Research, Stockholm.

Denotations

E^d	export volume demanded
E^s	export volume supplied
I_j	industrial production in country j
$EXCAP$	excess capacity in Swedish industry
p^w	world market prices
p^h	home market prices

Thus the demand for Swedish goods abroad is assumed to depend on industrial production in different countries —a justifiable assumption in view of the large proportion of exports made up of products for industrial use. Supply is adjusted to demand but is modified according to current capacity/output ratio and the relation of export prices to home market prices. The ratio p^h/p^w can be said to denote the opportunity cost of exports.

Using a similar theoretical approach, Hans Lindblom of the National Institute of Economic Research has estimated the following function for exports including ships in million kronor at 1959 prices:

$$x_0 = \underset{}{1847} + \underset{(7.6)}{108.9\, x_1} + \underset{(0.320)}{0.991\, (x_2)} - \underset{(8.83}{15.81\, x_3} - \underset{(90.24)}{161.05\, x_4}$$

$$R = 0.998; \quad DW = 1.94$$

x_0 Estimated exports excluding ships

x_1 $\Sigma a_j x_j$, where a_j is the average share of country j of total exports

x_2 Unemployment minus vacancies

x_3 Wage cost per unit of product in Swedish industry divided by the export price

x_4 A dummy which is given the value of 1 in the first half of 1956, 1963 and 1966 respectively, periods characterized by very hard winters.

Thus excess capacity is here measured by the labour market situation. The greater the excess demand for labour, the more spare capacity is available for exports and vice versa. For lack of relevant home market and export market prices it has been assumed that exports are always sold at prevailing world market prices. Home market prices have been assumed to follow the cost situation in Sweden.[1]) The equation thus derived gives a very good fit to actual exports, but it could not explain the steep rise in exports in 1970. It does not explain the consequence of the shortage of capacity in 1969, namely the big accumulation of export orders on which firms "lived" during 1970.

2.5.2. Durable goods purchases. The current theory for the demand for consumer durables is the so-called stock adjustment theory.[1]) According to this theory stock demand is regarded as a function of disposable incomes, relative prices, liquidity etc. The difference between this demand and the actual level of stocks together with

[1]) The result need not of course be interpreted in this way. It is perhaps more natural to regard the ratio in question as a measure of the international competitiveness of Swedish industry.

[1]) Cf. Michael K. Evans, Macroeconomic Activity, New York 1969.

Exports, excl. ships. Mill. kronor. 1959 prices.

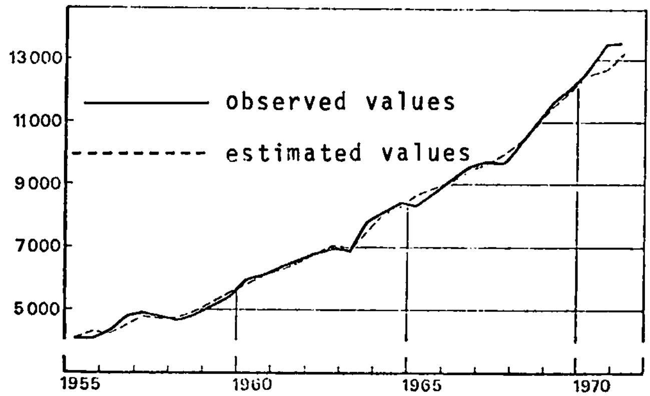


Fig. 9

the speed of adjustment and the replacement speed determine how much purchases households are willing to make during a period.[1])

For purposes of estimation the stock adjustment theory suffers from a considerable disadvantage particularly as regards other durable goods than cars, namely the difficulty of obtaining relevant observations of the capital stock. It is possible by hook or by crook to arrive at estimates based on the theory in question, but these estimates also entail assumptions which it is hard to verify. It is therefore worth while, not least from the point of view of forecasting, to try other theoretical approaches as well.

Let us assume that the distribution of total disposable income between purchases of different kinds of consumer goods and saving is determined according to a certain principle of priority whereby households first provide for certain fundamental consumption requirements before the question of purchasing other goods and saving can arise. Assume moreover that purchases of durable goods by households are dependent on this residual income and possibly on the price of durables in relation to those of rival groups of products, while on the other hand their stocks affect only the distribution of purchases between different kinds of durables. If a household has recently bought a car then, ceteris paribus, if its income rises

[1]) An approach of this kind is used by Gustav Endrédi in a study of new purchases of cars in Sweden 1952—64, Resekonsumtionen, IUI, Stockholm 1967. This study is one of a series of studies of consumption carried out at the IUI. The seminal work in this connection is Bentzel R. et al. Den privata konsumtionen i Sverige 1931—65, Uppsala 1957. A sequel to this work is provided by Albinsson G. and Endrédi G., Den privata konsumtionen 1950—70, IUI, Stockholm 1966. A later study from the same institute, by C. J. Dahlman and A. Klevmarken. Den privata konsumtionen 1931—75, Stockholm 1971, diverges somewhat from Bentzel's approach.

it will increase its purchases of other durables.[1]) This approach makes it possible to divide saving into two components, *precautionary* saving, which for present purposes is treated on a level with the consumption of necessary goods and *purposive* saving with a view to subsequent purchases of durables.[2]) These hypotheses can hardly apply to households with very large incomes. We shall however assume that they apply approximatively for society as a whole.[3])

The relations thus postulated can be expressed by the following formula

$$CD = f[(DY - CN - SN), P]$$

Denotations

CD Purchases of consumer durables
DY Disposable income
CN Consumption of "necessary goods"
SN "necessary saving"
P Relative prices of consumer durables

The artihmetically and logarithmically linear versions of this general hypothesis have been tested on annual data for the period 1955—70. Disposable income minus expenditure on food and housing has been used here as a measure of the residual income (DYR) available for the purchase of non-necessaries and services.[4]) SN is preliminarily assumed to be constant. A Koyck approach was tested for the lag structure in DY.[5])

The following relations were obtained when price was discounted as an independent variable (the variables are expressed in million kronor at 1959 prices)

$$CD = -1976 + \underset{(0.0546)}{0.1962}\, DYR_{-1/2} + \underset{(0.2210)}{0.3465}\, CD_{-1} - \underset{(180)}{392}\, DUM$$

$$R = 0.993; \quad DW = 2.08$$

[1]) Replacement purchases will also be taken in this connection to be determined by income development. Thus the approach adopted here is an extremely simplified version of Stone's linear expenditure systems (See Stone, R., The linear Expenditure Systems and Demand Analysis, The Economic Journal, Vol. LXIV, Sept. 1954). This approach has been applied in Sweden by Klevmarken (See C. J. Dahlman and A. Klevmarken, op. cit., cap. 3).

[2]) Consequently the demand for new purchases is always greater than or equal to the income remaining after deductions have been made for necessary consumption and necessary saving. The occurrence of purposive saving can therefore be said to be due to the inadequate divisibility of durable goods.

[3]) We disregard here the problems that arise when studying aggregates of households. Corresponding problems of aggregation are dealt with however in Part III.

[4]) In Sweden the opportunities for families to adjust their housing expenditure with regard to prices etc. have been severely limited.

[5]) See part III.

$$\log CD = -1.805 + \underset{(0.263)}{0.882} \log DYR_{-1/2} + \log \underset{(0.1945)}{0.4327}\, CD_{-1} -$$
$$- \underset{(0.0110)}{0.0269}\, DUM$$

$R = 0.995; \quad DW = 2.15$

We find that CD can be reasonably well described by $DYR_{-1/2}$ and CD_{-1}. The dummy variable has the value of zero for the years 1955—65 and the value of 1 for the period 1966—70. According to the coefficient estimate the value of the constant fell by 392 million kronor and 6 per cent. The change which then occurred in the relation is attributable in its entirety to car purchases. This change has been thought to be connected with the introduction of the compulsory inspection of old cars, which is claimed to have increased the durability of cars.[1])

If the relative prices of steel are inserted as independent variables, still maintaining the Koyck approach, we obtain the general relation

$$CD = a_0 + a_1\, bDYR + a_1 b^2 DYR_{-1} + \ldots + cP$$

This expression can be re-written as

$$CD = a_0(1 - b) + a_1 bDYR + bCD_{-1} + cP - bcP_{-1}$$

Now P is autocorrelated, so that it is described by the relation

$$P = dP_{-1} + \epsilon$$

where ϵ is a stochastic variable with a mean value of zero. The last two terms on the right hand side can therefore be written.

$$c\,(d - b)\, P_{-1}$$

If $d > b$ then according to our expectations the entire coefficient for P_{-1} will be < 0. The following coefficient estimates are obtained for the period 1955—70:

	arithmetically linear version		logarithmically linear version	
$a_1 b$	0.1556	(0.0339)	0.7695	(0.0092)
b	0.1499	(0.1396)	0.2810	(0.1262)
$c\,(d - b)$	— 143.07	(30.36)	— 1.792	(0.403)
R	0.9978		0.9982	
DW	2.20		2.45	

In both cases DYR has lagged half a year and the dummy variable described above has been used. By means of special least square estimations b has been estimated at 1.061 and 1.075 respectively[2]).

[1]) See Lars Jacobsson, op.cit.

[2]) The following estimates were obtained:

$$\hat{P} = -7.10 + \underset{(0.043)}{1.061}\, P_{-1} \qquad R = 0.989; \; DW = 2.27$$

In this way c can be estimated at -156.3 and -2.26 respectively. Thus consumption of durables would appear to have a price elasticity in the region of -2.

2.5.3. Investments in goods in process. The quantity of goods in process provides an expression of the level of activity in an industry. For mechanical reasons, however, the ratio $_pL/Q$ need not be constant. Congestion due to limited capacity at certain stages of processing can result in a rise in the amount of goods in process which is not matched by a rise in output. It is also conceivable for firms to increase their inventories of goods in process for purely speculative reasons. But speculative fluctuations in $_pL$ are probably aggregated out in the annual data. Since for statistical reasons we are obliged here to work with annual data, we shall disregard the possibility of speculations in this inventory category. Our basic hypothesis is that firms planning their production automatically plan the quantity of goods in process according to a linear decision rule. The output planned is not necessarily realized during the period. We shall assume that the difference between plans and their implementation is due to the state of the labour market. If the market is strained achievement will fall short of what is planned, while if it is easy actual output will be greater than planned. Thus it is assumed that firms always plan as though the supply of labour were normal. Even if output plans are not realized, it is assumed that input and, consequently, the rise in goods in process, proceeds as planned or at least goes more according to plan than output. Finally a reservation must be made for a delayed adjustment in inventories of goods in process of the kind described in closer detail in Part III, cap. 2.

These hypotheses and the equation for inventory increase which we shall derive from them can be formulated as follows.

Denotations:

L^*_{-1}	equilibrium inventories at the end of period $(t-1)$
Q^*	production planned for period t
$\Delta^* L$	inventory increase planned for period t

$$\log \hat{P} = -0.155 + \underset{(0.042)}{1.075} \log P_{-1} \qquad R = 0.990;\ DW = 2.25$$

The results show that P is a function of time. Both regression equations can be expressed as difference equations, the numerical expression of the first one being

$$P_t = (1.06)^t P_0 - 7.10 \frac{1 - 1.06^t}{1 - 1.06} \qquad t = 0,1,2\ldots$$

In this case P_t is a monotone increasing function of time, since $1.06 > 1 + 7.10/P_0$. Now it shall be argued that it does matter if we use t instead of P in our regression equations. In the first place the results would not have been the same. The essential issue is however that the price influence found here really is a price effect and not an effect of other variables which are monotone functions of time. This means that if the correlation between P and e^t would be incidental this fact will not influence our "belief" in the estimated structure.

LS	labour shortage during period t
λ, α	constants expressing dynamic properties of the model
a_0, a_1, b_0, b_1	structural coefficients

a) desired (optimum) stock: $L^*_{-1} = a_0 + a_1 Q^*$
b) adjustment function: $\Delta^*L = \lambda(L^*_{-1} - L_{-1})$; $0 < \lambda < 1$
c) plan-realization function for investment in goods in process:

$$\Delta L - \Delta^*L = \alpha \lambda a_1 (Q - Q^*); \; 0 < \alpha < 1$$

d) plan-realization function for output: $Q^* - Q = b_0 + b_1 LS$

We thus obtain the following function for inventory investments

e) $\Delta L_t = \lambda (L^*_{-1} - L_{-1}) - \alpha \lambda (a_1 b_1 + a_1 b_1 LS)$

If we then insert the expression $a_0 + a_1 Q^*$ for L^*_{-1} and use the identity $Q^* = Q + Q^* - Q$, the equation can be written[2])

f) $\Delta L = A_0 + A_1 Q + A_2 LS + A_3 L_{-1}$

where

$$A_0 = \lambda [a_0 + a_1 b_0 (1 - \alpha)]$$
$$A_1 = \lambda a_1$$
$$A_2 = \lambda a_1 b_1 (1 - \alpha)$$
$$A_3 = -\lambda$$

A regression analysis for the period 1958—69 gives the following values (standard deviations are given in parenthesis):

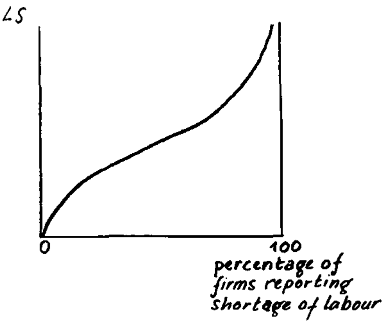
$\hat{A}_0 = 417.5$
$\hat{A}_1 = 0.33843 \; (0.0778)$
$\hat{A}_2 = 4.910 \; (1.954)$
$\hat{A}_3 = -0.97949 \; (0.27069)$
$R = 0.940$
$DW = 2.54$

In this estimate the number of firms, weighted according to size, reporting a shortage of skilled labour in mid-year and expressed as a percentage of the total number of firms has been used as a gauge of LS. Output is the value in 1959 prices of the total production of the engineering industry minus the increase in goods in process. As can be seen from the R value and the accompanying figure, the model gives a fair explanation of actual developments. Agreement between the model and reality is particularly good when there are considerable variations in $_pL$. As regards the coefficient values, we

[1]) If $\alpha = 1$ inventories will be fully adjusted to output. If $\alpha = 0$ the plans drawn up at the end of $(t-1)$ will be entirely adhered to. According to the hypothesis which is being tested here, inventories will follow the original plans to a certain extent. α is therefore assumed to lie between zero and 1.
[2]) From this identity and equation d) we obtain $Q^* = b_0 + b_1 LS + Q$

find that λ is very close to 1, so that for reasons of goodness of fit the adjustment function could be excluded from the system at once.[1]) The coefficient for Q is less than the mean value of the ratio ${}_pL/Q$, which suggests that $a_0 < 0$. This is partly due to a falling trend in the ratio mentioned. It is also possible however that the coefficient estimates express the extremely common phenomenon of a decline in Q, all other things being equal, leading to a fall in processing speed and a corresponding rise in the inventory ratio.

According to the result of the regression analysis, the situation on the labour market (LS) has accentuated the fluctuations in the volume of goods in process. Here the linearity of the relation is a probable rough approximation which can be particularly misguiding at values near to 0 and 100 respectively. A third degree equation of the kind illustrated in the accompanying figure would probably have been more justifiable.



If we alter the plan realization function to apply to the relative deviation between plan and reality, i.e. so that

d 1) $Q^*/Q = b_0 + b_1 LS$

ΔL becomes a linear function of Q, $LS \cdot Q$ and L_{-1}.[2]) An estimate of this relation on the same data as above gives

$$\Delta L = 634.14 + \underset{(0.0614)}{0.2269} \cdot Q + \underset{(0.003519)}{0.008379}\, Q \cdot LS - \underset{(0.2234)}{0.9071}\, L_{-1}$$

$R = 0.960;\quad DW = 2.55$

2.5.4. An alternative specification of the final demand model. We have now studied the determination of three important final demand categories, i.e. exports, purchases of consumer durables and investments in stocks of goods in process. It will be interesting to see how the value of the final demand model

[1]) If we consider the quantity of goods in process as technically governed by the level of activity in an industry, then the theoretical foundation for a constant $\lambda < 1$ is extremely unsteady. If we assume that $\lambda = 1$ we obtain an accelerator model modified with a function for variations in the inventory ratio:

$$\Delta L = -96.69 + 0.5590 \cdot \Delta Q + 3.791 \cdot \Delta LS;\ R = 0.868$$

Here we see a definite falling trend in the quantity of goods in process of almost 100 million kronor p.a. Related to the average for L during the period in question, this figure corresponds to a relative decrease of 3.8 % p.a.

[2]) By using equation d 1 and the identity $Q^* = (Q^*/Q) \cdot Q$ we obtain

$$\begin{aligned} \Delta L &= B_0 + B_1 Q + B_2 \Delta QLS + B_3 L_{-1}, \text{ where} \\ B_0 &= \lambda a_0 \\ B_1 &= \lambda a_1 [b_0 (1 - \alpha) + \alpha] \\ B_2 &= \lambda a_1 b_1 (1 - \alpha) \\ B_3 &= -\lambda \end{aligned}$$

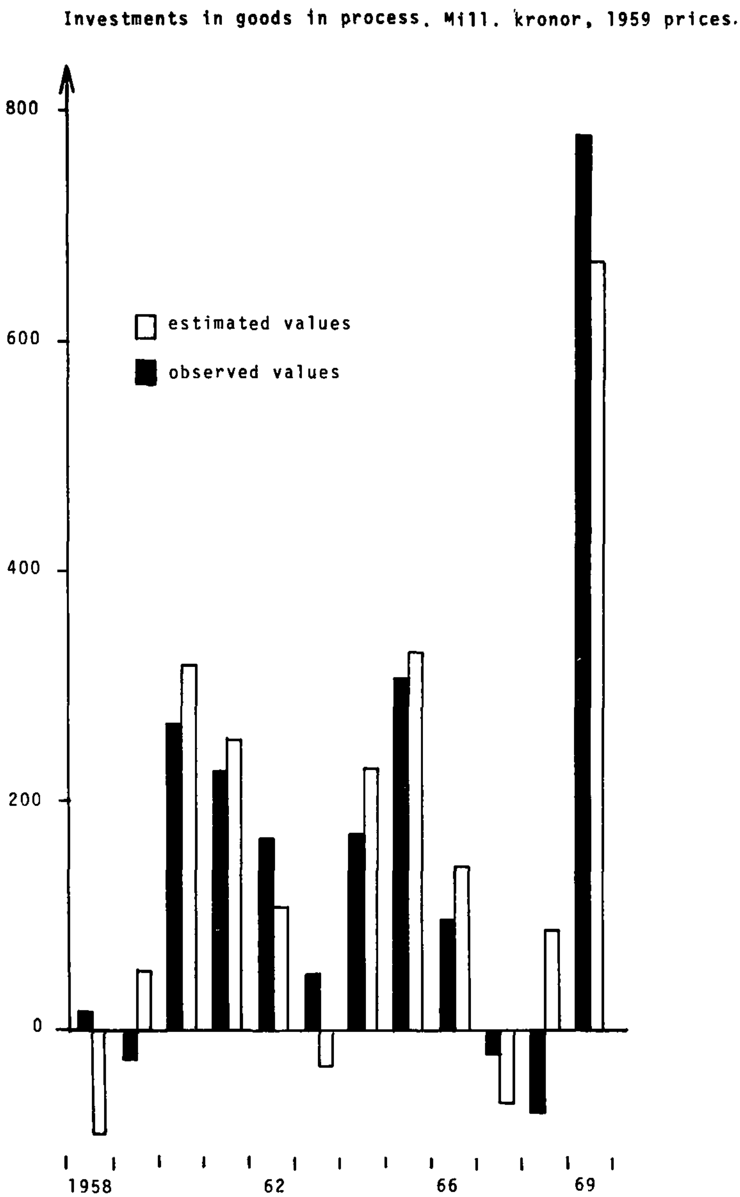

Investments in goods in process. Mill. kronor, 1959 prices.
800
600
400
200
0
estimated values
observed values
1958
62
66
69

Fig. 10

is affected by our insertion of the estimated values instead of the observed values of the Y_k quantities in question. At the same time we shall also greatly increase the level of aggregation of the model in relation ot that applied in preceding sections. The relation we are to investigate can be written

$$\hat{C} = [0.511\,Y_1 + 0.099\,Y_2 + 0.224\,\hat{Y}_3 + 0.135\,\hat{Y}_4 + 0.031\,\hat{Y}_5]\cdot b_t$$
$$b_t = b_0 e^{-0.009\cdot t}$$

Denotations

Y_1 Total investments
Y_2 Exports of ships
Y_3 Exports of other products
Y_4 Consumption of durable goods
Y_5 Investments in goods in process

The circumflexes over Y_3, Y_4 and Y_5 denote that these quantities are estimated from the models presented earlier. The predetermined quantities thus comprise, apart from Y_1 and Y_2, industrial production in importing countries, excess capacity in Swedish industry, disposable income etc. The trend factor $e^{-0.008}$ is that which was estimated from the original final demand relation.[1]) b_0 is a level constant. By correlating steel consumption as estimated above with actual steel consumption we obtain an R value of 0.99. The correlation between ΔC and $\Delta\hat{C}$ is 0.80. Both correlations are calculated from annual data for the period 1957—69. We can thus say that the loss of information, when usirg estimated instead of observed values as explanatory variables, in terms of correlation is a small one.

[1]) See p. 63 n. 1.

3. Steel consumption as a function of total economic activity

3.1. Fragmentation or concentration of explanatory variables. Global models

In the previous chapter a study was made of steel consumption on the basis of a quantified model of the Swedish economy. This model, the input-output model, goes a long way in terms of fragmentation into sectors (15 and 45 sectors of production respectively together with 18 final demand categories), but in return it is simple in other respects, particularly as regards the mathematical functional form of the relations it describes. One alternative to this approach is to study steel consumption as a function of a small number of variables. An alternative of this kind is generally worth trying, especially for the following two reasons. Firstly, problems of statistical estimation in time series studies often make the use of a large number of explanatory variables completely pointless. Secondly, from the forecasting point of view it is not only simpler but—as a rule—unavoidable to use only a small number of variables. Here our reduction of the number of exogenous variables might proceed according to the following three principles:

- The original model can be closed
- The original variables can be aggregated into a smaller number
- Less important variables can be eliminated.

Of course we can also use a combination of these three procedures. In the transition from the $X \rightarrow C$ relation to the $Y \rightarrow C$ relation, the number of exogenous variables was reduced from 127 to 18. When we take the next step to the $Z \rightarrow C$ relation, both an increase and a reduction of the number of exogenous variables are conceivable. If we are prepared to go to such lengths in our pursuit of causality, there are a considerable number of interesting factors to be found when amplifying the analysis. In econometrics however one's aim is to utilize the analytical advantages posed by the interdependence existing in an economy. In the present case this means making use of the fact that certain Y quantities are determined by others and of the possibility of several Y variables being determined by one and the same exogenous variable. In this way the transition from a $Y \rightarrow C$ analysis to a $Z \rightarrow C$ analysis can entail a further reduction in the number of exogenous variables. Although the regression equations for exports, purchases of consumer durables and investments in goods in process which we were considering earlier included many independent variables, a large proportion of these were lagged endogenous variables, which do not give rise to any serious problems in forecasting. There were only a small number of pure exogenous variables.

In practice an aggregation follows two main principles

- An entire—and previously specified—model is aggregated, whereby the mathematical character of the resulting model is wholly determined by the original model
- The variables are aggregated into a smaller number. A model is constructed for the aggregated variables without a more detailed specification of more micro-economic relations first being given.

In this chapter we shall be concerned with a class of models following the latter principle. The distinctive feature of these models, which are generally termed global models, is that steel consumption is regarded as a function of a macro variable, usually *GNP*, industrial production or total fixed investments. They are generally used as a basis for long-term forecasts, but they have also been put to good use in short-term forecasts. They can be described as something between the models based on detailed knowledge of inter-industrial relations and pure trend models.

The method of relating steel consumption or steel demand to GNP or industrial output dates back to the 1930s. It came in the first instance as a reaction to the many attempts made previously in the spirit of Henry Schultz to estimate static demand curves for steel and other products on the basis of simple demand equations with price as the sole explanatory variable. Experience showed that shifts in the demand curves, at least in the steel sector, were far more important as an explanation of variations in quantity demanded than were price movements. One early and significant expression of the new perspective is an article published in Econometrica in 1936, in which R. H. Whitman describes the level of steel demand, defined as the production of steel ingots plus the increase in unfilled orders, as a function of industrial production, the price of steel and changes in that price.[1]) In later studies the price of steel has generally been eliminated altogether as a variable determining demand. Instead interest has focussed entirely on the dependence of steel consumption on total economic activity, especially in the long run. In one article P. Boschan put forward a method of estimation in which industrial production was divided into a capacitydetermined and an output-determined component where short-term demand was dependent on the ratio overall capacity/total output.[2]) Ruist begins with basically the same premises as Boschan but arrives at a simpler estimation procedure.[3]) A summary of different variations of global models, together with explicit forecast estimates for the OECD countries, is given by F. A. M. Vlemmings.[4]) It should be added that the global method has played a prominent part in the forecasts of steel consumption compiled by international organizations such as the ECE, the OECD and the High Authority.[5])

The global models boast a wide variety of mathematical costumes. Their abundance of functional forms is striking and seems by all accounts to be connected with the differences of theoretical premises associated with different applications. One contributory cause of the plethora of abstruse and at times unwieldy formulations of global relations has probably been the tendency of many forecaster to concentrate their analyses on the elasticity of steel consumption with respect to the macro variable (GNP) and to regard this quantity as a function of one or more exogenous variables.

In this chapter we shall be mainly concerned with the cyclical aspects. We shall begin by putting forward a theoretical frame of reference. From this we shall proceed to specify a group of models. These will first be tested on Swedish material, in which we shall above all study the difference between the cyclical properties of various gauges ef steel consumption. We shall then see how the models work when applied to other

1) R. H. Whitman, "The Statistical Law of Demand for a Producer's Good as Illustrated by the Demand for Steel", Econometrica, vol. 4. No. 2.

2) P. Boschan, "Productive Capacity, Industrial Production and Steel Requirements" in Income and Wealth, vol. 16, Princeton 1954. See also Sir Robert Shone and H.R. Fisher, "Industrial Production and Steel Consumption", The Journal of the Royal Statistical Society, Series A, Vol. 121, Part 3, 1958.

3) See E. Ruist op.cit. pp. 80—82.

4) F. A. M. Vlemmings, Prognoses van het staalverbruik Markt-onderzoek kwartalschrift 3/2, June 1970.

5) See Long Term Trends and Problems of the European Steel Industry, United Nations, ECE, Geneva, 1959.
Steel Demand Forecasting in OECD Countries, Paris 1969.

countries. In view of the lack of statistics on actual steel consumption we have opted for apparent steel consumption in crude steel weight (the ECE definition) as a dependent variable. Long-term relations are given a very thin deal in all these models. To remedy this defect we shall conclude with a brief discussion of problems in this connection together with a statement of a theory of trend relations which will be tested on cross-section data.

3.2. The basic hypotheses of the global method

In our application of the global method we shall study relations of the type

$$\Sigma_{j=1}^{m} X_j \rightarrow C;\ m \leqslant n$$

Thus we are investigating the relation between total production (*GNP*, or rather *GDP*, $m = n$) or e.g. total commodity production ($m < n$) on the one hand and steel consumption on the other. The question now arises: *are there any reasonable grounds for believing a priori in stable global relations and if so what is the nature of the functional forms describing these relations*? Before we attempt to answer these questions, the first of them must be expressed in rather more precise terms. Let χ be a measure of total production. We can now state the identity

$$C_t = A_t \chi_t$$

where A by definition is C/χ, which will here be termed *total steel intensity*. If the steel intensity of each sector of production were constant in time like the contribution of each sector to total production, the A_t would ipso facto be a constant function of time.[1]) Now we have already seen that steel input per unit of output varies considerably as between different sectors and that these sectors differ considerably with respect to long term growth rate and cyclical patterns. Consequently variations should occur in total steel intensity. Since in this model approach we wish to explain variations in steel consumption by the variations in total production, we shall endeavour to define the general functional relation

[1]) In this case $X_{jt} = \lambda_j \Sigma X_{jt}$, where λ_j is a constant and $\Sigma\lambda_j = 1$, and $C_t = \Sigma a_j \lambda_j \Sigma X_{jt} = A \Sigma X_{jt}$. This relation will hold if there is uniform growth of investments, consumption, etc. i.e. in the *Y*-categories, and if final deliveries for category k from sector j comprise a constant proportion of the total value of this category.

$$A_t = f\int_0^{\infty} g(\tau)\chi_{t-\tau}d\tau$$

The function $g\ (\tau)$ is a weighting function; $\int_0^{\infty} g(\tau)d(\tau) = 1$. The question put previously can now be expressed: *are there any acceptable reasons for the ratio steel consumption/total production* (A_t) *to co-vary with total production*?

Total steel intensity is determined by the steel intensity of the various sectors of production and their share of total production. By definition

$$C/\chi = \Sigma\,(C_j/X_j)\,(X_j/\chi)$$

If we designate the first parenthesis a_j and the second λ_j we obtain

$$A_t = \Sigma_j a_{jt}\lambda_{jt}$$

Hypotheses concerning the dependence of steel consumption on total production in an economy must apply to the development of steel intensity in different sectors and of the sector composition of total production.

3.2.1. Long-term relations. As regards very long-term relations, the current hypotheses concerning a_{jt} have been that they have diminished in time, due among other things to changing techniques. Since total production as a rule shows a high positive correlation with time, this hypothesis implies the assumption of a negative correlation between A_t and total production when its composition is unchanged, i.e. when λ_j are constant in time. This hypothesis has been confirmed by our earlier analysis.

The product mix of output and with it the whole of the industrial structure are changed by the development of wealth and production. In the earlier stages of development production is mostly confined to necessary everyday commodities such as food and clothing. During the industrialization process and especially during the construction of industrial society the building sector and heavy industry undergo a rapid process of expansion. The engineering industry then continues to increase its share of total production while foodstuffs and textiles decline in proportion. So far these hypotheses are supported by Maizels' oft-quoted study.[1]) In advanced economies, however, it has also been observed that engineering products change

[1]) A. Maizels, Industrial Growth and World Trade, Cambridge 1963.

character in such a way that output of "lighter" products grows more rapidly than production in the heavy sectors of the engineering industry. In a detailed sector analysis this will be observed as a change in the product or sector mix, but at the level of aggregation at which we are mostly operating, it will be regarded as changes in a sector influencing, among other things, the specific steel consumption of that sector.[1])

This means that the share of steel consumption in total production grows very rapidly during the industrialization process, later stagnating and eventually declining. The relation is sketched in the following figure.

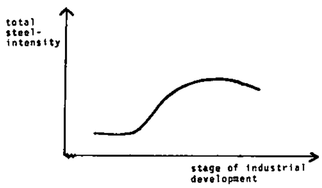


Fig. 11

We shall leave this long-term relation aside for the time being in order to discuss the hypotheses which we are to test in a time series analysis and which concern more short-term relations.

3.2.2. Cyclical relations. The time series studies we are to make concern the periods 1953—69 or 1954—69, thus comprising not more than 17 years. We can hardly expect in what, for trend studies, is a relatively short period as this to be able to identify long-term relations of the kind referred to above. We shall therefore assume in the first instance that A remains unchanged on a more long-term basis or that it changes according to a linear or an exponential trend.

We know from experience that total steel intensity exhibits cyclic variations. It seems reasonable to combine this knowledge with the observations we have made of variations in goods in process. Let us suppose that investments in goods in process have a higher steel intensity than the average of other final demand categories. Assume now that these inventory investments can by described by a simple accelerator model—an assumption for which we have previously found a certain justification. They will thus be proportional to the absolute increase in total production. We then obtain the following relations for steel consumption and total steel intensity respectively[2])

[1]) Clearly the question as to what can be referred to a_j and λ_j respectively when A changes will depend on the level of aggregation. The larger the aggregates we are dealing with, the more of A's changes will be ascribed to changes in specific steel consumption.

[2]) In this general review we will dispense with the trend term.

$$C \quad = a_0\chi + a_1 \Delta \chi_1 \qquad 13.$$

$$C/\chi = a_0 + a_1 (\Delta \chi/\chi) \qquad 13\text{ a.}$$

$C = {}_0C + {}_{sp}\Delta L$

Referring back to our previous division of steel consumption into two components, ${}_0C$ and ${}_{sp}\Delta L$, the former is decribed by the term $a_1\chi$ and the latter by the term $a_1\Delta\chi$.

This hypothesis regarding the genesis of cyclical variations in total steel intensity may seem too simple. In Sweden an the USA at least, fluctuations in total production have to a striking extent been attributable to inventory investments. Since the latter are predominantly concerned with durables, their steel intensity is probably above average. Other Y categories productive of instability have been investments and the consumption of durables. As we have already seen, these consist to a very great extent of steel-intensive products. Thus the share of the steel-intensive sectors in total production would seem to co-vary with the rate of growth of the latter quantity. We can therefore state the general hypothesis that total steel intensity is dependent on the growth rate of total production, i.e.

$$C/\chi = A = f(\chi/\chi_{-1})$$

A more precise version of this relation is

$$A = b_0 (\chi/\chi_{-1})^{b_1} \qquad 14.$$

Here the exponent b_1 describes the sensitivity of steel intensity to variations in the growth rate of production. A closely related functional form is

$$A = c_0\chi^{c_1};\ c_1 = c_{10} + c_{11}\,\Delta \log \chi \qquad 15.$$

Here cyclical sensitivity depends on the value of χ. If however we believe that variations in steel intensity increase with the value of total production, this functional form is a good complement to the preceding one. We shall assume here that $c_{10} = 0$. The equation for steel consumptoin will then be

$$c_0\chi^{1 + c_{11}\Delta \log \chi} \qquad 15\text{ a.}$$

Taking the logarithm and the first difference with respect to time of equations 14 and 15 a we obtain

$$\Delta \log C = \Delta \log \chi + b_1\Delta^2 \log \chi;\ b_1 > 0$$

and $\Delta \log C = \Delta \log \chi + c_{11}\Delta (\log \chi \cdot \Delta \log \chi);\ c_{11} > 0$

In both these cases the growth rate of steel consumption will show bigger fluctuations than the growth rate of total production. The differences between the growth rates during a certain interval of time are here determined by the increase in the rate of increase of total production.

The hypotheses on which the two previous specifications were based say that steel consumption will oscillate round total production. Naturally this can be expressed in a variety of ways. We shall conclude by considering a model constructed on the basis of a hypothesis concerning the long-term trend of steel consumption together with a hypothesis concerning deviations from this trend. Let the trend values for steel consumption and total production be C^T and χ^T respectively. It is assumed that χ^T together with the deviation between C^T and χ^T can be described by exponential trends. The deviation of steel consumption from its trend value is assumed to be dependent on the difference between actual value and trend value for total production. We shall specify the hypotheses as follows:

C	$= (C/C^T) \cdot C^T$	identity
C^T	$= B\chi^T e^{\gamma \cdot t}$	long-term relation
χ^T	$= De^{\beta \cdot t}$	trend value of production
C/C^T	$= G\,(\chi/\chi^T)^a$	short-term relation

From this we obtain[1])

$$C = H \cdot \chi^a \cdot e^{b \cdot t} \tag{16.}$$

or after taking logarithms and first differences

$$\Delta \log C = a\,\Delta \log \chi + b \tag{16 a.}$$

This expression or its counterpart, when the relative changes are expressed as percentages, is applied in many studies, but b is often interpreted as a pure trend, which in this case would express long-term changes in steel intensity and the production

[1]) By inserting the expressions for long-term and short-term relations in the identity we obtain

$$C = G\,(\chi/\chi^T)^a \cdot B^T e^{\gamma \cdot t}$$

After insertion of the expression for χ^T this relation can be written

$$C = (GBD^{1-a})\chi^a \cdot e^{[\beta(1-a)+\gamma]\cdot t} = H\chi^a e^{b \cdot t};$$

H and b are constants.

structure of the economy.[1]) However the coefficient b is dependent on the value of the cyclical sensitivity coefficient. For b can be written

$$b = \beta(1 - a) + \gamma$$

We shall return later to the problem of how b can be identified. It should also be pointed out that our basic assumption of the proportionality of the long-term relation will be modified somewhat in certain applications.

Finally it may be interesting to see what equations 14, 15 and 16 have to tell us concerning the elasticity of steel consumption with regard to total production. Rightly or wrongly, this concept has played and important part in the steel consumption forecasts that have been used. Let us define this elasticity ,δ, as $\Delta \log C/\Delta \log \chi$. Due to equations 14 and 15 the elasticity will be

$$\delta_{14} = \Delta \log C/\Delta \log \chi = 1 + b_1 \Delta^2 \log \chi/\Delta \log \chi \text{ and}$$

$$\delta_{15} = \Delta \log C/\Delta \log \chi = (1 + c_1) + c_1 \, [\Delta(\Delta \log \chi \cdot \log \chi)/\Delta \log \chi]$$

In these expressions we can discern a long-term component 1 and $1 + c_1$ respectively together with a short-term component which in both cases is determined by the size of b_1 and c_1 respectively and by the rate of the acceleration of production.[2])

$$\delta_{13} = \frac{\chi}{C}\frac{dC}{dt}\Big/\frac{d\chi}{dt} = (a_0 + a_1\, d^2\chi/dt^2)\frac{\chi}{C}$$

On the other hand a change in the growth rate is immaterial to the value of the elasticity governed by equation 16. This is

$$\delta_{16} = \Delta \log C/\Delta \log \chi = b/\Delta \log \chi + a$$

Elasticity δ_{16}, which depends on the parameter a and the growth rate of production, can assume all values between a and $+\infty$ or between a and $-\infty$ depending on the sign of b. The variability of this quantity is illustrated in the accompanying figure, where the slopes of the rays towards the line showing the relation between $\Delta \log C$ and $\Delta \log \chi$ are by definition the elasticities at the corresponding co-ordinates. Thus elasticity varies continuously with the values of $\Delta \log \chi$ in the open intervals $]0, +\infty[$ and $]0, -\infty[$

This elasticity, like the relation as a whole, comprises a

[1]) I have myself contributed a somewhat misleading description of this relation in The Swedish Steel Industry on the Threshold of the Seventies, suppl. 6, Stockholm 1969.

[2]) A similar interpretation can be put on the elasticity implied by equation 13.

short-term and a long-term component. If we are adhering to our original model, the former will be

$$\gamma/\Delta \log \chi^T + 1$$

This assumes values between 1 and $-\infty$ if $\gamma < 0$, otherwise it assumes values between 1 and $+\infty$. At $\gamma = 0$, δ is always $= 1$.

3.3. The global method applied to Swedish data

The global models defined in the preceding section will now be tested on data for the Swedish steel market. Our main interest here, as has already been intimated, will be in cyclical relations. Using the least square method applied to time series for the period 1955—69 we shall attempt to arrive at a quantitative picture of the "dynamic structure" of steel consumption. In this connection we shall be particularly concerned with the relation of steel consumption to general economic activity when the latter undergoes cyclical and more long-term changes. Apart from putting historical developments in perspective, the analysis is also aimed at developing practical instruments for forecasts of, say, from one to ten years ahead.

3.3.1. Indicators of consumption and hypotheses concerning inventory investments. Previously we have encountered five distinct indicators of consumption, namely actual consumption and deliveries to consumers of Swedish and imported steel in thousands of tons finished steel weight, apparent consumption in thousands of tons crude steel weight and, finally, actual and apparent consumption in millions of kronor in fixed prices (1960 prices). These gauges differ from the definitions given previously as regards their content of investments in steel inventories. No such changes are included in actual consumption, while deliveries to consumers include changes in the inventories of this category of firms. Apparent consumption includes investments in the inventories of producers, merchants and consumers.

Since our hypotheses regarding global relations applied to actual consumption, we must add hypotheses concerning inventory fluctuations if we are to use equations 13—16 to explain total deliveries and apparent consumption. These additions refer to cyclical relations. There is no reason to alter our long-term hypotheses, even though AC increases rather more slowly than C as a result of the ratio total steel inventories/actual consumption declining in time. This is naturally reflected in the size of the trend factor, but the general long-term relation still applies.

We found earlier that the different indicators of steel consumption are very much in agreement as regards the periodicity of cyclical fluctuations, even though their amplitude may vary. This observation is reason enough to make the models refer to all indicators. To simplify the interpretation of the regression results, however, we shall look more closely at the implications. Let us take apparent consumption (AC) as an example. The counterpart to equation 13 will now be

$$C = a_0 \chi + a_1 \Delta \chi_1 \qquad 13.$$

$$AC = \alpha_0 \chi + \alpha_1 \Delta \chi$$

Subtracting the corresponding parts of equation 13 from the left and right sides respectively we obtain[1])

$$AC - C = \Delta L = (\alpha_1 - a_1) \Delta \chi$$

In order for equation 13 to be applicable to AC, it must be possible to describe steel inventory investments (ΔL) in principally the same way as investments in goods in process. Thus the coefficient $(\alpha_1 - a_1)$ is assumed to be positive.
Similarly the counterpart of equation 14 can be written

$$C/\chi = b_0 \, (\chi/\chi_{-1})^{b_1} \qquad 14.$$

$$AC/\chi = \beta_0 \, (\chi/\chi_{-1})^{\beta_1}$$

Dividing the terms in this expression by the corresponding terms in equation 14, we obtain

$$AC/C = \beta_0/b_0 \, (\chi/\chi_{-1})^{\beta_1 - b_1}$$

In order to obtain a clearer view of the implied hypothesis concerning inventory investments, we shall first multiply the above expression by C and then reduce both sides by the same quantity. We then obtain

$$AC - C = \Delta L = C(\zeta - 1); \; \zeta = \beta_0/b_0 \, (\chi/\chi_{-1})^{\beta_1 - b_1}$$

If inventory investments are correlated with $\Delta \chi$ as in the preceding hypothesis, then $(\beta_1 - b_1) > 0$ and the cyclical sensitivity of AC with regard to total production will be greater than that of C. However, the inventory investment model is

[1]) N. B. According to the conditions given, $\alpha_0 = a_0$.

here somewhat more complicated than in equation 13. Inventory investments, ΔL, are dependent both on C and on the relative change in χ. We can say, however, that if equation 13 gives an accurate description of reality then equation 14 and, consequently, equation 15 will probably do the same.

According to our hypotheses the short-term relation in equation 16 can be written

$$AC/C^T = \delta_0 (\chi/\chi^T)^{\delta_1}$$

Dividing this expression by the short-term relation for C we obtain

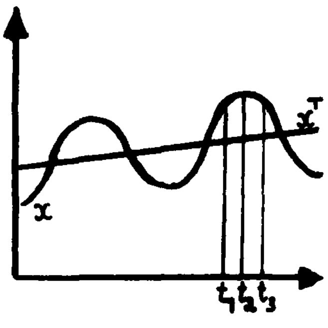
$$AC/C = (\delta_0/C)(\chi/\chi^T)^{\delta_1 - a}$$

Following the same procedure as above, we obtain the following equation for inventory investments

$$\Delta L = AC - C = C(\xi - 1);\ \xi = (\delta_0/C)(\chi/\chi^T)^{\delta_1 - a}$$

If $(\delta_1 - a) > 0$ this means that inventory investments increase with the relative distance between actual production and the trend value of production. This implied hypothesis regarding inventory movements need not agree with the hypotheses included in equation 13 and equation 14. Consider the accompanying figure, where the two curves describe a hypothetical development of χ and χ^T.

$$C = H\chi^a e^{b \cdot t} \qquad 16.$$



According to the acceleration principle and the closely related variant thereof implied by equation 14, the intensity of inventory investments dL/dt will be lower at t_2 than at t_1. If $\beta_0/b_0 = 1$ then at t_3 $dL/dt < 0$. According to equation 16 as applied to AC, the development of dL/dt will be different. Here inventory investments increase as long as the distance between χ and χ^T increases. Consequently, dL/dt, according to the last-mentioned relation, is greater at t_2 than at t_1. If $(\delta_0/g) = 1$ the intensity of inventory investments at t_3 is still lower than at t_2 but it remains positive.[1]) Of course we cannot dismiss this inventory relation merely on the grounds that it does not agree with the pure acceleration principle. There may for instance exist such systematic variations in involuntary inventory investments that actual inventory increases can be roughly described by the inventory model included in equation 16.

It should however be observed that the models are constructed to be tested on annual data. One can very well conceive of such series for total production as have an appearance giving a high correlation between χ/χ_{-1} and χ/χ^T. In this case both models will of course give a good description of the development of C, but we will not be able to discriminate between the original hypotheses.

3.3.2. Two measures of total production. In applying the four variants of the global model defined in the previous section, two indicators of total production will be used, namely *GNP* and the industrial production index. For the sake of greater

[1]) Cf, section 3.3.3.4.

comparability with other countries, we have used the OECD definitions. This means among other things that *GNP* is measured in dollars at the prices and exchange rates of 1963. Thus, referring back to the preceding section, *GNP* corresponds to total production, $\Sigma_{j=1}^{m} X_j$ where $m = n$, while industrial production measures only a part of this, i.e. $\Sigma_{j=1}^{k} X_j$, where $k < n$. In 1969 industrial value added in current prices was 28 per cent and in 1959 prices 35 per cent of *GNP*. In 1959 the share of industrial production in *GNP* was 28 per cent. Thus the share of industrial production in *GNP*, expressed in fixed prices, rose by 25 per cent during the period 1959—69.[1])

The main reasons for using the industrial production index here is that steel consumption is negligible in the other sectors, the building industry excepted. The omission of the building industry from the industrial production index used here has been dictated by problems of measuring technique, for in many countries, including Sweden, adequate data for the production of the building sector have been lacking. However we can hopefully assume that variations in this production are reflected in the index for the building materials industries, which of course are included in the production index.

3.3.3. **Account and analysis of the regression results.** The results of a regression study of the global models described above are summarized in tables 8; a, b, . . . h. Since in certain cases the form in which the equations are tested deviates from that in which they were presented and since we are using two indicators of total production, it may be worth while to set out the tested verions.[2]) By doing so we will also get a key to the tables.

$$C/GNP = a_{10} + a_{11} \Delta GNP/GNP + a_{12} \cdot t \qquad 13.a$$
$$C/I = a_{20} + a_{21} \Delta I/I + a_{22} \cdot t \qquad 13.b$$
$$\log C - \log GNP = a_{30} + a_{31} \Delta \log GNP + a_{32} \cdot t \qquad 14.c$$
$$\log C - \log I = a_{40} + a_{41} \Delta \log I + a_{42} \cdot t \qquad 14.d$$

[1]) The figures are calculated from table 1 and table 2 in National Accounts, N 1971: 11, the National Central Bureau of Statistics.

[2]) In equations 14 and 15, the necessary linearization has been undertaken, which means that these equations have been put in logarithmic form. Equation 16 has been subjected to an additional operation, namely the taking of first differences with respect to time. The reason for this is simply that we wish to avoid the misinterpretation that can arise in an estimate of the primitive function as a result of t and *GNP* or t and I being strongly correlated.

$$
\begin{aligned}
\log C - \log GNP &= a_{50} + a_{51}\,(\Delta \log GNP \cdot \log GNP) + \\
&\quad + a_{52} \cdot t && 15.e \\
\log C - \log I &= a_{60} + a_{61}\,(\Delta \log I \cdot \log I) + a_{62} \cdot t && 15.f \\
\Delta \log C &= a_{70} + a_{71} \cdot \Delta \log GNP && 16.g \\
\Delta \log C &= a_{80} + a_{81} \cdot \Delta \log I && 16.h
\end{aligned}
$$

Three values are accounted in the tables under the coefficients a_{11}, a_{12}, a_{21} etc. The uppermost figure denotes the estimated value of the coefficient. The figure in parenthesis describes the appurtenant standard deviation and the bottom figure the value of the so-called beta coefficient. A measure of total adjustment is also given for each regression equation, the correlation coefficient (R), together with a measure of the autocorrelation in the residuals (DW). The purpose and use of these statistics are stated in Part III cap. 8, which also contains a general description of them.

It should be pointed out, however, that the R values refer to the explanatory value of the special hypothesis denoted by each regression equation. Thus the R values are *not* intended to describe the correlation between actual and estimated steel consumption (C and $\hat{C}$) implied by the estimated relations. Thus the R value of, say, equation h can be lower than the R value of equation f, while the relation between the implied correlations between C and $\hat{C}$ can be the reverse. Since however we are interested—not least for purposes of forecasting—to know the correlation between C and $\hat{C}$, this has also been

Table 8

a) $C/GNP = a_{10} + a_{11} \quad \Delta GNP/GNP + a_{12} \cdot t$

Dependent variable		a_{10}	a_{11}	a_{12}	R	DW
C	1000 ton	151.66	167.58 (132.84) 0.250	1.5243 (0.4475) 0.676	0.762 (0.988)	1.63
C	mill.kronor	143.89	114.53 (122.46) 0.153	2.0248 (0.4121) 0.800	0.845 (0.989)	1.78
J	1000 ton	151.99	233.30 (171.75) 0.305	1.2012 (0.5280) 0.511	0.653 (0.982)	2.17
ACc	100 ton	214.93	595.89 (330.54) 0.436	1.229 (1.017) 0.292	0.578 (0.965)	1.95
AC	mill.kronor	140.65	292.35 (195.75) 0.321	1.7806 (0.6594) 0.581	0.713 (0.974)	1.78

b) $C/I = a_{20} + a_{21}\,\Delta I/I + a_{22}\cdot t$

Dependent variable		a_{20}	a_{21}	a_{22}	R	DW
C	1000 ton	30.323	31.730 (9.784) 0.503	-0.30175 (0.0547) -0.856	0.794 (0.994)	1.17
C	mill.kronor	29.018	19.871 (11.003) 0.404	-0.18972 (0.06184) -0.856	0.700 (0.993)	1.75
J	1000 ton	29.636	49.342 (9.773) 0.621	-0.34115 (0.04930) -0.852	0.912 (0.994)	1.81
ACc	100 ton	42.003	105.01 (19.62) 0.703	-0.58569 (0.09897) -0.777	0.899 (0.987)	1.65
AC	mill.kronor	28.238	51.325 (13.243) 0.704	-0.26150 (0.07400) -0.642	0.815 (0.989)	1.75

c) $\log C - \log GNP = a_{30} + a_{31}\,\Delta \log GNP + a_{32}\cdot t$

Dependent variable		a_{30}	a_{31}	a_{32}	R	DW
C	1000 ton	2.1831	0.90402 (0.73613) 0.251	0.0039157 (0.0011284) 0.682	0.768 (0.987)	1.65
C	mill.kronor	2.1611	0.67119 (0.70150) 0.155	0.0053423 (0.0010753) 0.806	0.848 (0.988)	1.60
J	1000 ton	2.1841	1.3117 (0.9457) 0.309	0.0030711 (0.0013238) 0.517	0.660 (0.982)	2.15
ACc	1000 ton	2.3355	2.3212 (1.2303) 0.444	0.0021950 (0.0017501) 0.300	0.591 (0.964)	2.06
AC	mill.kronor	2.1531	1.6752 (1.1009) 0.323	0.0046877 (0.0016871) 0.590	0.721 (0.973)	2.02

d) $\log C - \log I = a_{40} + a_{41}\,\Delta \log I + a_{42} \cdot t$

Dependent variable		a_{40}	a_{41}	a_{42}	R	DW
C	1000 ton	1.4827	1.0222	-0.0045375	0.870	1.21
			(0.3164)	(0.0008138)	(0.998)	
			0.497	-0.859		
C	mill.kronor	1.4629	0.67195	-0.0029455	0.703	1.29
			(0.36861)	(0.0009479)	(0.998)	
			0.406	-0.692		
J	1000 ton	1.4727	1.5823	-0.0051032	0.915	1.85
			(0.3987)	(0.0007171)	(0.994)	
			0.618	-0.858		
ACc	$\overline{1000}$ ton	1.6247	2.3301	-0.0061129	0.901	1.71
			(0.4354)	(0.0010108)	(0.987)	
AC	mill.kronor	1.4517	1.6927	-0.0040216	0.815	1.77
			(0.4395)	(0.0011303)	(0.988)	
			0.698	-0.645		

e) $\log C - \log GNP = a_{50} + a_{51}\,\Delta \log GNP \cdot \log GNP + a_{52} \cdot t$

Dependent variable		a_{50}	a_{51}	a_{52}	R	DW
C	1000 ton	2.1857	0.75127	0.0036910	0.767	1.60
			(0.59362)	(0.0011752		
			0.259	0.643		
C	mill.kronor	2.1627	0.54306	0.0051776	0.848	1.58
			(0.56479)	(0.0011182)		
			0.162	0.782		
J	1000 ton	2.1871	1.0743	0.0027510	0.662	2.13
			(0.07603)	(0.0013882)		
			0.330	0.463		
ACc	1000 ton	2.34129	1.8692	0.0016505	0.590	2.03
			(1.0082)	(0.0018406)		
			0.467	0.226		
AC	mill.kronor	2.1572	1.3618	0.0042724	0.723	1.99
			(0.8850)	(0.0017523)		
			0.339	0.537		

f) $\log C - \log I = a_{60} + a_{61}\, \Delta \log I \cdot \log I + a_2 \cdot t$

Dependent variable		a_{60}	a_{61}	a_{62}	R	DW
C	1000 ton	1.4857	0.50359 (0.16274) 0.504	-0.0048116 (0.0008603) -0.911	0.865	1.13
C	mill.kronor	1.4648	0.33490 (0.18632) 0.416	-0.0031332 (0.0009849) -0.736	0.700	1.25
J	1000 ton	1.47701	0.78716 (0.15985) 0.634	-0.0055434 (0.0007659) -0.932	0.910	1.79
ACc	1000 ton	1.6309	1.1619 (0.2247) 0.715	-0.0067659 (0.0010765) -0.869	0.896	1.65
AC	mill.kronor	1.4561	0.84849 (0.22297) 0.720	-0.0045037 (0.001787) -0.722	0.812	1.73

g) $\Delta \log C = a_{70} + a_{71}\, \Delta \log GNP$

Dependent variable		a_{70}	a_{71}	R	DW	$\hat{\gamma}$
C	1000 ton	-0.0071011	1.6861 (0.7325) 0.553	0.553 (0.985)	2.24	0.0050737
C	mill.kronor	-0.0035885	1.5313 (0.7126) 0.527	0.527 (0.980)	2.40	0.0053894
J	1000 ton	-0.01276	2.1085 (1.2984) 0.411	0.411 (0.961)	2.36	0.0071974
ACc	1000 ton	-0.028710	2.9318 (1.5234) 0.471	0.471 (0.961)	2.40	0.0060701
AC	mill.kronor	-0.031433	2.9524 (1.3442)	0.535 (0.962)	2.64	0.0037180

h) $\Delta \log C = a_{80} + a_{81} \Delta \log I$

Dependent variable		a_{80}	a_{81}	R	DW	$\hat{\gamma}$
C	1000 ton	-0.011929	1.4163 (0.3282) 0.780	0.780 (0.993)	1.08	-0.001588
C	mill.kronor	-0.006991	1.2468 (0.3468) 0.720	0.720 (0.993)	1.55	-0.0008613
J	1000 ton	-0.028702	2.1608 (0.6149)	0.698 (0.981)	1.80	-0.0000395
ACc	1000 ton	-0.043825	2.7191 (0.7179) 0.724	0.724 (0.987)	1.86	-0.001373
AC	mill.kronor	-0.040191	2.4923 (0.6185) 0.758	0.758 (0.982)	2.12	-0.003122

estimated. The value of R (C, $\hat{C}$), which will be termed the *comparable coefficient of correlation*, is given in parenthesis.

3.3.3.1. *General explanatory value.* A cursory review of the tables shows that the general explanatory value of the equations is fair, especially bearing in mind that the dependent variables of the regression analysis have been differences or ratios between two variables—equations *a* to *f*—and first differences with respect to time —equations *g* and *h*. Evidently we have obtained reasonable coefficient values and, with a few exceptions, there is no reason to suspect that the residuals are systematic (autocorrelated). In fact it is difficult to see on acceptable grounds that any one model is better than the others, which of course is very much due to their being so closely related to one another.

One interesting comparison between the different approaches concerns the correlation between actual steel consumption and that implied by the various regression equations, i.e. the comparable coefficient of correlation. In the first place we find that all these R values are very high and that no significant differences can be discerned in this respect.[1])

[1]) The comparable coefficient of correlation may not seem to be uniquely determined in the case of equations *g* and *h*, for we can at least define two $\hat{C}$:s. The first one is

$$\hat{C}_{1t} = \text{antilog} (\log C_{-1} + \Delta \log \hat{C}_t)$$

However there is an obivous relation between explanatory value and indication of total production. Although the tested equations sometimes acquire a greater R value when the latter is indicated by GNP, the industrial production index always gives a higher correlation between actual and estimated steel consumption. We can take row 2 of table 8 a and b as an example of a case showing the lack of agreement between the R value of the estimated relation and the correlation between C and $\hat{C}$. Here the R value of the estimated relation is 0.845 if GNP is used to measure χ, as against 0.700 if we use the industrial production index instead. In the former case the correlation between C and $\hat{C}$ will be 0.989 and in the latter case 0.995. This change is easily explained. C/GNP has fluctuated far more than the ratio C/I. Furthermore I has been much more correlated with C than GNP has been. Consequently the fact that the variations in C/GNP have been explained more than the variations in C/I has not been sufficient to make the comparable coefficient of correlation in equation a larger than in equation b.

Finally we may observe that the comparable coefficient of correlation is consistently higher when the dependent variable is actual consumption in thousands of tons or million kronor than when any of the various apparent consumption quantities is used as independent variable. On the other hand the explained variation in the ratio AC/χ can be greater than the explained variation in C/χ, which means that part but not all of the difference between AC and C, i.e. inventory increase, is explained by the implied inventory model. The equations for realized purchases by consumers exhibit much the same comparable coefficient of correlation as the equations for actual consumption.

3.3.3.2. *Long-term relations.* Our hypotheses concerning long-term relations are very simple. It is assumed in equations $a-f$ that long-term changes in A, total steel intensity, can be directly described by a trend factor. In equations g and h too, long-term development is expressed by a trend factor, which

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and the second

$$\hat{C}_{2t} = \text{antilog}\,(\log C_0 + \Delta^{-1}\,(\Delta \log C)_t]$$

In the last expression C_0 denotes steel consumption in the base period. Here we have used the second definition which generally gives a lower R-value than the former.

however in this case cannot be derived directly from the coefficient estimates but has to be estimated separately.

The first thing we notice when we substitute the industrial production index for *GNP* as a measure of total production is that the trend changes signs. This reflects the fact that the annual growth rate of *GNP* during the observation period was over 4 per cent as against almost 6 per cent for the industrial production index and that the growth rate of steel consumption was midway between the two. If we consider table *d* we find that the size of the trend varies between the various indicators of steel consumption. The trends are given in the margin as percentages. Not only do the tonnage measurements show a stronger negative trend than the corresponding constant price gauges, the trend becomes more negative as we increase the inventory content of the consumption gauge. The latter phenomenon is an expression of the long-term decline of relative inventories (L/C) while the small trend difference between steel consumption in tons and steel consumption in million kronor at 1960 prices is probably mainly due to an increase in the proportion of special steel products in steel consumption. The particularly big negative trend in ACc may reflect an increase in yield which, at a given product distribution has reduced the quantity of crude steel required to produce one ton of finished steel.

	Trend %
C 1000 tons	− 1.0
C m. kronor	− 0.7
J 1000 tons	− 1.1
ACc 1000 tons	− 1.4
AC m. kronor	− 0.9

Equations *b* and *f* naturally give a description of the long-term relations resembling that given by equation *d*. Since the coefficient values in equation *b* are dependent on the unit of measurement of variable *I*, it is difficult at first to interpret their implications. This interpretation is made easier by giving I the same mean value as *C*. The estimated relation e.g. for *C* in 1000 tons will then be

$$C/I = 1.048 + 1.096\,\Delta I - 0.010 \cdot t$$

Here we can see directly that the long-term decline of total steel intensity is one per cent a year of its average value during the years 1955—69, a result which agrees well with that given previously.

In equations *g* and *h*, as has already been pointed out, the trend factor (γ) is concealed in the constants a_{70} and a_{80} respectively which are estimates of the constant *b* (see margin). In order to be able to calculate the values of γ we first have to estimate β. One such

$$b = \beta\,(1 - \alpha) + \gamma$$

estimate is arrived at by calculating the exponential trend in GNP and I respectively. Thus in the latter case the estimate will be

$$\hat{\beta} = [\Sigma(\log I \cdot t)/\Sigma t^2]^{-1/8};\ \Sigma t = 0$$

The estimated value of γ is then obtained as

$$a_{80} - \hat{\beta}(1 - a_{81})$$

	Trend %
C	-0.36
C	-0.20
J	-0.01
ACc	-0.32
AC	-0.72

The estimated trend values are given in the appropiate tables. To simplify interpretation, the corresponding values are given in the margin as percentages. Here, when the industrial production index is used as a gauge of total production, the long-term fall in total steel intensity is smaller than in the estimates given previously. Generally speaking the differences are to be attributed to the fact that the trend estimates are influenced by the estimates of the cyclical relations. In the first three cases, where short-term relations are described by a simple accelerator model, the fact that the quantities GNP and I and thereby also log GNP and log I have undergone a certain long-term increase while the inventory investments included in the various indicators of steel consumption have taken the opposite course or have been constant in the long run, has depressed the trend estimate. Even in this latter case the two estimates may be dependent upon each other. We may say that an overestimate of the indicator of cyclical sensitivity (a) leads to an overestimate of the trend factor (γ), but an overestimate of this kind is hard to prove.

In equations g and h we gave the exponent of χ^T the value of 1. We did this in order to be able to calculate the trend factor γ. As we have already seen, the result obtained from this estimate is a composite expression of changes in sector composition and in specific steel consumption. Suppose that we wish to express the latter quantity in a trend factor and leave the description of the effect of shifts in the production structure on steel to the exponent of χ^T. Let this be denoted l. The constant b in equation 16 can now be written.

$$b = \beta(l - a) + \gamma$$

In order to estimate l we now need a value for γ. We have already presented such values in section 2.4. If we apply the estimated trend in the ratio $C/\Sigma a_j X_j$ as an estimate of γ and eliminate l, we obtain the following long-term relation for actual steel consumption in 1000 tons finished weight[1])

$$\hat{l} = 1/\beta(a_{80} - \hat{\gamma} + a_{81})$$

$$C^T = \text{constant}\ (GNP^T)^{1.732} \cdot e^{-0.0182 \cdot t}$$

and $C^T = \text{constant}\ (I^T)^{1.254} \cdot e^{-0.0182 \cdot t}$

These two equations show, if we know their construction, that the long-term elasticity of total steel consumption with regard to total production ($\Delta \log C^T / \Delta \log \chi^T$) at a given steel intensity in the

[1]) From equation h we obtain

various bransches is > 1 and that this is connected with the fact that the steelintensive industries increase their share of total production when the latter rises. Of course this pronouncement applies to Sweden during the period 1955—69 and is therefore of limited interest. We shall be returning to a more international consideration of this question.

3.3.3.3. *Short-term relations.* Short-term or cyclical relations are described by the a_{i1} coefficients, i.e. the figures in the second column of each table. Firstly we can say in general terms that short-term variations in steel consumption are better explained by the industrial production index than by *GNP*. The coefficient estimates are considerably more accurate in the former case than in the latter. Short-term relations also acquire more practical relevance in equations *b*, *d*, *f* and *h* than in their counterparts, i.e. *a*, *c*, *e* and *g*. Practical relevance is shown by the beta coefficients.[1]) The higher these are, the more of the total variations in the dependent variable can be ascribed to the corresponding independent variable. The tables also show that steel consumption is rather more sensitive to short-term variations in total production when it is measured in tons than when it is measured in kronor at constant prices. It is evident moreover that short-term sensitivity increase with the inventory increase content of the dependent variable. If we consider the tonnage indicators *C*, *J* and *ACc* we see e.g. that the corresponding coefficients for $\Delta \log I$ in equation *d* are 1.02, 1.58 and 2.33 respectively. Inventory investments have obviously been correlated with changes in industrial production.

Another interesting point in this connection is that the two indicators of actual consumption also exhibit a palpable sensitivity to the rate of increase in industrial production. This probably reflects above all the effects of investments in goods in process by steel consumers. The coefficient estimates obtained (a_{21}, a_{41} and a_{61}) are more significant as regards both the size of the standard deviations and the beta values when actual steel consumption is measured in tons than when it is measured in millions of kronor at constant prices.

As we saw earlier, the description of cycles in equations *g* and *h* differs from that given in the other equations, as witness among other things the implied model for inventory investments. The assumption here is that the detrended fluctuations in steel consumption are synchronized with corresponding movements in industrial production. The parameter a_{81} can

[1]) See Part III cap. 7.

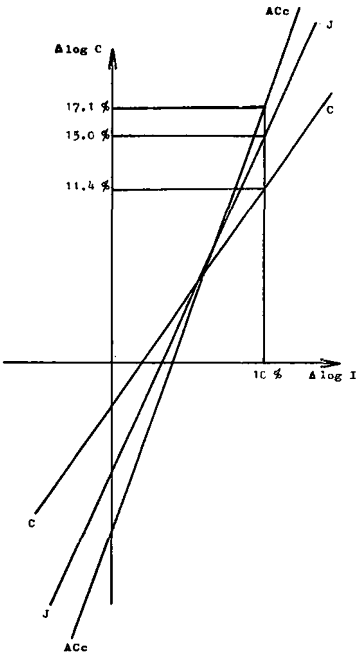

Fig. 12

be said to show the strength of short-term fluctuations in steel consumption in relation to industrial production. We can see from the table that, as we expected, this coefficient grows with the inventory content of the dependent variable. This result is also illustrated in the accompanying figure.

The effect of a rise in industrial production on steel consumption depends on the strength of the rise, but it varies according to the indicators of consumption. The greater the increases involved, the more pronounced the differences in effect between the various indicators. Thus a ten per cent rise in production results in a rise of 11.4 per cent in actual steel consumption, 15 per cent in total deliveries and 17.1 per cent in apparent steel consumption. The differences between the three relations is not only hypothetically but also historically relevant in connection with heavy increases in production.[1]) This is particularly true of the differences between the *C* and *J* relations. The differences between the *J* and *ACc* relations have however been more ambiguous because steelworks have sometimes succeeded in applying an anticyclical marketing policy.[2]) The upturn of 1968—69 is a case in point. The steep rise in production caused steel consumption in 1969 to attain a level 12.5 higher than that for 1968. The corresponding rise in total deliveries was c. 16 per cent. The rise in apparent steel consumption by contrast remained at just over 15 per cent.

3.3.3.4. A digression on leads and lags. In equations *g* and *h*, steel consumption and total production were assumed tp be simultaneous processes. Since input of steel generally occurs at the beginning of a production process, one imagines that variations in steel consumption have a certain lead over output. Earlier when discussing this relation we divided steel consumption into two components of which one was assumed to be proportional to output and the other proportional to investments in goods in process. In model *b* the index of industrial production was assumed to be a relevant gauge of output and it was further assumed that investments in goods in process could be described by a simple accelerator model. The question now arises: if this model is correct, what are its implications as regards the time lag between steel consumption and industrial production? A further interesting question in this context is: if the model is a good one, what is to be said concerning the short-term model incorporated in equation *h*?

$$\Delta \log C = a_{80} + a_{81} \Delta \log I \quad \text{h.}$$

Let industrial production be a continuous and stationary periodic function which can be described by the equation

[1]) There is nothing intrinsically remarkable about this, for the observations furthest from the average þlay a very important part in the regression calculations and have thus to a high degree determined the slope of the curves.

[2]) See Part IV.

$$I = \beta_0 \sin \omega t + \bar{I}$$

β_0 denotes the amplitude of the fluctuations, ω the number of radians covered per unit of time, i.e. the angular speed. The time needed to complete a cycle, the natural period, is represented by the ratio $2\pi t/\omega$. $\bar{I}$ is the average of I, which thus fluctuates between $I - \beta_0$ and $I + \beta_0$.

According to our premises steel consumption is

$$C = \beta_1 I + \beta_2 dI/dt$$

If we insert the expression for I and take the derivative of that expression with respect to t, we obtain

$$C = \beta_0\beta_1 \sin \omega t + \omega\beta_0\beta_2 \cos \omega t + \beta_1 \bar{I}$$

This expression can be written[1])

$$C = B \cos(\omega t + \theta) + \beta_1 \bar{I} = B \sin(\pi/2 - \theta - \omega t) + \beta_1 \bar{I}$$

Here $B = [\beta_0\beta_1)^2 + (\omega\beta_0\beta_2)^2]^{1/2}$ and

$\mathrm{tg}\, \theta = (\beta_1\beta_0/\omega\beta_0\beta_2) = -(\beta_1/\omega\beta_2)$

so that $\theta = \mathrm{arctg} - (\beta_1/\omega\beta_2)$ [2])

Thus steel consumption is also a sinusoidal function with the same period length as I. C differs from I however as regards amplitude and phase. For a given value of the length of period, i.e. for a fixed value of ω, the lag depends on the ratio β_1/β_2. When this approaches zero, the time lag approaches $\pi/2$ and when it approaches infinity the time lag approaches 0. Since $\beta_1 = L/I$, this means that the lag between C and I is determined entirely by the inventory ratio, which here refers to the quantity of goods in process/total production. The factor β_1 functions solely as a scale factor.

As an example of differences of amplitude and phase between C and I, let us consider the case where $\beta_1 = \beta_0\omega$. We then obtain

$$C = \sqrt{2} \cos(\omega t - \pi/4) + \beta_1 \bar{I} = \sqrt{2} \sin(\pi/4 + \omega t) + \beta_1 \bar{I}$$

We find that C has a lead of $\pi/4$ over I and that the amplitude of C's fluctuations is $\sqrt{2}$ times as great as that of I's. If the period length, $2\pi/\omega$, is 4 years then the lead is half a year.

The residual term $\bar{I}$ need not be a constant in order for the above argument to apply. We can equally well regard the sinus curves as fluctuations around an arithmetic or logarithmic linear trend. In the latter case they describe $\log(C/C^T)$ and $\log(I/I^T)$, where C^T and I^T denote trend values, as previously. The ratio between these

[1]) B and θ can be solved from the equations
$-\beta_0\beta_1 = B \sin\theta$ och $\omega\beta_0\beta_2 = B\cos\theta$

[2]) It will be recalled that when x goes from $-\infty$ to $+\infty$, arctg x goes from $\pi/2$ to $\pi/2$ and when $x = 0$, arctg $x = 0$.

quantities, after they have been given the same phase, is equal to the ratio between the various amplitudes, in our example = $\sqrt{2}$. In equations *g* and *h* this ratio is estimated from annual data. We then assumed that *C* and *I* were determined simultaneously. If there is in fact a certain lag between these variables then, if the lag is in the region of, say, 3 months, we will obtain biased estimates. Conversely we will make better estimates by giving *C* a certain lead over *I*. There is good reason for trying out such a procedure.

Now for the greater part of the period we are studying there are no quarterly data for actual consumption and the industrial production index broken down into quarters is obviously inferior to the annual production index: this is particularly the case for the earlier years. Let us therefore give the indicator *J* different leads in relation to *I* and look for the optimum lead, which is defined as the lead giving the greatest correlation between *J* and *I*.

The optimum lead for the period 1955—69 is 1 quarter and we obtain the relation

$$\Delta \log J_{-1/4} = -0.3772 + \underset{(0.6331)}{2.5199}\, \Delta \log I;$$

$$R = 0.741; \quad DW = 1.86$$

The one-quarter lead in *J* means that *J* during the period 1.9. year (t—1) to 31.8. year t is compared with *I* during year t. We see here that not only the *R* value but also the coefficient for log *I*, the estimate of the ratio of amplitudes, has risen in comparison with the estimate given in table 8 h. Since inventory data in particular were inferior during the 1950s to what they have become in recent years, it may be an advantage to restrict our backward perspective. If we consider the period 1959—69 we obtain the following relations

$$\Delta \log J_{-1/2} = -0.06721 + \underset{(0.5390)}{3.2419}\, \Delta \log I; \quad R = 0.895; \quad DW = 1.55$$

$$\Delta \log J_{-1/4} = -0.06692 + \underset{(0.5093)}{3.3097}\, \Delta \log I; \quad R = 0.908; \quad DW = 1.23$$

$$\Delta \log J \quad = -0.05032 + \underset{(0.64501)}{2.73402}\, \Delta \log I; \quad R = 0.816; \quad DW = 1.22$$

For this period too the optimum lead is 1 quarter. But since we obtain almost the same *R* value for a lead of 2 quarters, we may surmise that the optimum lead at an aggregation level of one year is in the region of 4—5 months. Now this does not necessarily mean that actual consumption has as large a lead over *I* as total deliveries. The contrary is indicated among other things by the fact that the coefficient for Δlog *I* in equation *d* is definitely lower when it is used to explain *C* than when *J* is the dependent variable. It is also corroborated by the fact that the optimum lead between *J* and *C* is 1 to 2 quarters.

3.3.4. **Ordinary steel and special steel.** So far we have regarded steel as a homogeneous product. Having already discussed the purpose and realism of such a procedure, we do not need to go into the matter any further. Steel products are generally defined in terms of two dimensions, form and chemical composition. In the type of economic analysis conducted in this book, an aggregation of products over the former dimension entails less anonymization in certain important respects than does an aggregation over the latter. In statistical accounts a line is drawn in terms of chemical composition between ordinary steels and special steels. In order to qualify as special steel, the steel in question must contain certain minimum proportions of alloys and carbon; in this connection one also speaks of alloy steels and high carbon steels. Both quantitatively speaking and in terms of value, ordinary steel predominates in total steel consumption, so that what has hitherto been said in general terms concerning the latter also applies to ordinary steel.

The distinction would be immaterial for our purposes if it were not accompanied by other differences. There are in fact relevant differences between the two groups of products. Some of these are connected with prices. The prices of special steels differ in three respects from the prices of ordinary products.

- They are far higher—on average the differences range between 250—350 per cent.
- They have a far wider dispersion
- They have different courses of demand in both the short run and the long run.

In the context of marketing too there are considerable differences, some of which are considered more closely in Part IV. As a rule the sale of special steel products calls for closer contacts between producers and consumers than the sale of ordinary products. Consequently sales through merchants are far less common in the case of the former than with the latter.

Table 9 shows equations *b*, *d* and *h* applied to apparent consumption of special and ordinary steels respectively. The calculation of *ACc* differs from that accounted previously. The conversion factors for ordinary steel are those applied in the ECSC statistical accounts, while the conversation factors for special steels are based on data from Swedish firms. In the absence of uniform data for the years preceding 1959, the regression estimates have been confined to the period 1959—69, which gives 11 and in equation *h* only 10 observations.

Table 9

Ordinary and special steels

$$C/I = a_{20}+a_{21}\ \Delta I/I+a_{22}\cdot t$$

Dependent variable	a_{20}	a_{21}	a_{22}	R	DW
ACc ord.st.	39.180	68.846	-0.77581	0.960	1.75
		(18.799)	(0.13035)		
		0.429	-0.697		
ACc spec.st.	66.890	157.12	-1.2864	0.736	1.80
		(110.70)	(0.7676)		
		0.400	-0.472		

$$\log C-\log I = a_{40}+a_{41}\Delta\log I+a_{42}\cdot t$$

Dependent variable	a_{40}	a_{41}	a_{42}	R	DW
ACc ord.st.	1.5958	1.8686	-0.00970	0.958	1.88
		(0.5192)	(0.00166)		
		0.430	-0.695		
ACc spec.st.	1.8164	2.4690	-0.00847	0.734	1.82
		(1.6575)	(0.00532)		
		0.421	-0.150		

$$\Delta\log C = a_{80}+a_{81}\ \Delta\log I$$

Dependent variable	a_{80}	a_{81}	R	DW
ACc ord.st.	-0.07545	3.4158	0.890	1.55
		(0.6172)		
		0.890		
ACc spec.st.	-0.14957	6.1661	0.838	2.15
		(1.4187)		
		0.838		

In all equations higher R values and more accurate coefficient estimates were obtained for consumption of ordinary steels than for consumption of special steels. However, the latter exhibit a far greater cyclical sensitivity than the former. But the differences in trend are more ambiguous, because estimates of this kind are always uncertain when one is faced with violently fluctuating quantities and a short observation period. The long-term trend implied in equation h is -1.5 per cent p.a. for ordinary steel and -0.5 per cent p.a. for special steels. These figures refer to steel consumption in crude steel weight. Since the yield on certain special steel products has risen appreciably during the observation period, the trend difference in finished steel weight is still more pronounced.

A large proportions of the differences in cyclical sensitivity are probably due to the fact that the inventory ratio (L/C) is greater for special steels than for ordinary steels, which in turn is probably due to inequalities in production flow. A considerable proportion of special steel output, as the name implies, is connected with special steel products which are not produced continuously but are rolled periodically, sometimes at very infrequent intervals. If the consumption is continuous then of course the technically necessary inventories will be relatively higher than in cases where production is continuous. Another contributory cause of the high cyclical sensitivity of special steel consumption is that its distribution between sectors seems more confined to branches of pronounced cyclical sensitivity than is the case with steel consumption as a whole.

Finally it should be noted that apparent consumption of special steels lags behind that of ordinary steels by approximately 1 quarter. One result of this is that the last of the three estimates accounted is comparatively better than the first two.[1]

3.3.5. The dependence of Swedish steel consumption on the international trade cycle. The versions of the global model presented here exhibit a strong relation between steel consumption and total production when the latter is indicated by the index of industrial production. We know from our earlier study of the sectoral distribution of steel consumption that a considerable proportion thereof is exported in the form of engineering products and ships. We also know that the average proportion of exports in other sectors is high. The overwhelming proportion of Swedish exports go to western Europe.

It is reasonable to assume that Swedish exports are dependent on total demand in western Europe, an assumption which we have already verified. Thus an upturn increases the demand for Swedish products and this is soon reflected by realized demand for steel in Sweden, which is also stimulated by the increases in inventory investments that follow in the wake of rising foreign demand. Gradually fixed investments are also induced to rise and this, not least as a result of the increased consumption of structurals, influences total steel consumption.[2]

The question now arises: *can the international aspect of*

[1]) From our excursus, 3.3.3.2., we can draw the conclusion that if special steel consumption is determined by I and ΔI in the way described but if it lags behind those quantities by 1 quarter, then equation *h* should give a good fit.

[2]) The time sequence of the aggregate variables in this description are taken from *A* Short-Term Policy Model for an Open High-Capacity Economy, by Assar Lindbeck and Erik Ruist, Stockholm 1971 (mimeographed).

Swedish steel consumption also be captured in a simple global relation? It follows from the description of the business cycle given above that there ought reasonably to exist a clear relation between total production in western Europe and steel consumption in Sweden. This is also suggested by the fact that many of the independent variables in the equations describing the determination of exports, investments in goods in process etc. should be correlated with indicators of the total economic activity of western Europe, e.g. variables such as planned production and labour shortage.

Let us therefore investigate the occurrence of a relation

$$GNPE \rightarrow I \rightarrow C$$

where *GNPE* denotes gross national product in the European OECD. If we test the most general of the global models used previously, equation *g*, we obtain

$$\Delta \log C = -\ 0.08052 + \underset{(0.8383)}{4.9733}\ \Delta \log GNPE;$$

$$R = 0.892;\ DW = 2.23$$

The remarkable thing here is that the relative change in steel consumption is far more correlated with the relative change in *GNP* for the whole of western Europe than with the *GNP* for Sweden. The estimate refers to the period 1959—69, which gives a correlation between $\Delta \log C$ and $\Delta \log GNP$ (Sweden) of only 0.33. However, the correlation between $\Delta \log C$ and $\Delta \log I$ (Sweden) is c. 0.90. The implied long-term trend in the relation specified above is + 0.2 per cent p.a.

3.4. The global model applied to OECD countries

Table 10 shows the results of the application of equations *a—h* to apparent consumption for different groups of nations and individual countries within the OECD. The observation period comprices the years 1953—69 for the USA and Japan and 1954—69 for other countries except Sweden, where as in the previous observations the period 1955—69 applies. The choice of apparent instead of actual consumption is entirely due to lack of data for the latter quantity in the majority of countries. According to the results previously given for Sweden, the coefficient estimates for *ACc* have much the same properties as for *C*, but if the former is used as an indicator of the latter there is reason to suspect that the cyclical sensitivity is exaggerated.

<u>Table 10</u>

a) $C/GNP = a_{10}+a_{11}\ \Delta GNP/GNP+a_{12}\cdot t$

b) $C/I = a_{20}+a_{21}\ \Delta I/I+a_{22}\cdot t$

Countries or groups of countries	a_{10}	a_{11}	a_{12}	R	DW	a_{20}	a_{21}	a_{22}	R	DW
OECD, Europe	188.87	838.98 (203.61) 0.742	0.6046 (0.4298) 0.256	0.763 (0.993	1.74	-	-	-	-	-
EEC	207.69	667.09 (198.58) 0.691	0.35384 (0.51910) 0.140	0.682 (0.988)	1.59	633.66	628.74 (158.66) 0.553	-3.5905 (0.9297) 0.539	0.877 (0.996)	1.66
Germany	271.60	884.85 (118.90) 0.844	-0.95300 (0.61930) -0.1745	0.927 (0.990)	1.68	305.33	361.91 (81.19) 0.523	-3.6966 (0.6953) -0.623	0.913 (0.987)	2.06
Italy	139.95	506.89 (516.68) 0.141	7.1488 (1.2418) 0.827	0.859 (0.975)	1.14	96.800	130.34 (72.88) 0.372	1.6143 (0.4746) 0.707	0.697 (0.986)	1.33
UK	244.52	534.01 (386.52) 0.319	-1.8278 (1.0038) -0.421	0.574 (0.852)	2.06	215.33	162.40 (122.27) 0.290	-1.7218 (0.7242) -0.520	0.620 (0.902)	1.99
Sweden	214.93	595.89 (330.55) 0.436	1.2290 (1.0167) 0.293	0.578 (0.965)	1.92	42.00	105.01 (19.62) 0.703	-0.5857 (0.0990) -0.777	0.899 (0.987)	1.653
USA	189.07	356.82 (176.33) 0.449	-2.2152 (0.8515) -0.577	0.613 (0.931)	0.93	1220.0	833.38 (396.30) 0.361	-17.829 (4.091) 0.747	0.774 (0.945)	0.91
Japan	165.55	763.12 (342.10) 0.258	12.831 (2.023) 0.790	0.915 (0.990)	2.17	192.29	297.67 (75.97) 0.598	3.2868 (0.8696) 0.577	0.821 (0.994)	2.07

Table 10

c) $\log C = \log GNP - a_{30} + a_{31} + \Delta \log GNP + a_{32} \cdot t$

d) $\log C - \log I = a_{40} + a_{41} \Delta \log I + a_{42} \cdot t$

Countries or groups of countries	a_{30}	a_{31}	a_{32}	R	DW	a_{40}	a_{41}	a_{42}	R	DW
OECD, Europe	2.2856	3.4669	0.0011289	0.767	1.76	-	-	-	-	-
		(0.8295)	(0.0007945)	(0.994						
		0.746	0.254							
EEC	2.32425	2.5773	0.00062	0.680	1.55	2.8024	0.9048	-0.002425	0.874	1.59
		(0.7705)	(0.00092)	(0.991)			(0.23277)	(0.000634)	(0.997)	
		0.689	0.139				0.549	-0.539		
Germany	2.4372	2.7130	-0.00133	0.929	1.922	2.4836	1.1463	-0.0054	0.919	1.888
		(0.3577)	(0.000855)	(0.989			(0.2462)	(0.000974)	(0.988	
		0.847	-1.174				0.527	-0.628		
Italy	2.1732	2.4257	0.01406	0.869	1.211	1.9938	1.0232	0.0059	0.707	1.354
		(2.1297)	(0.00234)	(0.976)			(0.5502)	(0.00168)	(0.996)	
		0.158	0.832				0.379	0.715		
UK	2.3862	2.1434	-0.00316	0.574	1.811	2.3316	0.7793	-0.0036	0.626	1.966
		(1.5140)	(0.001759)	(0.861)			(0.5623)	(0.00150)	(0.928)	
		0.327	-0.416				0.302	-0.517		
Sweden	2.3355	2.3217	0.00219	0.5906	2.063	1.6247	2.3301	-0.00611	0.901	1.706
		(1.2503)	(0.00175)	(0.964)			(0.4354)	(0.00101)	(0.987)	
		0.4443	0.3002				0.6949	-0.7853		
USA	2.2882	0.6963	-0.0045	0.445	1.220	3.0838	0.6747	-0.0067	0.763	0.931
		(0.9788)	(0.00246)	0.937			(0.3447)	(0.00158)	(0.953)	
		0.156	-0.509				0.342	-0.736		
Japan	2.3110	1.6851	0.0179	0.904	1.942	2.2977	1.0523	0.0057	0.842	1.960
		(0.9691)	(0.002739)	(0.987)			(0.2468)	(0.001373)	(0.986)	
		0.214	0.804				0.615	0.598		

<u>Table 10</u>

e) $\log C - \log GNP = a_{50} + a_{51} \Delta \log GNP \cdot \log GNP + a_{52} \cdot t$

f) $\log C - \log I = a_{60} + a_{61} \Delta \log I \cdot \log I + a_{62} \cdot t$

Countries or groups of countries	a_{50}	a_{51}	a_{52}	R	DW	a_{60}	a_{61}	a_{62}	R	DW
OECD, Europe	2.2895	1.3490 (0.3134) 0.755	0.000557 (0.000781) 0.125	0.776 (0.994)	1.77	-	-	-	-	-
EEC	2.3280	1.11154 (0.3193) 0.695	0.00002 (0.00089) 0.065	0.695	1.57	2.8024	0.90479 (0.23327) 0.549	-0.002425 (0.000634) 0.539	0.874	1.59
Germany	2.4452	1.4012 (0.1744) 0.816	-0.00221 (0.000777) -0.288	0.936	2.072	2.4895	0.5722 (0.1216) 0.516	-0.00598 (0.000943) 0.696	0.920	1.971
Italy	2.1810	1.447 (1.286) 0.170	0.0133 (0.00255) 0.785	0.869	1.211	1.9998	0.5198 (0.2790) 0.367	0.00531 (0.00152) 0.645	0.708	1.351
UK	2.3876	1.1212 (0.7874) 0.325	-0.00333 (0.001740) -0.437	0.575	1.808	2.3316	0.7793 (0.5623) 0.302	-0.003557 (0.001496) -0.517	0.626	1.966
Sweden	2.3413	1.8692 (1.0082) 0.4667	0.00165 (0.00184) 0.2257	0.5903	2.026	1.6310	1.1619 (0.2247) 0.7152	-0.00677 (0.00108) -0.8692	0.8958	1.650
USA	2.2883	0.2722 (0.3609) 0.211	-0.00465 (0.002496) -0.521	0.449	1.216	3.0842	0.3543 (0.1800) 0.346	-0.00678 (0.00159) -0.750	0.764	0.951
Japan	2.3265	0.9406 (0.5443) 0.249	0.01628 (0.00322) 0.730	0.903	1.894	2.3124	0.5974 (0.1334) 0.658	0.00359 (0.001399) 0.377	0.852	1.917

<u>Table 10</u>

g) $\Delta \log C = a_{70} + a_{71} \Delta \log GNP$

Countries or groups of countries	a_{70}	a_{71}	R	DW
OECD, Europe	-0.09309	5.7691 (0.9778) 0.844	0.844 (0.982)	2.0753
EEC	-0.07230	4.3430 (0.8450)	0.808 (0.980)	2.20
Germany	-0.05920	3.5182 (0.7152) 0.7959	0.7959 (0.911)	2.1569
Italy	-0.0968	5.7689 (1.9576) 0.6187	0.6187 (0.949)	2.0765
UK	-0.0584	5.6011 (1.7120) 0.6582	0.6582 (0.840)	2.5209
Sweden	-0.0287	2.9318 (1.5234) 0.4709	0.4709 (0.961)	2.4032
USA	-0.0215	2.528 (1.0204) 0.5388	0.5388 (0.930)	2.387
Japan	-0.0472	2.6571 (1.2402) 0.4826	0.4826 (0.961)	2.6645

h) $\Delta \log C = a_{80} + a_{81} \ \Delta \log I$

Countries or groups of countries	a_{80}	a_{81}	R	DW
OECD, Europe	-	-	-	-
EEC	-0.03339	2.1411 (0.2616)	0.909 (0.992)	2.40
Germany	-0.03803	2.1974 (0.4051) 0.8232	0.8232 (0.922)	2.5209
Italy	-0.0525	2.8420 (0.4841) 0.8433	0.8433 (0.951)	2.5122
UK	-0.02771	2.7326 (0.6727) 0.7355	0.7355 (0.858)	2.4454
Sweden	-0.0438	2.7191 (0.7179) 0.7243	0.7243 (0.987)	1.859
USA	-0.0294	2.3272 (0.2793) 0.9048	0.9068 (0.961)	2.5165
Japan	-0.0763	2.3910 (0.3744) 0.8550	0.855 (0.970)	2.7412

The general explanatory value of the models seems on the whole to be good. This applies both to the R values of the hypotheses tested and to the comparable coefficients of correlation implied by the estimates. According to the DW values, the residuals (with a few exceptions) are not correlated, so that there is no reason on this count to suspect any incorrect specification of the relations. Compared with our experience of the study of Swedish data, GNP and its changes over time work surprisingly well as explanatory variables for steel consumption. This is particularly true of the national groupings comprised by the European OECD and the EEC. In these cases the cyclical sensitivity components have been both theoretically and practically relevant. In more than half the cases, however, as with Sweden, the tested relations give higher R values when we substitute the industrial production index for GNP as explanatory variable and if we consider the comparable coefficient of correlation the results obtained are consistently better in the latter case.

The fact that in certain countries variations in steel consumption are better explained by variations in GNP than we found to be the case in Sweden is probably connected with a difference in the composition of steel consumption and with differences in the steel intensity of the building sector. In Sweden the difference between GNP and value added by industrial production consists to a relatively large extent of services which are of negligible importance to steel demand. Thus variations in their contribution to GNP are of little or no importance for the consumption of steel. If they are slightly or negatively correlated with industrial production, the relation between GNP and steel consumption will be less clear than the relation between industrial production and steel consumption. Agriculture plays a far more important part in other countries than it does in Sweden, and since, in the countries we are dealing with here, this sector is of considerable indirect importance for the consumption of steel, variations in the contribution of this sector to GNP will also affect the consumption of steel. Finally it should be pointed out that the share of the building sector in total steel consumption is usually far less in Sweden than in other countries. Consequently we lose important information on these countries if we use the industrial production index as an indicator of total production. The results of the regression analysis suggest however that variations in building production have been better correlated with variations in industrial production than with variations in the production of other sectors, so that the relation $I \to C$ has clearly been closer than the relation $GNP \to C$.

The observations of the long-term relations between total production and steel consumption that can be more or less directly deduced from the coefficient estimates leave a somewhat diffuse impression. Thus according to equation c, total steel intensity, C/GNP, shows a steeply rising trend in Japan and Italy while in Germany, the USA and the U.K. it has declined. According to equation *d*, steel intensity, C/I, has declined in all the countries referred to except Japan and Italy, where it has shown a rising trend of just over 1 per cent p.a. The long-term trends implied in equation *g* and *h* give roughly the same results. Here however we obtain a positive trend for C/GNP in the case of both the USA and the U.K. In the next section we shall endeavour to find explanations for these differences of trend relations.

Equations *a*—*f* are based on the assumption that cyclical changes in total steel intensity are due to an accelerator relation. In the present context this relation applies both to investments in steel inventories by producers, merchants and consumers, i.e. $AC-C$, and to investments in finished goods of high steel content and investments in goods in process. Judging by the results we have succeeded by means of this simple approach in capturing a considerable proportion of the cyclical variations in realized steel demand. It is interesting to note that the models in question give such an accurate description of developments in the whole of the European OECD.

On the other hand it is hard to explain the difference between the coefficients of cyclical sensitivity for different countries. If we consider equation *c*, the range of variation in this coefficient, a_{31}, is (2.71—0.69) while in equation *d* it is (2.33—0.67). In both cases the USA accounts for the lesser value. Now the estimates of this coefficient have probably been disrupted by our use of apparent consumption as an indicator of steel consumption. Since this indicator includes increases in steel inventories, the speculative inventory increases connected with the anticipations of a steel strike which generally accompany the expiry of wage agreements have detrimentally affected the estimates.

The most homogenous values for the coefficient of cyclical sensitivity are to be found in equation *h*. The coefficient a_{81} varies between 2.73 and 2.14. Since however the sensitivity of industrial production to variations in GNP fluctuates considerably, the range of variation for a_{71} is (5.8—2.5). It should be observed however that our method of estimating these coefficients can cause errors of measurement to influence the estimates considerably.

The international material does not bear out the hypothesis that cyclical sensitivity varies with the value of *GNP* or *I*, any more than the Swedish material was found to do so.

According to our basic hypotheses, the cyclical sensitivity of apparent consumption depends on the ratios of L/GNP and L/I respectively, where L denotes steel inventories including steel inventories in goods in process and in finished goods in other sectors than the steel sector. An investigation of the causes of the quantities in these ratios is beyond the scope of this study. In any case, the statistical data on this aspect are somewhat meagre in the majority of countries. One would imagine that a high growth rate, all other things being equal, makes heavier demands on relative inventories than does a low growth rate. We can see that Italy, Western Germany and Japan, all of which have been distinguished by high growth rates of total production, also show high coefficients of cyclic sensitivity and that the U.K., whose economic growth has been relatively low, has low coefficients. But it is hard to find any clear relation between growth rate and cyclical sensitivity in steel consumption.

3.5. Factors behind the long-term changes of total steel intensity

Changes in total steel intensity can be attributed to changes in the steel intensity of individual sectors and/or changes in their shares of total production. If we let *GNP* stand for the latter quantity, total steel intensity can be written

$$A_t = \Sigma a_{jt} \lambda_{jt}$$

where $a_j = C_j/X_j$ and $\lambda_j = X_j/GNP$

If we wish to distinguish the effects of the two groups of components on total steel intensity, our best course is to start from the input coefficients and the sector shares for a particular year. Let these be a_{j0} and λ_{j0}. Then we relate total steel intensity during a year to this base year. Thus we study the ratio

$$A_t/A_0 = \frac{\sum a_{jt} \chi_{jt}}{\sum a_{j0} \chi_{jt}} \cdot \frac{\sum a_{j0} \lambda_{jt}}{\sum a_{j0} \lambda_{j0}}$$

The first of these components will here be termed the *technique component* and the second the *structure component*. Thus the

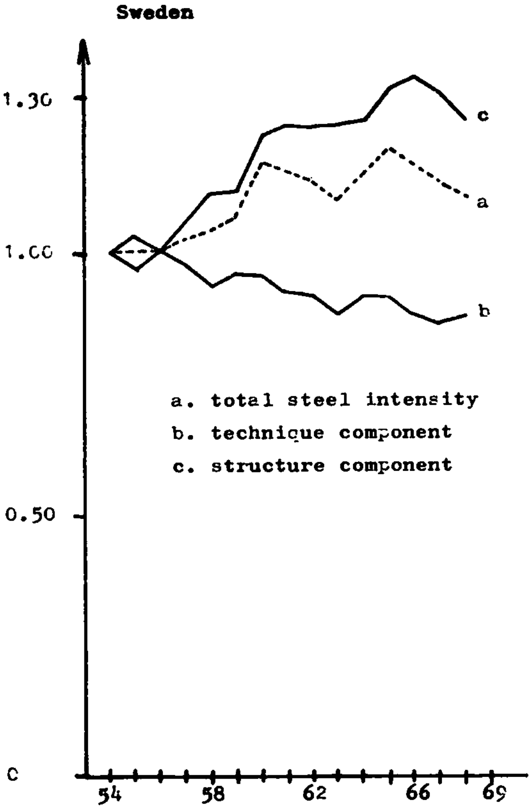

Fig. 13

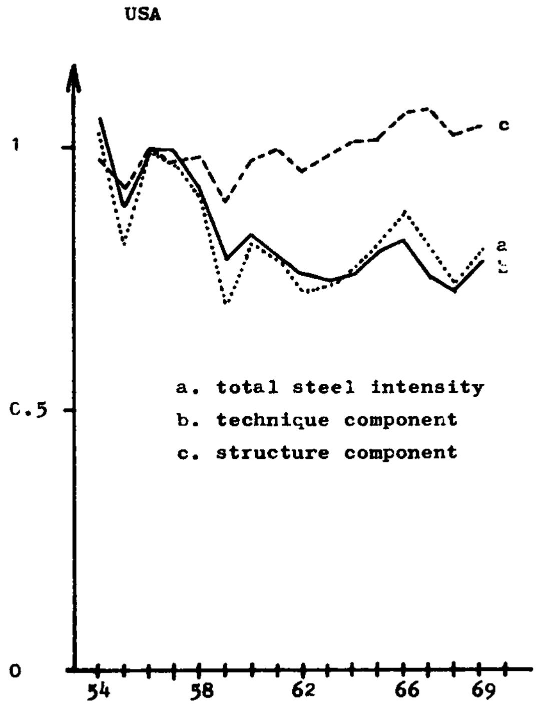

Fig. 14

technique component gives the total effect on steel intensity of changes in the input coefficients of individual sectors, while the structure component describes the development of this quantity at constant input coefficients.

Figures 13 and 14 show total steel intensity and its components for the USA and Sweden during the period 1954—69.[1]) As regards long-term development, we find that in both countries the structure component has had a positive and the technique component a negative effect on the growth of steel intensity. In the case of the USA the total effect has been a reduction in steel intensity. This has been brought about by a steep fall during the second half of the 1950s, which was

[1]) Although sector division in the two countries differs as regards product mix, an intuitive assessment suggests that the degree of aggregation is roughly the same in both cases.

followed by a definite but incomplete recovery during the 1960s. In Sweden, however, steel intensity, as can be seen, rose throughout the entire period. This increase seems however to have ended during the second half of the 1960s. In Sweden the positive trend in the structure component as well as the negative trend in the technique component were much stronger than corresponding trends in the USA. Thus the difference in change in steel market structure as seen from the demand side is probably much bigger than is implied by the mere figures for total steel intensity.

What have been the causes of these changes in technique and structure components? Concerning the former, as has already been indicated, we can only make the general observation that the qualitative properties of steel have improved, that new rival materials have appeared and that the properties of established rival materials have also improved. All of these factors should have reduced steel intensity in terms of kilo per krona output; thus the improved quality of steel is not assumed to have improved its competitive status to such an extent as to counterbalance the decline which this has caused in the input coefficients (in kg.) in traditional sectors of use.

Concerning the structure component, reference has already been made to Maizels' observations regarding the structure of production and stages of development.

Since, in view of Maizels' findings, the growth of the structure component can be expected to slow down when the state of industrial development has attained a certain level and since the possibility of utilizing technical advances e.g. in material techniques should increase with that state of development, we assumed that total steel intensity stagnates and eventually declines with advancing economic development. Let us specify this hypothesis in such a way that

$$A = f(GNP/CAP); f' < 0$$

Here then we are using GNP per capita (GNP/CAP) as a gauge of the state of industrial development. This hypothesis will be tested on cross-section data for the 20 member states of the OECD. The long-term rise in total steel intensity between 1954—69, in the present case ACc/GNP, will for this purpose be regarded as a linear function of GNP/CAP. Deviations from this basic relation will be assumed to be due to the GNP growth rate; the faster the growth rate the greater the increase in the structure component at a given value of GNP/CAP. The result of this experiment is described in the equation[1])

$$x_0 = 1.198 - \underset{(0.594)}{1.530}\, x_1 + \underset{(0.260)}{0.470}\, x_2; \; R = 0.733; \; R^2 = 0.537$$

Denotations:

x_0 estimate of the A trend 1954—69, per cent per annum

x_1 GNP/CAP in 1000 dollars, 1963 prices. Average for the years 1959—63

x_2 GNP trend 1954—69, per cent per annum

More than half the total variance of the A trend in the OECD countries during the period 1954—69 can be attributed to inequalitites in GNP/CAP and in the GNP growth rate. The β coefficients are $-$ 0.49 and 0.35 respectively.

The implications of the regression result can be illustrated by the following specimen calculation: if a country with a per capita income of 2000 dollars in 1963 prices has an annual growth rate of 0 per cent, total steel intensity will decline by 1.9 per cent p.a. An annual GNP growth rate of 3.9 per cent is needed to maintain constant steel intensity. The corresponding growth requirement for a country with a GNP/CAP of 3000 dollars is 7.2 per cent p.a., while for countries with a GNP/CAP $\leqslant$ 780 dollars no economic growth is required from this point of view.

If the linearity of the relation obtained should apply over a long interval, the long-term future prospects for steel producers are bleak. As wealth increases, steel consumption stagnates and eventually declines. But the steel producers can take comfort from the fact that this material offers no grounds for such a gloomy forecast—even though it may seem quite plausible to some of them. Instead we find on closer consideration that steel intensity tends to stagnate at higher levels of GNP/CAP. This is shown by the scatter diagram below. The horizontal axis represents GNP/CAP. The figures on the vertical axis denote the values of the difference ratio $\Delta A/\Delta(GNP/CAP)$.

This analysis, like the regression equation presented above, is based on the assumption that steel intensity ($A = C/GNP$) depends on the state of industrial development (here measured

[1]) The equation can be seen as an extension to 16.a, which now is interpreted as a long-term relation.

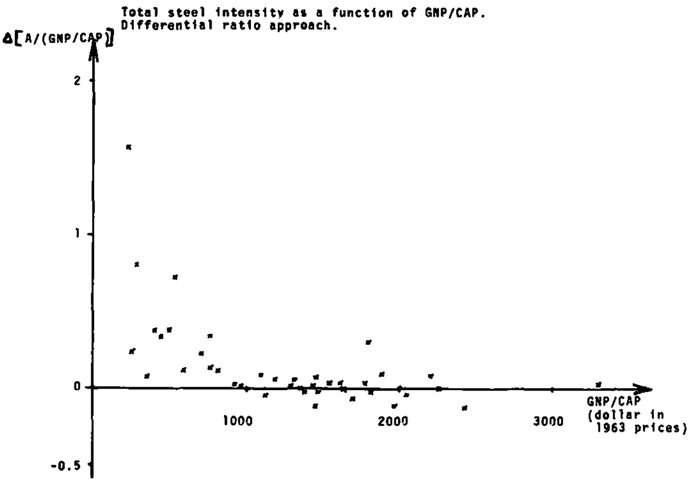

Fig. 15

by *GNP/CAP*). To eliminate the influence of factors which are here assumed to be independent of time and *GNP/CAP* and which lead to differences of level between the steel intensity of different countries, we shall study the derivatives of the function in question. This is approximated here by the corresponding difference ratio.

The observations refer originally to average values of *A* and *GNP/CAP* respectively during the five-year periods 1953—57, 1958—62 and 1963—67. From these figures two difference ratios were then constructed for all countries. These ratios were related to trend values for *GNP/CAP* in 1957 and 1962.

As can be seen from the figure, *A* will stop increasing at rising values of *GNP/CAP* when this ratio attains a level of 1000 dollars. A forecast of steel consumption based on this empirical material (and its presentation) leads to far more favourable results from the point of view of the steel industry. This approach, although presented in a slightly different manner, also formed the basis of the steel consumption forecasts made by a working party from the steel committee of the OECD headed by Professor Ruist.

An interpretation of the function relating the derivative of steel intensity with respect to *GNP/CAP* with the last mentioned variable gives a set of primitive functions which have the shape previously outlined, see section 3.2.1. The integration constant varies however between the different countries as a consequence of their dissimilarities as regards basic economic structure.

An alternative approach to the determination of steel inten-

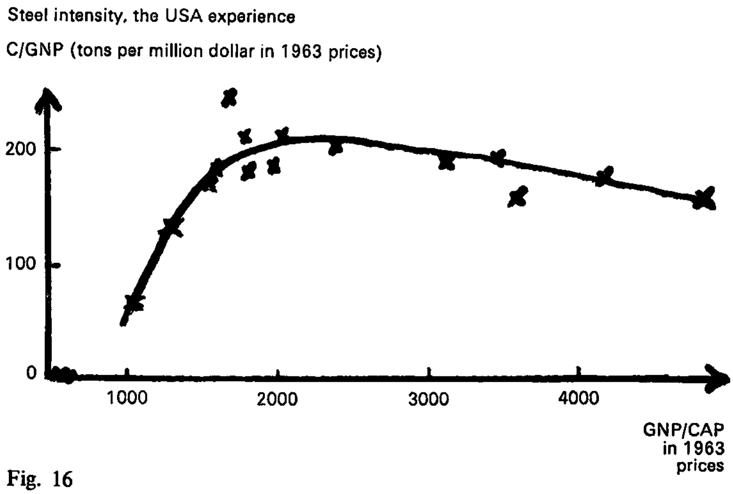

Fig. 16

sity as a function of the state of industrial development is to make a time series analysis corresponding to the performed cross-section study for a specific region. To do this we need data covering a very long period of time for a country the development of which has passed relevant stages. One of the few countries which can supply such data is U.S.A. In the figure given below we have plotted five years averages of steel intensities against corresponding values for *GNP/CAP*, the period of analysis being extended from 1895 to 1965.[1]) The free hand curve drawn between those points is no doubt of the same general shape as that derived from our cross section analysis. Our basic hypothesis is thus supported by two different kinds of tests.[2])

[1]) The averages are centered. Thus the five year average dated 1900 comprises the years 1898—1902.

[2]) In "A Theory of steel consumption" the following estimate of the total steel intensity is presented:

$$A = 3.8\dot{x} + [224x_1 + 199x_2 + 159x_3 + 89x_4]e^{-0.004\cdot t}$$

Denotations:

$\dot{x}$ long-term growth rate of *GNP*

$x_1 = 1$ if $GNP/CAP \geqslant 1000$ dollars
$x_2 = 1$ if $700 \leqslant GNP/CAP < 1000$ dollars
$x_3 = 1$ if $400 \leqslant GNP/CAP < 700$ dollars
$x_4 = 1$ if $GNP/CAP < 400$ dollars
$x_i = 1$ if all $x_j = 0$; $j = 1, 2, 3, 4$; $j \neq i$

$e^{-0.004\cdot t}$ is yearly downwards shift in the A-GNP/CAP-curve.

4. Some aspects of the price sensitivity of steel consumption

In the statistical studies of the determination of steel consumption that have been presented so far, no account has been taken of the price of steel and the prices of rival products. This was because we were primarily interested in short-term or cyclical fluctuations and because it seemed unlikely a priori that fluctuations in the price of steel could affect steel consumption in the short run. Since the differences between observed values for steel consumption and those implied by the various estimates are neither particularly large nor conspicuously systematic, one might think that there is little left of the variations in consumption for prices and any other factors to explain.

However we cannot tell without closer investigation whether the variables used have been correlated e.g. with the price of steel and have so come to "explain" part of the variations in consumption due to price changes. This is above all the case with the trend factor which occurs, explicitly or implicitly, in the regression equations presented. These circumstances are reason enough for considering the possible influence of price on steel consumption and purchases of steel, a part from which it is hard for an economist summarly to dismiss price as an unimportant variable in the analysis of changes in demand.

Before we set about trying to measure price effects we should first try to ascertain how prices can influence steel consumption. The insight this affords will help us with our methods of measurement and with our assessment and interpretation of our own results and those of others.

4.1. Price effects in static theory and in economic dynamics

With rising steel prices two changes will occur, ceteris paribus. Steel will become dearer in relation to rival materials and the costs of steel-consuming enterprises will be increased. Both kinds of change can affect the size of steel consumption.[1])

In section 1.2.1. we discussed certain aspects of the problem of price sensitivity in *static* terms, our purpose being to justify the use of the input-output model, which assumes fixed factor proportions. Let us for the sake of simplicity consider a case in which the quantity produced of a particular good (q) is a function of the quantity of capital and labour used and of the input of steel and aluminium. If the prices of the two raw materials are represented by r_1 and r_2, we obtain the following equation for input of steel (C)—se page 29.

$$C = f(r_1, r_2, q)$$

According to these assumptions the effect of a rise in the price of steel will be

$$dC = [\underbrace{\partial C/\partial r_1}_{\text{direct}} + \underbrace{(\partial C/\partial q)\,(\partial q/\partial r_1)}_{\text{indirect}}]\, dr_1$$

Here we can distinguish a direct and an indirect effect. The direct effect, $\partial C/\partial r_1$ is usually termed the substitution effect. The indirect effect will here be termed the breakthrough effect.

4.1.1. The substitution effect. In the short run, i.e. in a period of time sufficiently short to prevent the firm from varying the quantities of its buildings, equipments etc., we assumed earlier on that the possibilities of steel-consuming enterprises altering their factor combinations as regards raw materials and intermediate goods were very small or non-existent, for in order to change these factor combinations firms would be forced to change their equipment, i.e. the factor combination of capital inputs. In the long run, i.e. when the firm can chose between *known* techniques of production, substitution cannot of course be excluded. This relation can be illustrated by the following charts

[1]) A rise in the price of steel makes it more expensive to maintain inventtories of steel. This effect of rising costs on the demand for steel will not be studied in this section. It is dealt with fairly exhaustively however in Part III.

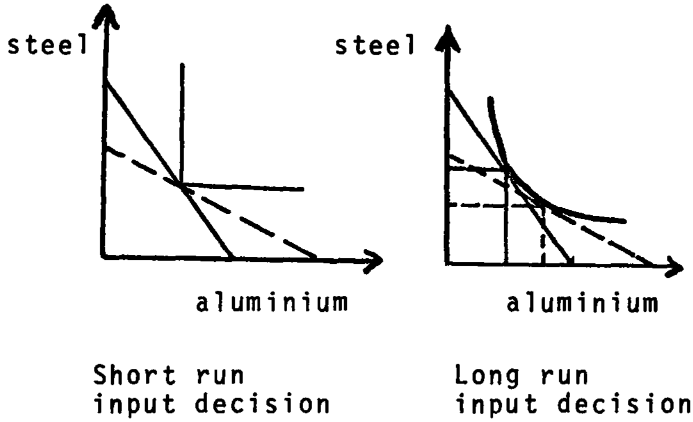

Fig. 17

These charts describe the effect of a change in prices on the input combination in two decision situations: the short run input decision and the long run input decision. In the former case the price relation (r_1/r_2) does not affect the input combination; the isoquant is L-shaped. In the latter case on the other hand the price relations influence the choice of input combination. A rise in the price of steel (represented here by a twist in the isocost from the smooth to the broken line) creates, at a given value of q, a reduction of steel input and a rise in aluminium input.[1])

If we introduce time into the picture and view the substitution problem in a dynamic perspective, two main problems arise.

- How long does adjustment to the new equilibrium created by a price change take?
- What price changes do firms consider relevant to long-term decisions?

When a price relation change occurs which is considered permanent and is so large that the cost of producing a given quantity of a good declines, i.e. after any other extra costs for other factors of production caused by a change in the raw material factor combination, the minimum adjustment

[1]) An isocost represents here the locus of combinations of steel and aluminium which results in a given total outlay for those outputs, while the points on a given isoquant represent factor combinations resulting in a certain level of production.

period is equal to the time needed to effect the requisite investments. As a rule the actual period will be longer owing to lags in decision making, imperfections in credit markets etc.

But all price changes cannot be expected to influence long-term decisions. In commodity markets of normal cyclical sensitivity, the consumers probably do not react in their choice of techniques to short-term price movements—even though the investment cycles in many branches betray a certain short-sightedness in the long-term planning of firms. We shall assume here that the price anticipations of firms, $(r_1/r_2)^*/(r_1/r_2)$, are determined by price developments over a longer period of time, which can be expressed[1])

$$(r_1/r_2)^* = \int_0^n g(\tau)\,(r_1/r_2)_{t-\tau}\,d\tau$$

We shall assume that the extent of the integration limit depends on the duration of the average cycle for the relative price of steel.

However the dynamic analysis need not be confined to a consideration of adjustment to static equilibrium and the formation of expectations. It must also illustrate the processes giving rise to changes in production techniques and product design. Here we are interested in changes affecting steel intensity in different sectors. Without venturing any further into the domains of the dynamic theory of the firm, we shall postulate here that firms concentrate their rationalization, invention and innovation on the sectors where the anticipated yield is greatest. It therefore seems reasonable to assume that factors of production which account for a relatively large proportion of the costs of production will also be the subject to a relatively large proportion of rationalization activities. The higher the price of steel in relation to other factors of production, the more reason for steel consumers to try to bring down their steel input. This may be done e.g. by reducing the wastes, by making the products easier (tensile strength requirements may be unnecessarily high, and so on) or by trying to use other materials. High steel prices will probably also encourage manufacturers of aluminium and other rival materials to see their own product development in a more profitable light.

Summing up we can say that a long-term rise in the relative price of steel should have a negative influence on consumption in terms both of substitution effects using given techniques and of potential substitution possibilities. The magnitude of

[1]) Cf. p. 52.

these effects will of course depend on the actual and potential opportunities for substitution.

$(\partial C/\partial q)\,(\partial q/\partial r_1)\,dr_1$

4.1.2. The breakthrough effect. In accordance with our previous argument, the breakthrough effect of the price of steel is taken to mean its effect on consumption via the size of the consumers' output. The relation between steel prices and production goes in turn via costs or via costs and prices. This will be illustrated in a number of examples, all of which will assume that steel input is proportional to output, which at given steel prices implies constant marginal steel costs. The exposition will be simplified without further loss of generality if steel input per unit of output is assumed to be equal to one.

A firm in perfect competition, which by definition is a price-taker, will reduce its output if there is a rise in the price of steel. The scale of this reduction will depend on the magnitude of the price rise and on the slope of the marginal cost curve. If this curve is linear, i.e. $mc = a_0 + a_1 q$, then a price rise of dr_1 will cause a parallel shift in the mc curve leading to a reduction in output of $-dr_1\,(1/a_1)$. The smaller the slope, the greater will be the effect of the price rise on production and steel consumption. This example is illustrated in the accompanying figure.

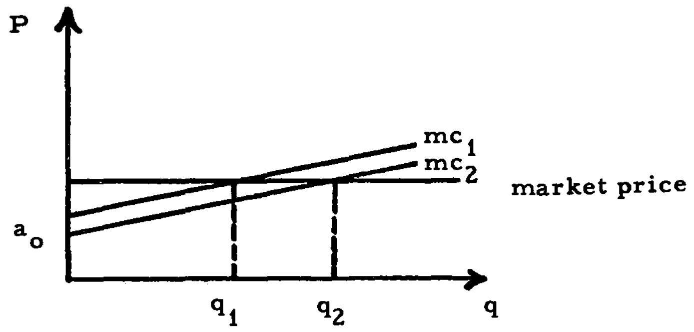

Fig. 18

In a perfectly competitive market the rise in costs will by definition affect all firms. The shift in the supply curve of the market in which this results will however lead to an increase in the equilibrium price of the end product, so that the fall in production will be less than $(q_1 - q_2)$.[1]

Let both the demand and the supply curves be linear. We then obtain the following market system:

[1] We shall confine ourselves to normal conditions, i.e. falling demand and rising supply curves.

supply relation	$q^s = A_0 + A_1 p$	$A_0 \leqslant 0;\ A_1 > 0$
demand relation	$q^d = B_0 + B_1 p$	$B_0 > 0;\ B_1 < 0$
equilibrium condition	$q^s = q^d = q$	
If we solve for q we obtain	$q = \dfrac{A_1 B_0 - B_1 A_0}{A_1 - B_1}$	

A rise of dr_1 in the price of steel will now lead to a reduction of the constant term by $dr_1 \cdot A_1$, so that the change in production will be $dr_1 \cdot A_1 \cdot B_1/(A_1 - B_1)$ which can also be written

$$dr_1 \cdot A_1 \, (A_1/B_1 - 1)$$

Thus the production and steel consumption effect of the price of steel increase with the ratio B_1/A_1. We can also say that the larger the price elasticity of demand in relation to that of supply at equilibrium, the greater the impact effect of a rise in the price of steel will be.

The price elasticity of steel consumption $[(dq/dr_1)\,(r_1/q)]$ depends on—if we are content to consider the breakthrough effect—

- the proportion of steel costs to total costs (price and quantity—determining)
- the extent to which rising costs are allowed to affect prices
- the price elasticity of demand for the product in question.

The first and last of these factors are measurable. The second factor, as we have already seen to a certain extent, depends on the market situation. In the above case it is measurable if we kow the supply and demand curves. In oligopolistic markets, assumptions of profit maximization do not lead to unequivocal principles of pricing, and in practice these principles are found to vary from one case to another.

If we assume that rising costs are completely absorbed by product prices and that firms adjust their production to the output arising at this price, then the price elasticity of steel consumption with regard to the breakthrough effect can be calculated as the product of the share of steel costs and the price elasticity of the commodity group in question. Let the two latter quantities be v and u respectively. The steel price elasticity of steel consumption is by definition equal to the elasticity of production with regard to the price of steel (η). Thus we have

$$\eta = (dq/q)/(dr_1/r_1)$$

Now $u = (dq/q)/(dp/p)$ and $dp/p = v \cdot dr_1/r_1$, so that

$$\eta = v \cdot u$$

The assumption that rising costs are entirely absorbed by prices is consistent with mark-up pricing, where price is a constant multiple of variable costs. For a firm with fixed factor proportions and with a constant elastic demand (where $u < -1$) this is in fact the pricing rule that gives the maximum profit.[1] As the previous examples have shown, rising costs will not lead to equal rises in price in markets characterized by pure competition monopoly or monopolistic competition. Nor is this likely to be the case if we also take into account the shift in the demand curves that can occur via income formation. By studying the share of steel in total costs and the price elasticity of steel-consuming products we can however arrive at an estimate of an upper limit for the breakthrough effect.

So much for the statical analysis. Here too however we are interested in certain dynamic effects. How long does it take steel consumers to adjust the prices of certain products after steel prices have changed? How long does it take for consumers of these products to react to price changes? These two types of adjustment processes, the price and demand adjustment processes respectively, determine the lag between changes in the price of steel and the change in steel consumption in which those changes result. Here too, however, steel consumers are unlikely to react very noticeably to price changes which they suppose to be of a short-term variety. Here as with substitution effects, the breakthrough effect is probably greater in the long run than in the short run.

4.2. Attempts to quantify the price sensitivity of steel consumption

4.2.1. **Substitution effect and technology.** In many sectors of use steel competes with other materials. The most important of these materials are non-ferrous metals, especially aluminium and plastics, but even such materials as asbestos-cement, timber and glass compete with steel to a certain extent in the packaging and construction sectors. In an informative UN

[1]) In this case the share of marginal steel costs in the marginal cost, which is independent of q, is the same as the share of total steel costs in total costs, i.e. v. If the price of steel is increased by x per cent, the marginal cost will rise by $v \cdot x$ per cent. The marginal revenue (mr) will also rise by the same amount. According to the so-called Amoroso-Robinson formula $mr = p\,(1 + 1/u)$. If mr is increased by z per cent this implies a corresponding increase in p, u being by definition constant.

study published in 1966[1]), statistical material has been compiled on the basis of data from several countries to illustrate the actual and potential replacement of steel use by other materials in a hypothetical "typical industrial economy" with "highly developed motor vehicle, engineering and shipbuilding industries".

According to this study the quantity of steel actually replaced by other materials amounted to c. 5 per cent of average steel consumption during the period 1960—64. Potential replacement using techniques known at the time is put at 7.5 per cent of steel consumption. Despite the comparative vagueness of these estimates and their premises, the study shows quite clearly that, historically speaking, substitution between steel and other materials has only been capable of affecting a small proportion of steel use. Thus the possibilities of substitution have for technological reasons been small. But we can also observe that technology has changed very fast, not least in the plastics sector. In certain quarters, e.g. packaging, this has led to a considerable rise in the capacity of plastics to replace steel.

Per capita consumption of steel, plastics and aluminium Sweden

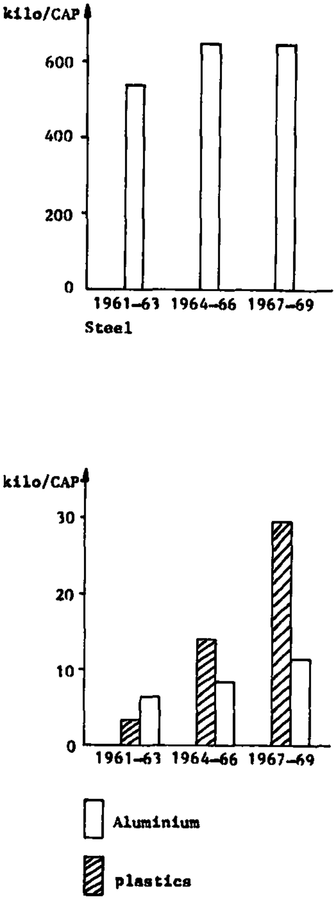

Fig. 19a

The accompanying diagram shows that both aluminium and—above all—plastic consumption have grown far more rapidly than steel consumption in both the USA and Sweden. According to the UN study approximately half the consumption of aluminium and only about 7 per cent of the consumption of plastics during the first half of the 1960s concerned sectors where steel is used or has been used previously. Plastics and aluminium have, however, advanced very rapidly, even if their advance has so far been limited to what from the point of view of the steel industry are marginal sectors. The declining trend we observed for steel intensity in the industrial production of the USA and western Europe during the fifties and sixties is therefore probably due to no small extent to the intrusion of aluminium and plastics into the tradional domains of steel and their containment of steel in the output of new products.

What then has been the part played by the development of steel, metal and plastic prices in the development of steel intensity? Or to put the question in a more futuristic light: what is the sensitivity of steel consumption to variations in these prices? In order more or less to isolate the substitution effect, we are best advised to start with production weighted in terms

[1]) Aspects of Competition between Steel and Other Materials, United Nations, New York 1966.

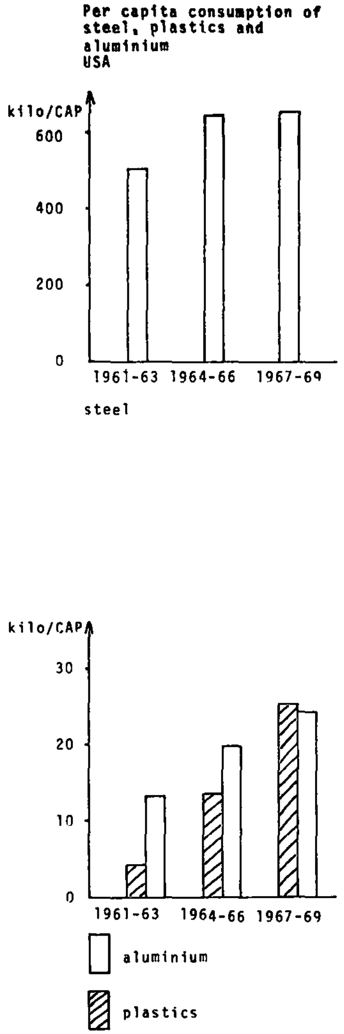

Fig. 19b

of steel intensity, i.e. $\Sigma a_j X_j$. Let us see how fluctuations in the ratio $C/\Sigma a_j X_j$ in Sweden are explained by variations in the price of steel (r_1) in relation to the prices of aluminium and plastic (r_2). We shall content ourselves with testing a constant elastic relation:

$$C/\Sigma a_j X_j = a_0 (r_1/r_2)^{a_1} \cdot e^{\epsilon_t}$$

ϵ_t is a stochastic variable with an average value of zero.

This relation has been applied to data for the period 1955–69. For this purpose the prices of steel and metals have been measured at two stages, the finished stage at steelworks and metal works and at the manufacturing stage. This is justified by the fact that the relevant differences in the costs of different materials, seen from the point of view of the consumer of those materials, is not confined to purchasing prices but also involves the processing costs to which the materials in question give rise. The price index used for plastic products is the only one avaible and refers primarily to semi-manufactured products.

Steel prices (as well as the prices of non-ferrous metals) may be said to be exogenously determined in the Swedish market.[1]) This means that the traditional problems of identification connected with a direct estimate of demand equations (or of other relations picked out from a simultaneous system) do not arise.

The results are given in table 11, which shows that the steel price index divided by the price index for plastic and non-ferrous metals is negatively correlated with steel intensity. The significance of the price correlation is greater when the price of plastic is the sole measure of the prices of rival materials.

Table 11

r_1/r_2	Price elasticity		R	DW
PSM/PCM	-0.554	(0.090)	0.872	0.97
-"- , m.a.	-0.531	(0.080)	0.886	0.87
PSM/PPL	-0.326	(0.036)	0.932	1.44
-"- , m.a.	-0.349	(0.035)	0.945	1.42

note:

PSM Price index for manufacturers of steel
PCM Price index for "competing materials"; the geometrical mean of price indices for plastics and metals respectively
PPL Price index for plastics
m.a. 4 years' moving average

[1]) See Part IV.

Since during the period in question the prices of plastics underwent a fairly steady decline, there is reason to suspect that the variable in question occurs as a trend factor and consequently absorbs the effect of improved steel qualities and other long-term factors referred to previously. But this also reflects the fact that changes in the prices of steel and non-ferrous metals have been well-correlated, which in turn is due to the fact that steel and metal are not only substitutes but—to a greater extent, if anything—complementary goods as well. Consequently we have few or no relevant observations of variations in the ratio price of steel/price of aluminium.

It makes little difference to the coefficient estimates whether we use smoothed price series or directly observed ones. The occurrence of autocorrelation e.g. in r_2 also causes the coefficient of this quantity to absorb parts of the effect of $r_{2,t-1}$, $r_{2,t-2}$ etc.

It may be interesting to compare these results with Anne P. Carter's observations in a study of input-output tables for the USA with reference to 1947 and 1958.[1]) Comparing direct plus indirect requirements in the 1947 input-output tables and those in the 1958 input-output tables, she finds that the rise in the total input coefficients for new products such as plastics and synthetics is "relatively small in dollar volume" but adds: "It is probably also true, however, that the revolutionary new substitutions replace old inputs with new ones of much smaller value. Despite these qualifications, one is impressed by the fact that the decline in steel requirements between 1947 and 1958 is at least six times as great as the rise in basic plastics and synthetics, and that the growth of aluminium does not begin to dominate the declining nonferrous metals sector until 1958."

Her observations suggest that declining share of steel in total production costs is total production costs is due more to circumstances such as changes in steel itself rather than to its replacement by other metals.

4.2.2. An estimate of steel cost shares. According to our previous argument, the indirect effect of a change in the price of steel on the consumption of steel operates via demand for and output of goods in which steel is incorporated as a raw material. If changes in the price of steel affect the prices of these products, demand for the latter will change to the extent determined by their price elasticities. If we know the share of steel costs in total costs and the price elasticities of the final products then, provided that changes in costs are entirely transmitted to the

[1]) Changes in the Structure of the American Economy, 1947 to 1958 and 1962, the Review of Economics and Statistics, Vol. XLIX, May 1967, pp. 209—224.

price, we can gauge an upper limit for the breakthrough effect.

But the question is how to calculate steel cost shares. One way of course is to collect empirical material by studying the cost accounts of individual firms or cost surveys for the branch, but for our purposes this procedure would be unduly expensive and still not altogether satisfactory, for we are interested in the *total* effect of an increase in the price of steel. Thus we are interested not merely in the direct but also in the indirect steel costs of different groups of products. Once again we can resort to the input-output table. The total input coefficients, i.e. the elements in the inverted matrix, provide the very data we need.

These values are given in table 13 with allowance made for imports of steel for the larger of the matrices used, *M* 45. It will be observed that the dispersion is considerable. But it is also obvious that even products with a relatively large proportion of steel costs need to have a very price-sensitive demand for the breakthrough effect on the steel demand of corresponding sectors to be of any real importance. Thus demand for ships needs to have a price elasticity of – 3.8 in order for steel demand from the shipyards to be normal elastic, i.e. to have a price elasticity of – 1, in the event of changes in the price of steel being fully transmitted to shipping prices. This requirement of price sensitivity becomes still greater if we consider an average for all sectors weighted with proportion of total steel consumption. In this context we are interested in the expression[1])

$$\eta = (1/C)\sum_j \alpha_{sj}{}^2 \cdot y_j \cdot u_j \quad j \neq s$$

Denotations:

η the price elasticity of steel consumption as determined by the breakthrough effect

α_{sj} total input of steel for output of one product unit in sector j (steel cost share)

y_j deliveries to final demand from sector j

[1]) By definition

$$C = \alpha_{s1}y_1 + \alpha_{s2}y_2 + \ldots +_{sn}y_n = \Sigma_j \alpha_{sj}y_j;\ s \neq j.$$

The part of total steel consumption accounted for by the final demand of sector j is $(1/C)\alpha_{sj}y_j$. According to our previous argument the price elasticity of demand for steel in sector j is $\alpha_{sj} \cdot u$. If this is weighted with the share of the deliveries to final demand of the sector in total steel consumption, we obtain

$$(1/C)\,\alpha_{sj}{}^2 \cdot y_j \cdot u_j$$

Table 12

The relative importance of steel costs

s	%	s	%	s	%	s	%	s	%
1	2.4	12	9.4	22	16.8	32	12.5	42	0.5
3	5.1	13	18.1	23	34.7	33	4.8	43	0.8
4	20.5	14	9.8	24	8.3	34	12.7	44	5.1
5	42.2	15	16.9	25	9.8	35	6.1	45	0.7
6	11.8	16	31.8	26	11.0	36	11.3		
7	20.2	17	7.3	27	18.0	37	7.0		
8	53.7	18	25.5	28	13.9	38	2.1		
9	5.9	19	11.8	29	27.1	39	1.4		
10	44.6	20	20.5	30	45.2	40	0.9		
11	21.5	21	15.7	31	26.6	41	0.6		

s sector in M 45

u_j price elasticity of demand for the products of sector j

s steel sector (in the input-output tables given in this study, $s = 2$, see page 370)

Assume for the time being that $u_j = 1$ for all j. η is then the weighted steel cost, the weights being the sectors' shares of total steel consumption. If we go by *M* 45, this steel cost share is 16.5 %. This figure would appear to be very high by international standards.[1]) A corresponding calculation from the input-output study for the USA referring to 1958 gives a value of 9.8 %.[2]) In Sweden a weighted average of -6 is

[1]) The main reason for the high average share of steel costs in Sweden is probably to be found in the unusually large share of shipyards in total consumption.

[2]) As an alternative to this average one can calculate the average direct input of steel per unit of output weighted with share of total steel consumption, i.e. $(1/C) \cdot \Sigma_j a_j{}^2 X_j$. According to M 45 this amounts to 22 %, while an application of the same formula to the 1958 input-output tables for the USA gives a direct steel cost share of 9.2 %. The fact that in the case of Sweeden this share is far higher than the average figures calculated from final demand while in the USA it is somewhat lower than this average is not necessarily connected with structural differences between these economies, for the differences in question are almost exclusively concerned with differences of aggregation level and sector division. The Swedish matrix includes many sectors which are relatively large consumers of steel and show high direct input coefficients but which deliver little to final demand. In the American matrix these are incorporated in the sectors supplying final demand. The effect of the

required for u_j in order to obatin a value for $\eta = -1$, while the corresponding requirement in the USA is -10.

These values then refer to the input-output tables for 1957 and 1958 respectively. For Sweden at least the input-output table exaggerates steel cost shares today. We have already observed that average steel intensity in tons fell by 1.8 per cent annually during the years following 1957. What is still more important however is that steel prices in Sweden were exceptionally high in 1957 owing to the current boom. Subsequently steel prices fell for eleven years, except for the boom years 1960 and 1964, at the same time as other prices rose on average. We can see the influence of price trends on the development of steel costs if we study the development of the ratio between the steel price index and a weighted index for finished products. The accompanying figure shows that the share of steel prices in the price of engineering products fell by almost 33 per cent during the period 1957—68.[1]) The unexpectedly steep rise in prices in 1969—70 raised these price ratios again, however, though in 1970 they were still 18 and 29 per cent below the 1957 level respectively.

The shares of steel costs has declined far less in the USA than in Sweden, judging by the corresponding indicators. Weighted steel intensity in tons was not much lower in 1969 than it had been in 1958. Besides, steel prices in the USA have risen at a rate insignificantly less than the price index for all industrial products.[2])

4.2.3. The effect of steel prices on the prices of engineering products. In terms of the size of steel cost shares, then, the breakthrough effect, or the indirect price effect, cannot have been very considerable.

[1]) Probably these curves exaggerate the decrease in steel cost shares. The price series for steel included in these ratios are based on wholesale price quotations. Since these fluctuate more violently than the actual prices paid by the consumers, they give an exaggerated idea of the difference between steel cost shares at the peak of the steel price cycle, in 1957, and its low in 1968.

[2]) According to the input-output tables for 1954 and 1962 constructed by Deutsche Institut für Wirtshaftsforschung in Berlin, long-term steel cost shares in Western Germany have also apparently been more stable than in Sweden.

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aggregation is shown by the fact that the average share of direct costs $(1/C\ \Sigma a_j{}^2 X_j)$ according to M 15 is only 13.5 %. For these reasons of aggregation the comparison between the pictures given by the Swedish and American input-output tables of steel cost shares at the final demand stage is more relevant than the alternative described in this note.

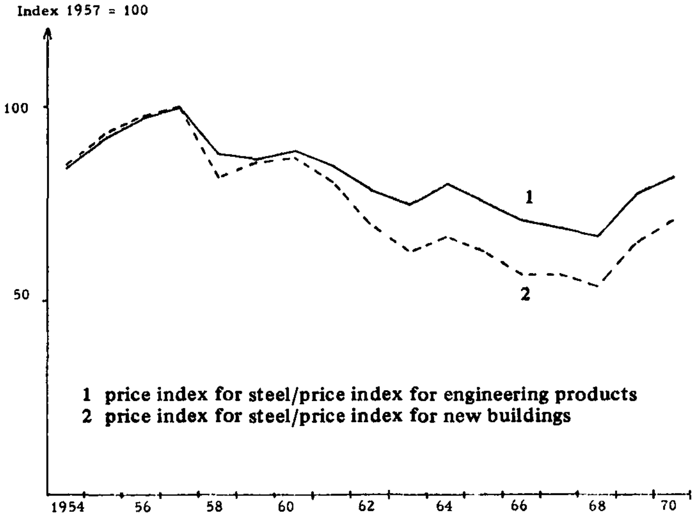


Fig. 20

It may nonetheless be of interest to consider somewhat the question of the effect of steel prices on the prices of engineering products. Let us assume that the influence on these prices of other costs besides steel costs can be described by a trend factor and by a stochastic variable with a mean value of zero. Thus we consider the general relation

$$p = f(r_1, t, \epsilon)$$

where p is the price index for engineering products, r_1 the price of steel, t time $(1, 2 \ldots T)$ and ϵ the above-mentioned stochastic variable.

The table 13 shows the coefficient estimates from an arithmetically and a logarithmically linear version of this relation. It will be seen from this table that the estimates agree well with the cost shares given in the input-output tables, which in turn supports the hypothesis of the impact of rises in steel prices on the prices of engineering products.[1]) It is also worth noting as regards manufactures of steel and the average for engineering products that adjustment to increased steel prices is a fairly rapid process, since the introduction of a one-year lag does not improve the result. If on the other hand we consider certain finished products such as the machinery group, which on average has a fairly long production time and in which the period between contract and delivery sometimes exceeds one year, we obtain the result

$$\Delta PM = 2.609 + \underset{(0.04764)}{0.09583}\, \Delta PS_{-1}; \; R = 0.501; \; DW = 2.36$$

[1]) Mark up pricing would appear to have been the dominant pricing rule in the Swedish engineering industry, at least during the greater part of the period in question. From this point of view, therefore, the result is not unexpected.

Table 13

Dependent variable	ΔPS	$\Delta^e \log PS$	Constant	R	DW
ΔPSM	0.345 (0.052)		3.48	0.888	2.06
$\Delta^e \log PSM$		0.279 (0.043)	0.027	0.883	2.16
ΔPEP	0.122 (0.034)		2.80	0.722	1.49
$\Delta^e \log PEP$		0.108 0.033	0.022	0.689	1.52

note:

PS Price index for steels
PSM Price index for manufactures of steel
PEP Price index for engineering products

Here then we have a lag of one year between a change in the price of steel and changes in the machinery price index (*PM*). Although the coefficient estimate agrees well with the values given in the input-output tables we find that the total fit and the precision in the coefficient estimates are distinctly lower than the estimates given in the table.

4.2.4. What are the relevant price elasticities? If increases in the price of steel are fully transmitted to prices in the steel consuming sectors, the resultant changes in the demand for steel are by definition determined by the share of steel costs and the price elasticity of demand for the products in question. Earlier a simple formula was presented for calculating the breakthrough effect. But the simplicity of this formula is spurious, for the price elasticities, u_j, are quantities of unknown values. The demand studies on cars, refrigerators and other products of interest in this connection in which particular attention has been paid to price effects are partial almost without exception, in the sense that the demand function—sometimes the demand and supply functions as well have been estimated on the assumption that they are separable or segmentable, i.e. distinguishable from the network of relations that characterizes a modern economy.

In this context knowledge of price elasticities thus calculated, at least in a closed economy, is of very little use. Increases in the price of steel affect all steel consumers and not merely certain individual sectors. If the consumers in turn increase their prices to the same extent then admittedly this will primarily lead to a shift in relative prices which is entirely dependent on steel cost shares, but if this in turn reduces the demand for the products in question, then changes of income may reduce the demand for non-steelconsuming products, with the result that relative prices may revert almost entirely to their original level. But of course shifts in the raw material price structure can in the long run lead to a shift in the product content of final demand in favour of products based on cheap raw materials.

Once again we are obliged to work with total models. It is small comfort to know that the econometric macro models at present available can do little to help us quantify the breakthrough effects of rises in the price of steel. Naturally the total incidence of rises in steel prices, i.e. when allowance is also made for the effects of wage demands in the steel industry and their spread to other sectors, is still more difficult to assess. In the USA the steel industry has been ascribed a key position in this context within the economy, which from time to time has prompted some rather drastic presidential interventions.

In Sweden, which is an open economy with a considerable foreign trade, the problem of price elasticity differs from that of a closed economy. The price of steel in Sweden can deviate considerably from steel prices in other countries. Since the Swedish engineering industry is faced with competition from foreign firms both at home and on its export markets, changes in the relation between Swedish and foreign steel prices can influence its competitiveness and indirectly also steel demand in Sweden. Thus the relevant price elasticity in this connection is not that regarding the demand for engineering products in general but that regarding the demand for *Swedish* engineering products. Elasticities of the latter kind (at least as regards price rises) are probably far higher than those of the former kind.[1]) The effect of the price of steel can be considerably greater than has previously been indicated, especially where competition operates within narrow price margins.

An example of such a price effect is given in an article in Jernkontorets Annaler.[2]) The object of this study is the share of Swedish exports of machinery in the British market *(ma-*

[1]) The main problem here is how changes in the prices of Swedish products relative to the price of rival foreign products alter the market shares of Swedish firms. In many engineering markets it is apparently easier for a firm to lose ground through a price rise than to gain ground by a price reduction.

[2]) L. Vinell, The Post-War Swedish Steel Market, with Special Regard to Variations in Demand, Jernkontorets Annaler, vol. 152, 1968. See especially p. 319.

chinery exports to Great Britain from Sweden/total machinery investments in Great Britain). This share is regarded in the article as a function of the relation between wage costs per unit of output in the two countries and of the relation between their steel prices.

Since the price of steel in Great Britain has been "administered" it has taken a different course of development from that of the price of steel in Sweden both in the short run and in the long run.[1]) This means that there are clear observations of variations in the ratio between steel prices in Sweden and steel prices in Great Britain. When a logarithmically linear function is applied to annual data for the period 1955—66, a price elasticity of — 0.53 (0.21) is obtained. The absolute value of this price elasticity is approximately five times the average steel cost share in the machinery sector during the same period.

4.2.5. The global relations completed with price variables. Earlier we studied the way in which steel consumption changed with *GNP* and industrial production. In doing so we used a trend factor to describe the long-term relation. Let us instead assume that the long-term deviation between steel consumption and industrial production is referable to changes in price relations between steel and its rivals in the materials sector. Relative prices are assumed not only to lead to substitution at given techniques but also to influence the product mix as a whole. If then the price of steel rises in relation to other materials, then according to hypotheses discussed previously both the substitution effect and more typically dynamic effects will lead to a reduction of the "steel content" of *GNP* or industrial production.

From *one* point of view Sweden is a suitable object of analysis regarding the effect of price variations on demand in the steel sector, for as we have already seen steel prices can to a great extent be regarded as exogenously determined. Consequently none of the usual problems of identification should arise. Since however Sweden is an exporting country and steel-consuming industries predominate among its exporters, steel intensity in Swedish industry has come to co-vary with business cycles in western Europe and, consequently, with the world market prices of steel, which including customs and freight comprise the prices of ordinary steel in Sweden. Here we encounter different problems from those connected with the separation

[1]) See L. Fridén, Instability in the International Steel Market, Stockholm 1972.

of a demand equation from a system of demand and supply equations. We are faced with the practical difficulties of finding relevant relative prices and avoiding the disruptive effects of co-variation between shift parameter and price variable. From this point of view it is better to study demand relations for the USA, which is more of a closed market than Sweden. Admittedly steel prices in the USA are not exogenously determined, but even here the price of steel should be predetermined and the industry demand curve identifiable. Here, in the terminology of F. M. Fischer, we have the type of tightly knit oligopoly which results in a species of administered prices which in the short run are not of a market clearing character and which even in the medium and long run are slow to adjust to conditions of demand.[1]) The price one has to pay for this kind of identifiability of demand relations takes the form of a lack of large price variations.

By grouping steel consumption, prices and industrial production in four-year periods we can isolate the long-term relations between these quantities from short-term relations better than if we confine ourselves to annual data. For this reason the period 1947—70 has been divided into six subperiods. We shall then study the dependence of steel intensity on the relative price of steel, defined partly as the *price of steel/wholesale price index for industrial products* and partly as the *price of steel/wholesale price index for non-ferrous metals*, and on a trend factor. The latter can be regarded as a proxy variable for the influence of other factors apart from the relative price of steel on the long-term trend of steel intensity. We thus obtain the relations

$$\log (C/I) = 0.01962 - \underset{(0.4057)}{0.7218} \log (PS/PI) - \underset{(0.00769)}{0.01937} \cdot t$$

$$R = 0.997$$

$$\log (C/I) = 0.3079 - \underset{(0.04953)}{0.5899} \log (PS/PNF) - \underset{(0.00083)}{0.03088} \cdot t$$

$$R = 0.999$$

PS, *PNF* and *PI* denote wholesale price indices for finished steel mill products, non-ferrous metals and non-farm products respectively. In both cases we obtain a price elasticity within the interval [0, — 1]. Since the number of degrees of freedom is as little as 3 there is hardly any cause to look more closely

[1]) See F. M. Fisher, A priori Information and Time Series Analyses, Amsterdam 1962, cap. 5.

at the various indicators of significance. It should however be noted that the standard deviation in the coefficient for log (PS/PI) falls steeply if we give the variable in question a lag of 1/4 period—in this case one year. The results show that the hypothesis of the price of steel influencing steel consumption in the long run is not to be rejected without further consideration. If we take into account the dynamic effects discussed previously, there are no a priori objections to be raised against a price elasticity of the order of -0.50 either. The coefficients for t denote long-term reductions of steel intensity by -1.1 and -1.6 per cent p.a. respectively. The estimate of the partial trend in C/I (i.e. the trend not dependent on the relative price of steel) is thus partially dependent on the measure of the relative steel price we use. However it is only to be expected that (PS/PI) should leave less to be explained by other quantities than (PS/PNF), which only measures the development of the price of steel in relation to *one* group of rival materials.

Using time series date for the USA, one can also obtain a certain measure of support for the hypothesis that steel demand adjusts so rapidly to changes in price relations that when dealing with annual data we can regard steel consumption as simultaneously determined by steel prices, the prices of non-ferrous metals, industrial production (or GNP) and its rate of increase. For the period 1953—69 we obtain the relations

$$\log C = 2.7058 + \underset{(0.1016)}{0.8216} \log GNP + \underset{(0.738)}{1.053} \Delta \log GNP -$$

$$- \underset{(0.8623)}{0.9455} \log (PS/PI) + \underset{(0.2625)}{0.6254} \log (PNF/PI);$$

$$R = 0.961; \; DW = 1.97$$

[1]) The results change very little if instead we estimate the relations in question from first differences. In this way, if we confine ourselves to a study of the effect of (PS/PNF), we obtain:

$$\Delta \log (C/I) = -0.03123 - \underset{(0.0750)}{0.6040} \Delta \log (PS/PNF); \; R = 0.978$$

If we allow the coefficient for $\Delta \log I$ to be chosen freely we obtain

$$\Delta \log C = -0.05569 + \underset{(0.290)}{1.328} \Delta \log I - \underset{(0.1275)}{0.4845} \Delta \log (PS/PNF)$$

$$R = 0.995$$

It is interesting to note that the elasticity of steel consumption with regard to industry production acquires a value > 1 in this case as well. If the price variable is excluded from the estimate, the elasticity value will be 2.24 (0.38).

$$\log C = 3.524 + \underset{(0.0813)}{0.7383} \log I + \underset{(0.3347)}{0.3783} \Delta \log I -$$

$$- \underset{(0.823)}{1.113} \log (PS/PI) + \underset{(0.2587)}{0.5111} \log (PNF/PI);$$

$$R = 0.967; \; DW = 1.79$$

According to these equations price elasticity ≈ -1 and the cross elasticity of non-ferrous metals with retard to steel consumption is over 0.5. Certain objections will immediately be raised to diminish the "promising" impression made by these estimates.

- The fact that there are no lags in the relations except those concealed in the $\Delta \log GNP$ and $\Delta \log I$ variables does not mean that we have confirmed the hypothesis that prices in previous years have not had any influence on steel consumption in a particular year. Because prices, especially steel prices, are autocorrelated, the effect on steel consumption of e.g. P_{t-1} and P_{t-2} is absorbed by P_t.
- Although to outward appearances the USA steel market has the character of tightly knit oligopoly which can make it possible to identify demand curves, the character of this market is no guarantee for the identifiability of demand relations. It may be that steel companies consider the price sensitivity of demand small within large intervals and endeavour by means of price variations to smooth the fluctuations in revenues to which tonnage fluctuations can give rise. Price-quantity developments during certain years seem to warrant such an interpretation. Instead of observing the relation *price* $\rightarrow$ *quantity demanded* we are concerned with the relation *quantity demanded* $\rightarrow$ *price*.
- The price of non-ferrous metals has to a greater extent than steel prices co-varied with general business trends and, consequently, with steel consumption. This may have affected the estimate of cross elasticity.

Corresponding estimates from Swedish data with industrial production and its changes as shift variables give a price elasticity of -0.109 (0.110) and a cross elasticity of 0.801 (0.266). For reasons given earlier, cross elasticity has probably been greatly overestimated, while price elasticity from a priori points of view is of reasonable proportions.

5. Summary

Steel consumption in a closed economy is derived from the demand for consumer and investment goods, the common term of which is final goods. Knowing the total output and the total amount of steel needed per unit of output of each final good we have by definition the necessary information to calculate the total steel consumption. The study of steel consumption can therefore be split up into two parts, one dealing with the determination of steel consumption per unit of output of final goods and the other treating the composition of GNP with regard to final demand goods. This general approach has been followed in this essay, the main purpose of which has been to show and to provide an explanation to the cyclical and long term growth properties of steel consumption as they have appeared in Sweden and other countries.

The analysis started from a general model, which later on was given the properties of an open input output model for a country with foreign trade. From this model, which described the production system and the links between final demand categories in a linear equation system, steel consumption was calculated firstly as a weighted sum of output in different sectors and secondly as a wieghted sum of final demand categories, the latter indicating different kind of uses of the final goods.

The steel intensity of a production sector, i.e. steel consumption per unit of output, is fixed like all other input/output ratios in the input-output theory. These assumptions were modified as the analysis was turned from a static to a dynamic one. Steel intensities were assumed to vary with investments in goods in process and to be a monotonously decreasing function of time.

In order to analyse the sector composition of the economy we made some attempt to incorporate the demand for final goods in a macro economic model. In doing so we got steel consumption as a function of lagged endogenous and exogenous variables to the economic system being considered. The main emphasis in this part of the study, however, was laid on so called global models, which relate steel consumption to different measures of total production.

Two sets of hypotheses were proposed and combined. The first one concerns the relation between total steel intensity, i.e. steel consumption/total production, and the stage of industrial development, while the second one ended up in specified functions due to which changes in total production causes fluctuations in steel intensities.

The first part of the empirical analysis performed in this essay was tied to a modified version of Höglund and Werin's input-output study, which as concerns steel consuming sectors is unusually well specified. From this study we obtained a static picture of the distribution of steel consumption on production sectors as well as on final demand categories.

In a time series analysis investigating the dynamic properties of steel intensities we found

- that yearly variations of steel consumption in Sweden in the period 1954—69 was very well explained by a production (or a final demand) index and time.
- that the yearly decrease in the weighted average of steel intensities was 0.8 percent (or 0.4 in the final demand case) and
- that short term variations in steel input/output ratios were highly correlated with investments in goods in process, the variations of which are well explained by an accelerator model modified with a variable expressing labour shortage.

Furthermore we investigated the contribution to the growth of steel consumption by different demand categories finding that exports of engineering products (incl.ships) had been far more expansive than domestic demand for consumer and investment goods. This indicates the importance of the European economy as a whole for steel consumption in Sweden.

The different kinds of global models were applied to Swedish data and data from other OECD nations. In a combined cross section/time series analysis total steel intensity was found to increase with per capita income in the less industrialized regions (GNP/CAP $<$ \$ 1000 in 1963 prices) but that it seemed to be independent of the income level in the mature economies. This stability property applies to the structural component of total steel intensity. There is however an obvious tendency of a long run decrease in its technical component as shown by data from the USA and Sweden. This means that total steel intensity will tend to decrease over time. It is also shown that this decrease can be outweighed by a rapid rate of growth in total production, which generally effectuates a change in the composition of GNP in favour of typical steel consuming sectors.

Changes of growth rate in GNP and in industrial production plays a dominant role in the time series versions of the global approach. In general the cyclical variations in total steel intensities can be captured in simple models containing industrial production, the rate of change of this variable and time as the only independent variables.

The cyclical sensitivity of total steel intensity depends very much on the measurement of steel consumption. The only available measure for international comparisons is that of apparent steel consumption which is equal to steel input plus all inventory investments in steel. Results from the application of the models on Sweden, where we have access to reasonably good inventory data, suggest that the cyclical variations in this variable are roughly twice as big as those in actual consumption, i.e. apparent consumption minus steel inventory investments. The fact that actual steel consumption is also very sensitive to variations in the rate of growth in GNP or industrial production gives further support to our hypothesis of the important role of investments in goods in process in cyclical fluctuations in total steel requirements.

The final section of Part II is devoted to a study of the price sensitivity of steel demand. Two types of price effects, which are derived from a static model, are considered: the substitution (direct) and the breakthrough (indirect) effects respectively. The first of these concerns the willingness and ability of steel consumers to substitute steel for other materials as a consequence of change in total relative steel price. The latter deals with the cost increase in the steel-consuming industries followed by an increase in the steel price and how this affects the prices of and demand for the steel intensive products. It is found that total steel intensity in Sweden in the long run is inversely correlated to a price index for finished steels divided by a weighted price index for plastics and non-ferrous metals. Since this ratio appears roughly like a time variable no firm conclusion can however be made from this approach.

As regards the breakthrough effects it is shown that the *steel cost/total costs* ratio is so small that the price elasticities of the demand for steel intensive products must be very high in order to result in a noticable price elasticity of steel demand. It is also pointed out that a steel price increase which affects all sectors is not very likely to affect the product composition of final demand in a closed country very much.

If however steel prices are different in different countries this can of course effect the competitiveness of their engineering and other steel transforming industries. The market share of Swedish machines in the U.K. is negatively correlated with the price ratio *steel price in Sweden/steel price in the U.K.*

A time series study for the USA results in a price elasticity of -1 and a cross elasticity (non ferrous metals) of $+0.5$.

This result is however questioned on several grounds. So the conclusion is that the price sensitivity of steel consumption seems to be small in the short run but that it may be of importance in the long run. The support for the last assertion found in our empirical investigations is, however, not very strong.

Part III

Steel Inventory Cycles

0. Steel Inventories During the 1950s and 1960s

0.1. Two characteristic features of developments

Total steel inventories in Sweden during the 1950s and 1960s were distinguished by two main characteristics, namely a markedly falling trend in relation to steel consumption and a high degree of instability. The first of these characteristics can be illustrated by the following figures. During the period 1954—68 steel consumption rose by almost 6 per cent annually, at the same time as the annual growth rate of consumers', stockholding steel merchants' and producers' steel inventories was no more than 2.4 per cent. This trend implied a more rapid turnover of steel inventories. In the period 1954—56 steel inventories comprised on average just over half the mean annual consumption. Twelve years later (1966—68) the average duration of steel inventories was only 4 months.

It will be evident from the above that the growth of steel inventories has been anything but even. On the contrary, as can be seen from fig. 1, inventories have been characterised by pronounced fluctuations. Thus their average deviation from their trend value has been approximately 5 per cent. One interesting question however concerns the effect of changes in steel inventories on steel demand. This is preliminarily illustrated in figures 2.a. and 2.b. These suggest that changes in steel inventories have had farreaching effects on variations of apparent consumption. The latter, consisting of steel consumption plus inventory increase, has to a striking degree derived its "trade cycle profile" from inventory variations. To give an idea of the importance of these changes, the sensitivity of apparent consumption to business fluctuations, defined as mean deviation from the trend, is virtually twice that of consumption. Variations in apparent consumption have of

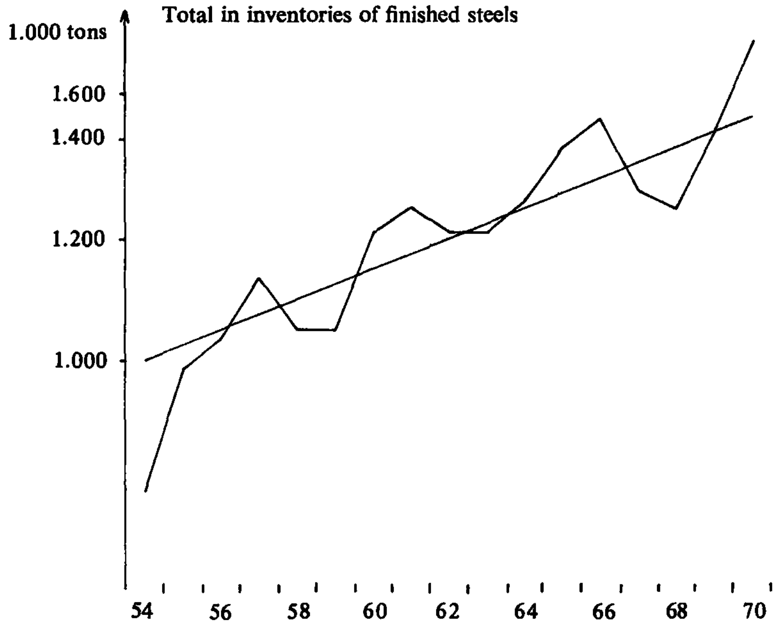

Total in inventories of finished steels
1.000 tons
1.600
1.400
1.200
1.000
54
56
58
60
62
64
66
68
70

Fig 1

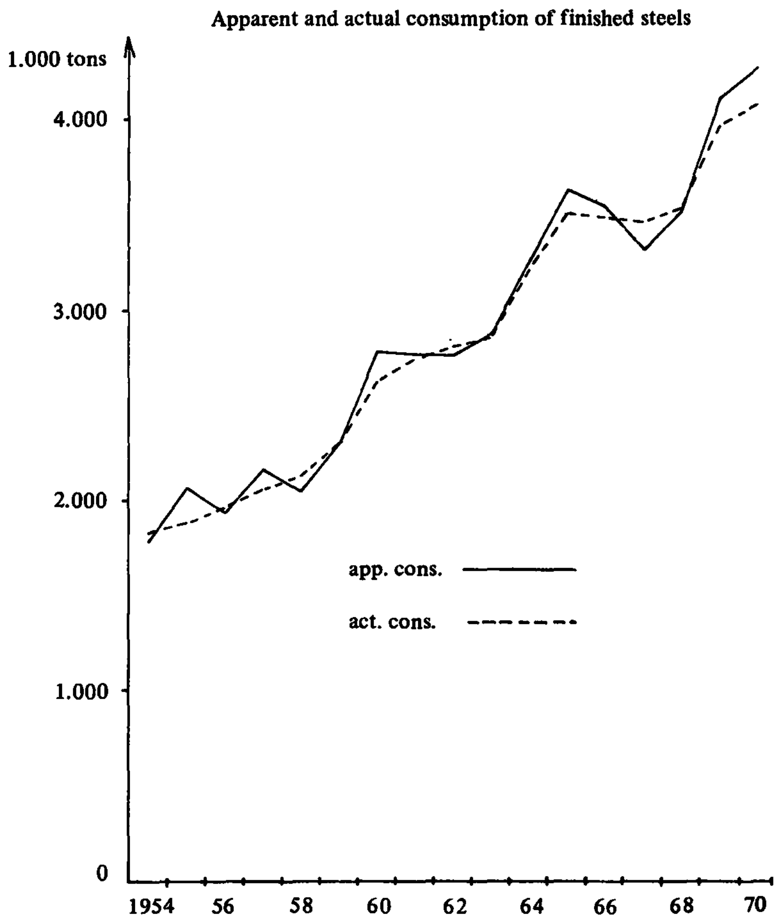

Apparent and actual consumption of finished steels
1.000 tons
4.000
3.000
2.000
1.000
0
app. cons.
act. cons.
1954
56
58
60
62
64
66
68
70

Fig 2 a

course been particularly pronounced when large increases (falls) in consumption have coincided with large increases (falls) in steel inventory investments. This occurred e.g. during the typical boom years 1960, 1965 and 1969 and during the recession year 1967.

0.2. Investments in steel inventories by producers, merchants and consumers

It is interesting to divide up steel inventories in terms of owner categories. The importance of different inventory determinants probably varies from one group of inventory owners to another, so that their inventories do not increase and decrease uniformly.

Changes in apparent consumption, actual consumption and inventory investments

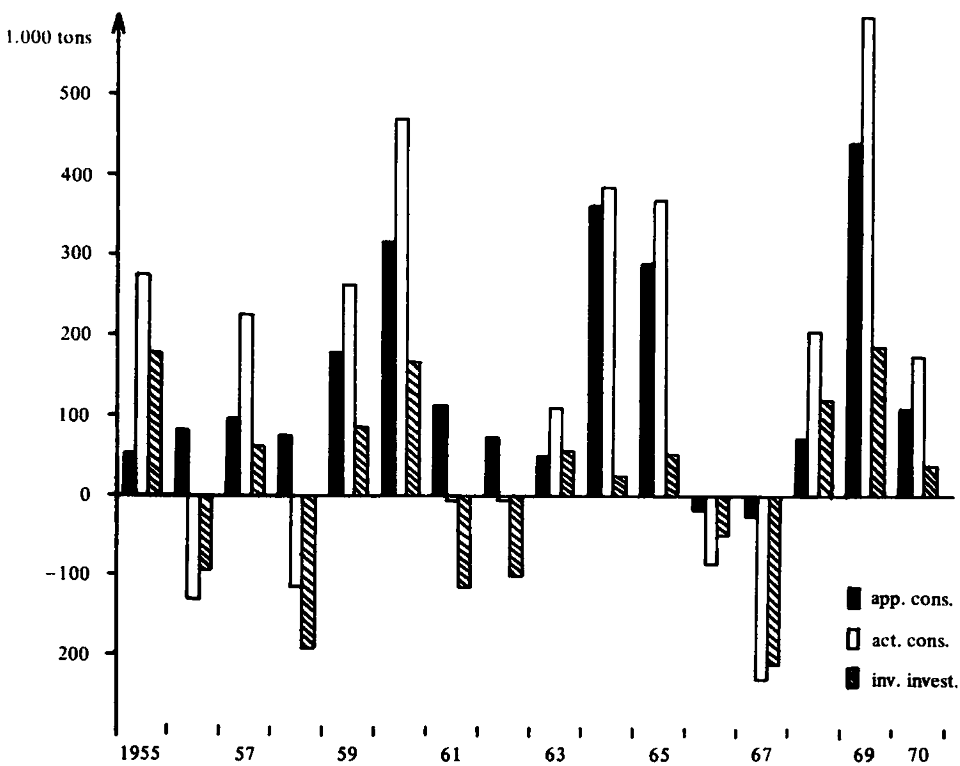


Fig 2 b

Consequently a division of this kind must be a necessary preliminary to the study of stabilizing and destabilizing ingredients in inventory investments.

Figures 3.a. and 3.b. show steel inventories of consumers, merchants and steelworks. It is evident that

- steel inventories at steelworks have grown considerably
- steel inventories at consuming industries (including shipyards) and merchants have stagnated
- consumers' (engineering industry, including shipyards) steel inventories fluctuate more than those of steelworks and merchants
- the contribution by merchants' inventories to the instability of total steel inventories is of surprisingly little importance

It should be emphasized at this point that fluctuations in merchants' steel inventory investments are more apparent in quarterly than in annual statistics. During certain years, e.g, 1961, 1963, 1966 and 1969 inventory investments by steelworks have varied inversely with steel inventory investments by consumers. The demand for steel declined in 1961 and 1966, while the latter half of 1963 saw the beginning of the rise in demand which was to attain its peak in 1965. This raises the question whether the inventory policy of the steelworks has had a stabilizing effect on production, a question however which can scarecly be answered on the strength of figure 3.b alone. The problem will be briefly discussed in Part IV of this book, where the inventory policy of steelworks and steelmerchants is considered as an integrated part of their overall marketing policy. The long-term tendencies in the steel inventories of different entrepreneurial categories are briefly considered in a later section of this book.

0.3. Consumption of steel and investment in steel inventories by the steelconsumers

Variations in consumers' inventory investments have on average had much the same influence on variations in purchasing as variations in consumption—see figure 4. This picture is however incomplete, for two main reasons.

- It has been possible to observe a phase shift in the inventory cycle in relation to the consumption cycle, in the sense that variations in inventory investments have preceded variations in consumption.[1])

Consumers', steelworks' and merchants' inventories of finished steels. (Stocks held at the end of each year)

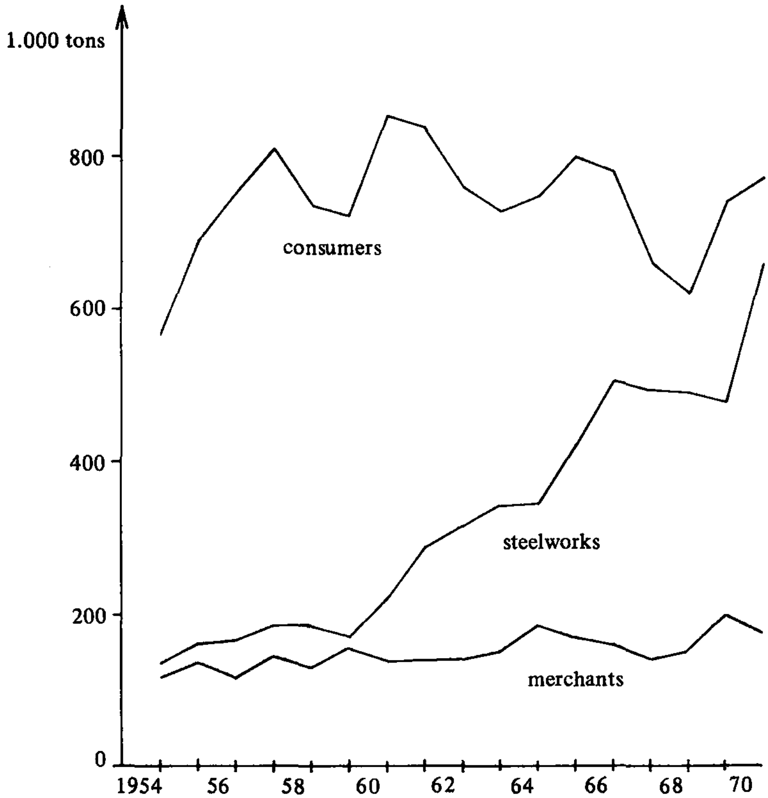


Fig 3 a

- The quantity we observe as actual consumption consists to a certain extent of inventory variations.

The time lag between inventory and consumption variations means that a study of the effect of inventory variations on total demand at the aggregation level of one year requires data for periods of less than one year. This problem, which has done much to determine the disposition of the present

[1]) This conclusion has been arrived at indirectly by studying the time lag between consumers' purchases and their consumption. The time lag giving the greatest correlation between these two quantities is $\frac{1}{4}$ year, i.e. purchases $(t - \frac{1}{4}) \rightarrow$ consumption (t). This was shown in Part II.

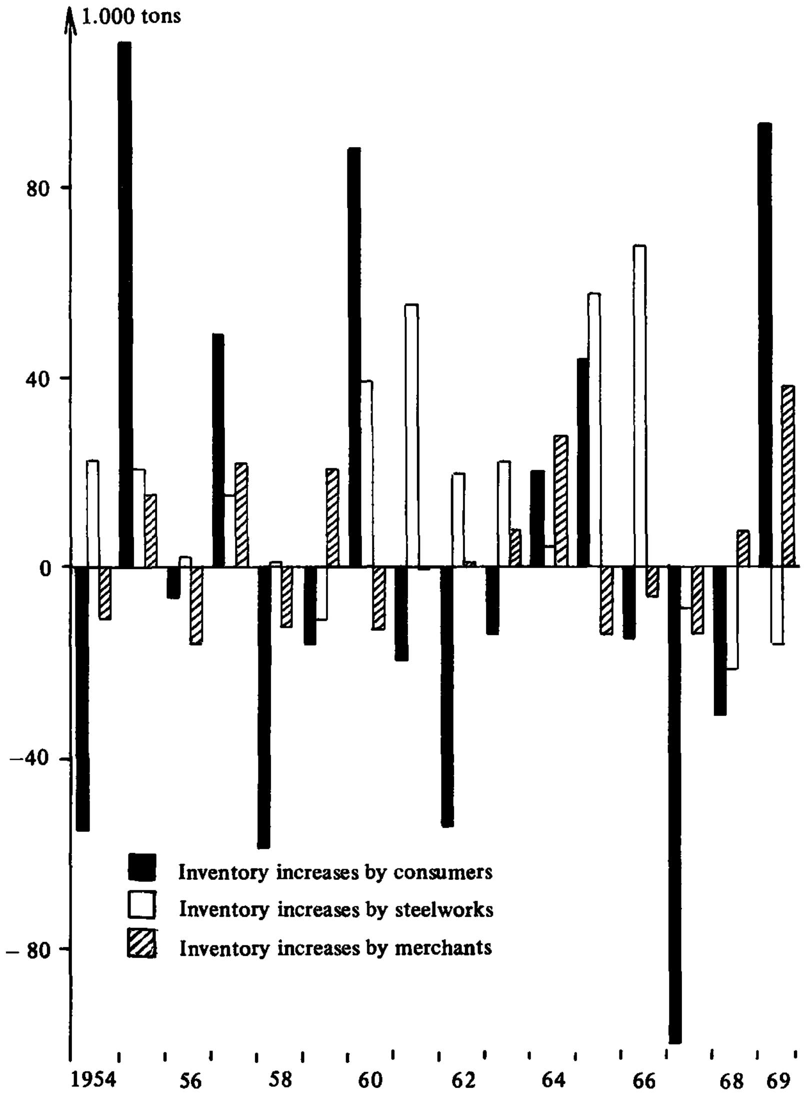


Fig 3 b

essay, will be dealt with at greater length in a later section.

The importance of investments in steel incorporated in goods in process in the engineering industry is shown by figure 5, taken from an article in Jernkontorets Annaler[2]). Thus these inventory variations did a great deal to accentuate the rise in demand in 1960 and the falls in demand in 1962—63 and

[2]) L. Vinell: Efterkrigstidens svenska stålmarknad (The Steel Market in Postwar Sweden), Jernkontorets Annaler, vol. 152, 1968, pp. 306—307.

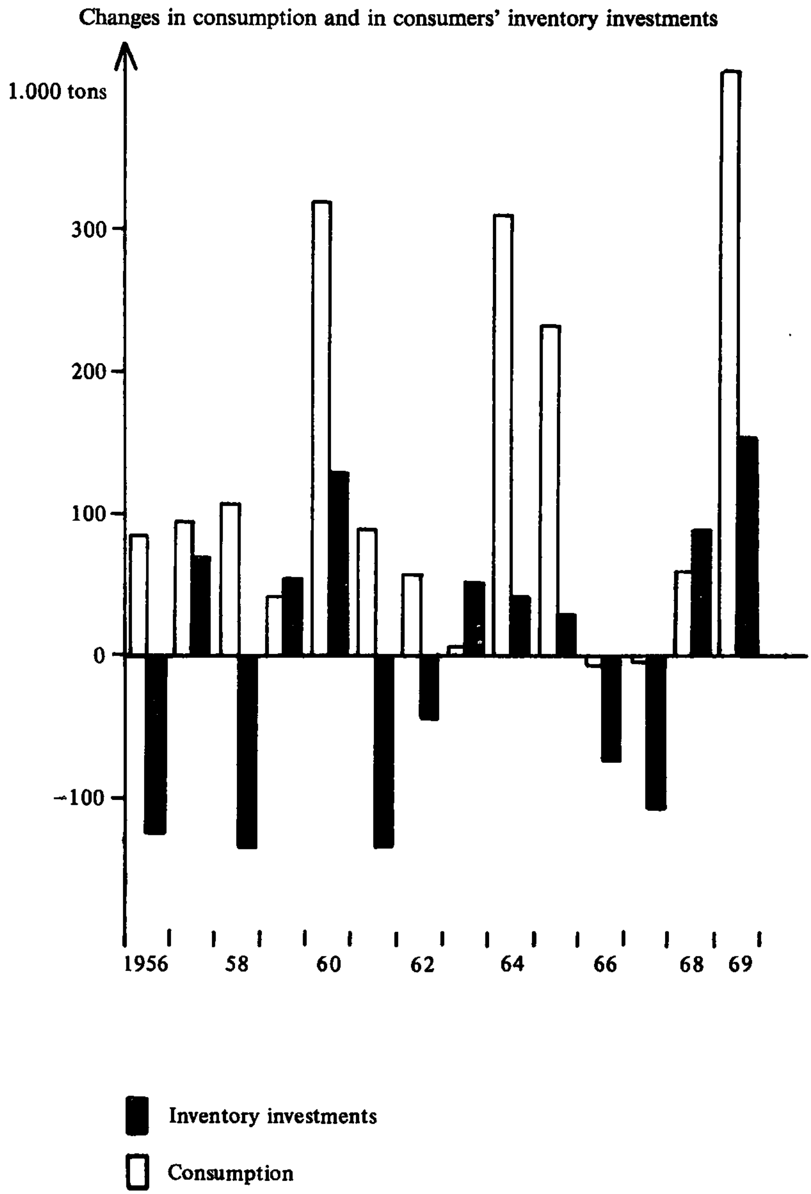
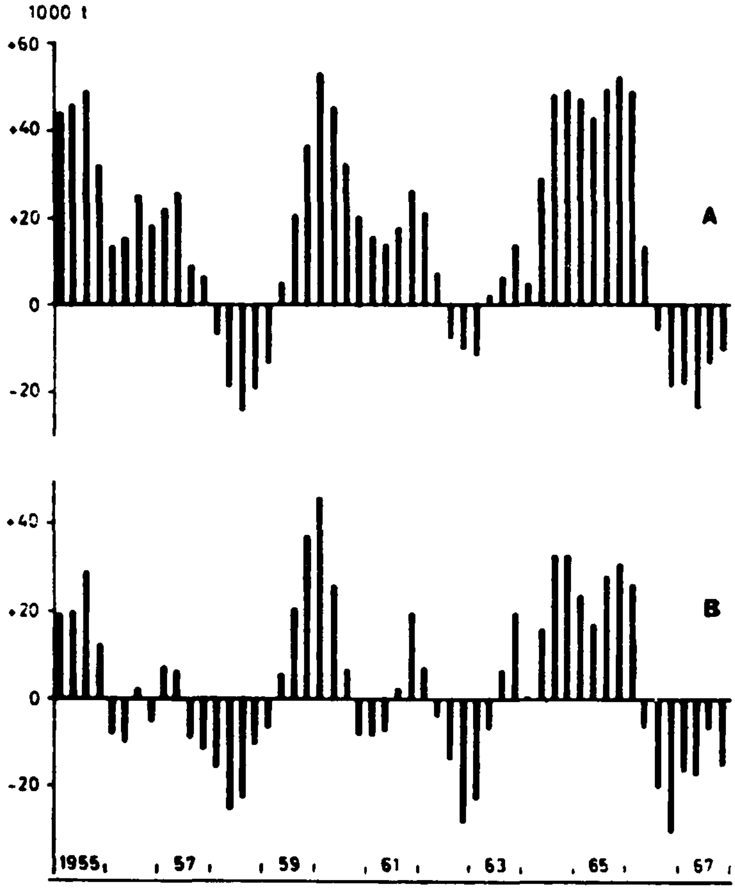


Fig 4

1966—67[3]). Consequently steel consumption corrected for variations in steel in process shows a definitely more even growth than statistically observed steel consumption.

[3]) It may be added that this kind of inventory investment played a dominant role for the upswing in steel consumption in 1969.



The increase in inventories of finished steel in the engineering industry, 1955—67. A) including and B) excluding steel in goods in process.

1. General problems; Definitions

1.1. Objective and limitations

The fluctuations of realized steel demand, which is here taken to mean actual purchases by consumers, has as we have already seen to a very great extent been due to changes in their steel inventories. The ultimate aim of this study is to find explanations for these inventory variations.

Since variations in consumption (as it is usually measured) are also to a considerable extent to be seen as the result of certain inventory movements, namely changes in steel consumers' steel in process, it would appear inappropriate to limit our attention to fluctuations in "visible" inventories. For this reason—and for other reasons which will be put forward in due course—we shall define the general problem as: What has determined purchases of steel on the Swedish market? and Why have these fluctuated so violently? In the statistical study of this problem we shall confine ourselves to steel purchases by the engineering industry. This is however no significant limitation, for not only does the engineering industry account for 2/3 of total steel consumption, variations in its purchases have come to dominate the pattern of cyclic fluctuations in steel purchases as a whole. See fig. 6.

In Part II section 4 the sum of steel consumption and steel inventory investment were regarded as a function of total production of the economy. The specified relations were based on simple theories of consumption and stock building respectively. This essay then can be seen as an expansion and continuation of those studies. The principal aim of the latter was a rather

[1]) The term "purchases" refers to deliveries received.

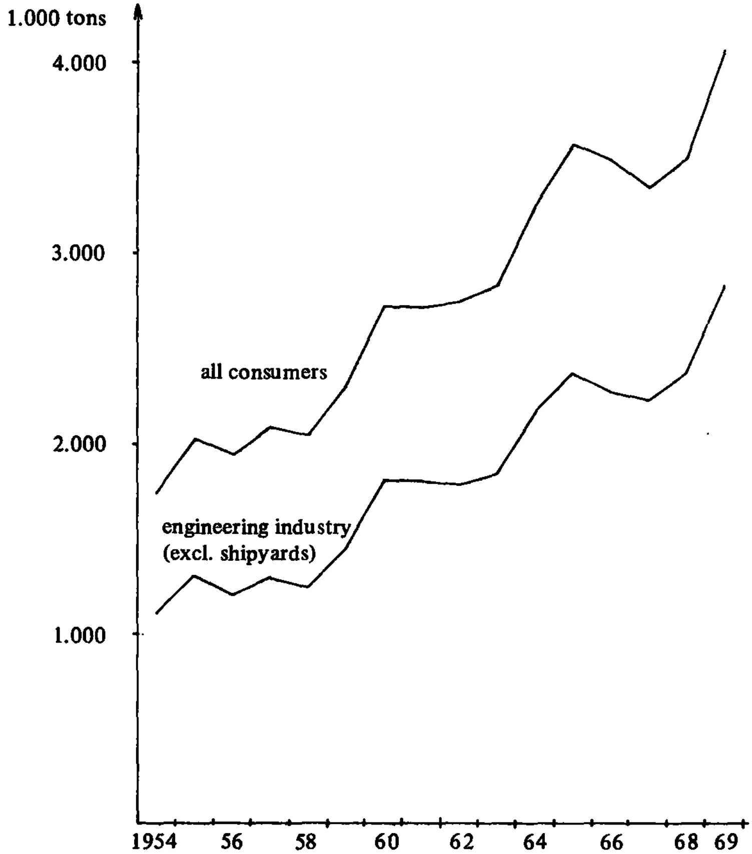


Fig 6

pragmatical one of finding an explanation for purchasing fluctuations which is capable of being used in forecasts. Here we are more concerned with the properties of different inventory models especially as they appear when applied to data concerning the Swedish steel market. We will therefore dig a little deeper into the matter of the steelstock formation process than we did in the former part. The difference between these objectives is marginal, for a workable forecasting model must have stable relations. In order to obtain such a model one has to work with what from the point of view of economic theory are reasonable models, which in turn involves a discussion of the issues raised here.

1.2. A subordinate aim

Part of the aim this essay is to describe the interaction between the formulation of a model and the properties of data which can be observed and is presumably necessary when attempting to try out economic theories on reality as represented in data of various kinds. This situation is illustrated in the accompanying figure.

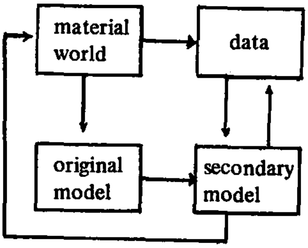


Figure 7.

This figure shows how the material world, the world as we experience it through our senses (not necessarily in the form of data) gives rise to theories aimed at describing this reality in a simplified form. Certain aspects of it are reflected by data in which classification and the like may be determined by some pre-existing theory. If one then wishes to study the feasibility of a theory by comparing it with the existing data, this is not immediately possible as a rule, since the data do not often correspond to the quantities specified in the theory. Working on the basis of the original theory one has to construct a model which can both claim to include the main content of the theory and is formulated in such a way that it can be tested on data. Thus the theory that is tested is a model of reality as it appears in data, the statistical image of the material world, and it can accordingly be described as secondary. The real issue concerns the ability of the original model to explain the material worlds.

It should be emphasized that our criteria of significance only apply to the value of the description of the statistical picture of the material world provided by the secondary model. In order to be able to evaluate the explanatory value of the original model on this basis we have to know the properties of the data and particularly their relation to the concepts employed in the original theory. We shall therefore devote a special section to the consideration of data and the choice of indicators of the economic quantities we are interested in.

1.3. Essay plan

The main section begins with a methodological discussion occasioned by the fact that inventory fluctuations are being studied as the result of processes of adjustment. Here we shall consider the question of the observability and identification of adjustment functions and the possibility of unequivocally determining reaction coefficients of the kind that in recent years have become so common in studies of capital (and inventory) theory with empirical associations. This discussion will be couched in very general terms and without any theory of inventory demand having been formulated. A theory of inventory demand is framed on the basis of assumptions regarding the reasons for keeping inventories. Starting from a general theory arrived at in this way, the following section specifies models for steel consumers' inventory investments. These specifications follow two principal lines referred to as direct and indirect method respectively. This division is due both to factors of estimation technique and to the nature of the data.

For obvious reasons, the supply of data concerning inventory determinants is limited; we are predominantly concerned here with expectation (ex ante) variables. A special section is therefore devoted to the consideration and evaluation of more or less indirect gauges of the quantities we wish to know. However the argument is not limited to this kind of indication problem, consideration also being given to the reliability of e.g. existing production measurements in the engineering industry.

The ensuing sections are devoted to a statistical analysis of the inventory models defined previously. The introductory discussion treats among other things the justifiability of choosing one body of hypotheses rather than another from statistical analysis of time series data. This is followed by a summary of the results of the statistical survey. These are then taken as the basis for an analysis of certain interesting cyclical aspects of the development of the steel market during the last few decades.

However before proceeding to the main section it would perhaps be advisable to define more closely the principal concepts with which we shall be dealing. In this connection we shall devote particular attention to the concept of steel in process.

1.4. Definitions; commentary on the concept of steel in process

We have already defined apparent consumption of finished steel[1]) as production plus imports minus exports. Apparent consumption was divided into two components, consumption and inventory increase, which in turn were divided into two

[1]) Finished steel is in general taken to mean steel ready for delivery. This product concept comprises items 73.07—73.16 and 73.18—73.19 in the Brussels tariff nomenclature. For the purposes of this study, finished steel is not taken to include semis for sale. This limitation is insignificant. For the sake of convenience "steel" will here be used as a synonym of "finished steel".

and three parts respectively. Finally our interest was focussed on consumers' purchases, which consist of consumption and inventory increase by consumers. More exactly we have thus introduced the following definitions:

$$_{w}Q_t + M_t - E_t = AC_t \qquad 1.1.$$

$$AC_t = C_t + \Delta L_t \qquad 1.2.$$

$$\Delta L_t = \Delta_w L_t + \Delta_m L_t + \Delta_c L_t \qquad 1.3.$$

$$C_t = \Delta_p L_t + {}_0C_t \qquad 1.4.$$

$$J_t = C_t + \Delta_c L_t = {}_0C_t + \Delta_p L_t + \Delta_c L_t \qquad 1.5.$$

Symbols: Q = Production
M = Imports
E = Exports
AC = Apparent consumption
C = (Actual) Consumption
ΔL = Inventory increase
J = Consumers' purchases

All figures refer to finished steel during period t.
Subscripts w, m and c before ΔL denote inventory increases by steelworks, merchants and consumers respectively. $_{p}L_t$ and $_{0}C_t$ denote the quantity of steel in process at the end of period t and the quantity of steel leaving the production process of the steel-consuming enterprises during period t.

The division of consumption into two components is designed to illustrate two related questions. The first of these is occasioned by the length of the production time while the other is a problem of measurement connected with it. The quantity which we observe as steel consumption is the receiption of steel for further processing. Steel received during period t but still not having left the process at the end of period $(t+1)$ is thus registered as consumption during period t but not during the period that follows. Also the amount of steel in process increases during period t[1]). If the product leaves the process during period $(t+2)$, the amount of steel in process decreases during this period[2]). The example can

[1]) Steel in process refers to steel incorporated in the commodities which the manufacturer (consumer) has processed in some way but which have not yet reached the stage where they are ready to be marketed.

[2]) Observed steel consumption during period t (C_t) can thus be defined as in 1.4, i.e. $C_t = \Delta_p L_t + {}_0C_t$ where $_0C_t$ is the steel leaving the production process in the form of finished goods or as scrap and $\Delta_p L_t$ is the increase in steel in process.

be specified as follows:

$$
\begin{array}{ll}
t & \Delta_p L = C \\
t+1 & \Delta_p L = O \\
t+2 & \Delta_p L = -C
\end{array}
$$

This example illustrates a circumstance which will be of majo importance in the remainder of this essay: Consumptio during a given period cannot be assumed to be unequivocall related to production during the period in question. Thre important factors emerge here:

1. The time taken by production, e.g. the time betwee primary input and output.
2. The length of the observation period.
3. The criterion of production.

The longer a production period is, given a certain observatio period, the less distinct the relation between production an consumption and vice versa. This applies if production i measured as average activity (the degree of employment of al the factors of production). If the criterion of production mainl reflects activity in the earlier processes the relation betwee consumption and production will be better. If production i measured in terms of output the relation disappears entirely In the last-mentioned of these cases consumption (t) is de pendent on production ($t + 2$). So far the problem o variations in the amount of steel in process has been viewe solely as a combined problem of production measurement an time lag; for a given unit of production and a given productio time we can obtain a relation $C_t \rightarrow Q_{t+i}$ in which Q is a index of the steel consumers' production.

However inventories in process do not necessarily increas in proportion to production in the steel industry. A rise i production may be accompanied by a greater increase in stee consumption than is apparently necessary to attain the pro duction result. This means that the increase in inventorie in process in the example during period t is greater than th fall during period ($t + 2$). There may be at least two reason for this inventory increase:

- The amount of steel in process performs the same functio as raw material inventories. This seems reasonable in viev of the fact that inventories in process in a discontinuou production process consist partly of intermediate inventories[1])

[1]) It is interesting to note in this connection that statistics concernin inventories in process seem predominantly to refer to inventories o this kind. The degree of continuity of the production process can i

- Differences between desired and actual growth of output can create involuntary changes of the stock of goods in process.

In both cases consumption of steel will oscillate around production.

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this context be regarded as an aggregation problem of measuring technique. If a firm producing a certain kind of product is divided vertically into several sub-branches, more intermediate inventories are converted into stocks of raw materials and finished goods respectively.

2. Basic hypothesis and problems of method connected therewith

2.1. The tension between desired and actual inventory level as a cause of inventory movements

The basic or working hypothesis of the present work is that inventory movements result from the development of a discrepancy between what according to some decision rule is a "prescribed" inventory level (equilibrium inventory, L^*_T) and the actual inventory level (L_T)[1]). This hypothesis can be written

$$(L^*_T - L_T) \rightarrow \frac{dL}{dT} \qquad 2.1.$$

According to transformation 2.1. the analysis of steel inventory investments can be divided into two stages, namely

- the determination of an equilibrium inventory
- the description of an adjustment function

We shall disregard the first point for the time being so as to devote closer attention to certain of the problems attaching to the study of adjustment processes.

In this connection we shall consider two main questions, the first of which concerns the difficulties involved in the determination of coefficients in a continuous adjustment function from time series data. The second concerns the often neglected problems arising in connection with the use of the "flexible accelerator" inventory model[2]), which is the period

[1]) L (without subscript) will in the ensuing pages denote consumers inventories of steel, except where otherwise indicated.

[2]) This concept was introduced by Richard M. Goodwin in his paper Secular and Cyclical Aspects of the Multiplier and Accelerator in Income, Employment and Public Policy: Essays in Honour of Alvin Hansen, New York 1948. The concept was given an empirical content by Michael C. Lovell, Manufacturers' Inventories, Sales Expectations and the Acceleration Principle, Econometrica vol. 29 No. 3, 1961. For further references see "Determinants of Inventory Investment" by the same author in Models of Income Determination, Princeton 1964

version of the continuous model. This approach entails considerable problems of interpretation and identification. We shall endeavour here to unravel these problems and put forward solutions to them.

If relation 2.1. is regarded as a single-valued function, this means that inventory fluctuations are entirely determined by the consumers' demand for steel. Although the traditional problem of identification associated with market studies may not appear in the present case to constitute a very serious obstacle to a meaningful analysis, the hypothesis will be modified considerably in due course.

A process of adjustment is by definition time-consuming. If it is to be of interest in an empirical context it must moreover take long enough for the lack of equilibrium to be clearly discernible, for if adjustments to new equilibriums materialized almost immediately, an analysis of inventory fluctuations would not have to comprise more than the first of the two stages mentioned above, namely the determination of equilibrium inventories.

The occurrence of adjustment processes can be attributed to various kinds of inertia, e.g. in the making and execution of decisions. It may however also be due to caution on the part of purchasers. If a change occurs in the factors determining the equilibrium inventory, causing it to rise, firms do not immediately increase their inventories to equilibrium, instead they successively add to them on the grounds that they are not sure of the current situation persisting and that abrupt changes of quantity purchased are expensive.

2.2. The verification of adjustment mechanisms from time series data

2.2.1. A continuous adjustment model. Assume that a change in L^* occurs in all firms (of the same size) within a branch. Assume further that each firm receives deliveries of raw materials at regular intervals, say once a week, but that these deliveries are evenly divided between the days of the week A successive adjustment of the kind described above will in this case have the appearance of a continuous process from the point of view of inventory investments within the branch as a whole. We shall consider such a process as defined more closely by the following equation

$$\frac{dL}{d\tau} = K(L^*_\tau - L_\tau) \qquad 2.2.$$

in which K is a constant. Let L^*_T be unchanged throughout a certain interval of time. The solution to the differential equation within this interval will then be

$$L_T = L^* + ce^{-KT} \qquad 2.3.$$

If the inventory at a point in time t is equal to L_t its size at a point in time $(t + i)$ will be

$$L_{t+i} = L^* + (L_t - L^*)e^{-Ki} \qquad 2.4.$$

and the inventory increase during i

$$L_{t+i} - L_t = (L^* - L_t)\,(1 - e^{-Ki}) \qquad 2.5.$$

Thus at a given value for K and for the initial difference between L^* and L_t the acutal inventory increase will depend on the value of i and as the value of i increases L_{t+i} approaches L^* asymtotically.

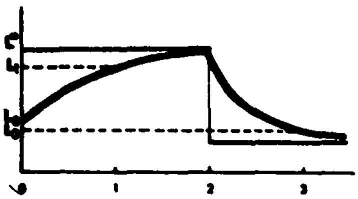

Fig. 8

The model is illustrated in figure 8. At a point in time t_0 there exists a difference between the equilibrium inventory and the actual inventory of $(L^* - L_0)$. This difference is successively reduced during period $t_0 - t_2$. At t_2 L^* momentarily falls (according to the thin continuous line) and an adjustment to the new equilibrium commences.

2.2.2. The identification of the relation from time series studies. Assume that we wish to estimate K in 2.4. or 2.5. with the aid of time series data. To start with we have figures for L and L^*[1]) at regular intervals, from which we obtain $(L_{t+i} - L_t)$ for a certain minimum value of i, e.g. one month. With a given value for i equation 2.5. can be written

$$\Delta L_{t+i} = L_{t+i} - L_t = k(L^* - L_t) \qquad 2.6.$$

in which $O \leqslant k = 1 - e^{-Ki} < 1$.

The definition of k indicates that the value obtained for this parameter is dependent on the length of the observation interval (i)[2]), a fact which seems self-evident but has nonetheless

[1]) To simplify the argument we shall for the time being proceed on the unrealistic assumption of complete knowledge of the size of the equilibrium inventory. Later on we shall consider the problems connected with a simultaneous measurement of K and L^*.

[2]) With given values for k and i, K can be calculated from the equation

$$K = -\frac{\log(1-k)}{i}.$$

caused and may cause problems of interpretation in comparisons of different studies. We shall be returning to this problem later on.

What happens if L^* changes within an interval, i.e. between two moments of obervation? This can be illustrated with the help of fig. 8. Assume that the observation times are 0, 3, 6 . . . etc. and that L^* changes in the way indicated by the figure. If we apply equation 2.6. with L^* equal to its original value we obtain a value for k which is < 0, which contradicts the hypothesis that firms endeavour to attain equilibrium. If instead, somewhat improperly, we apply to our estimates the value of L^* at the point in time 3, we obtain a reasonable but nevertheless unusable value for k. It is after all of no predictive value whatsoever.

The conclusion to be drawn from this example is that the observation interval is too long to allow of a meaningful adjustment analysis with the aid of equation 2.6. Thus an application of this equation requires that L^* remain unchanged between the observation junctures. If this condition is satisfied k can be calculated.[1])

2.3. The significance and limitations of the flexible accelerator model in econometric studies

2.3.1. Behavioural assumptions and model formulation. The equilibrium inventory, L^*, can be assumed to be determined in two principally different ways: as the result of an *optimum account*, in which allowance is made for probable sales and production trends, probable changes in various cost items etc., or—the approach followed in the present essay—by the application on the part of firms of simple *rules of thumb*. Thus in the latter event the equilibrium inventory may be determined so as to stand in a desired relation to production per unit of time. Such a rule of thumb may conceivably be modified one way or another. We remarked earlier that firms can act cautiously and that they can be deliberately slow to adapt inventories to the level determined by the rule of thumb.

[1]) In cases where L^* varies within a single period it is a help to know when these changes occurred and how large they are. Subject to this condition K in the example can be determined from the equations

a) $L_t = (1 - e^{-2/3K})(L^*_{t-1} - L_{t-1}) + (1 - e^{-1/3K})$
$(L^*_{t-1/3} - L_{t-1/3}) + L_{t-1}$

b) $L_{t-1/3} = (1 - e^{-2/3K})(L^*_{t-1} - L_{t-1}) + L_{t-1}$

One such policy principle is hinted at by Fromm, among others:[1]) "Due to many factors, however, principally the uncertainty of future sales volume and the cost of radically altering ordering and production plans for many heterogeneous items, the firm may not wish to adjust the discrepancy between the beginning-of-period equilibrium stock and the actual stock in one period". One general formulation of such a policy model (rule of thumb + inertia)—if like Fromm we make it in terms of periods—is

$$L^{**}_t = L^* - \phi\,(L^* - L_{t-1}) \tag{2.7.}$$

where L^{**}_t is the inventory the firms plan at the beginning of period t to have at the end of the same period, L^* is the inventory indicated by the primary rule of thumb and $\phi(L^* - L_{t-1})$ is a smoothing function to prevent variations in L^* acting in full force within one period, i.e. if $L^* > L_{t-1}$ then $L^{**}_t < L^*$ and vice versa. Assume now that the smoothing function can be written $a\,(L^* - L_{t-1})$ where a is a constant and that the planned inventories are always attained, i.e. $L^{**}_t = L_t$. We then obtain

$$L^{**}_t = L_t = L^* - a\,(L^* - L_{t-1}) \tag{2.8.}$$

if both sides are reduced by L_{t-1} we obtain

$$L_t - L_{t-1} = \Delta L_t = \lambda\,(L^* - L_{t-1}) \tag{2.9.}$$

$$\lambda = (1 - a)$$

Equation 2.9., which will be referred to as the *flexible* or as the *generalized accelerator model*, is formally identical with equation 2.6. and the two can be said to have the same economic implications with regard to their assumptions. The only difference between them is one of deduction. Whereas 2.6. is obtained by integrating a continuous adjustment model, 2.9. was derived from hypotheses which were originally formulated in period terms. The period concept in the two approaches thus acquires different contents, referring in 2.6. to an observation period and in 2.9. to a planning period.

In the first instance (2.6.), as was shown earlier, subject to L^* remaining unchanged the value of k is unequivocally dependent on the length of the period. In the latter case (2.9.) there is no such connection specified: λ there is defined for a particular interval.

Thus in order to test a period model completely it must be possible to obtain observation intervals corresponding to the planning periods. This problem resembles that which we encountered regarding the choice of observation period in the study of continuous

[1]) Gary Fromm: Inventories, Business Cycles and Economic Stabilization, in Inventory Fluctuations and Economic Stabilization, Part IV, pp. 41—42.

models (cf. pp. 158). In practice it is probably of minor consequence whether a continuous model or a period model is chosen as point of departure. A statistical analysis of 2.6. or 2.9. gives an estimate of k or λ, thus providing an answer to the question of inertia in adjustment to an equilibrium inventory. On the other hand an analysis of this kind tells us nothing about the plausibility of the original differential equation (2.3.) if it is based on time series data referring to a definite observation interval, e.g. a quarter. Nor does it tell us anything regarding the agreement between planning and observation periods.

2.3.2. The realism of the assumption of a constant delay factor. Can one justify the occurrence of a constant α making equations 2.8. and 2.9. realistic descriptions of reality?[1]) In principle Fromm's argument only supports the hypothesis of the occurrence of a function α which has an evening effect on variations in L, not really the idea that it can be expressed e.g. as in equation 2.9. One is more inclined to assume that the part of the difference between L^* and L_{t-1} which it is desired to cover is dependent on the absolute quantity of this difference. This means that inventory investments are described by the equation

$$\Delta L_t = \gamma\,(L^* - L_{t-1}) \qquad 2.10.$$

where γ is a variable factor the size of which is determined by the difference between the equilibrium inventory and the current inventory. This relation is illustrated in the accompanying figures (9.a. and 9.b.).

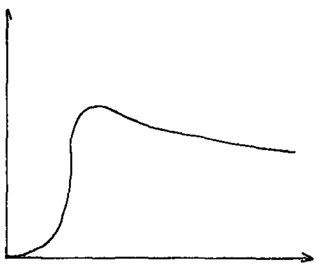

Fig. 9a

In figure 9.a. firms are assumed not to worry about adjusting to L^* if it differs only slightly from the current situation. As the difference increases so too does their willingness to adjust. In the event of very great differences, however, caution is assumed to predominate more and more, so that firms only go a small part of the way towards closing the gap. It would seem reasonable however to suppose that the ratio $\left|\frac{d\gamma}{\gamma}\Big/\frac{d(L^* - L_{t-1})}{L^* - L_{t-1}}\right| < 1$ in the interval where the curve declines, so that ΔL_t is always a monotonously rising function of $(L^* - L_{t-1})$.

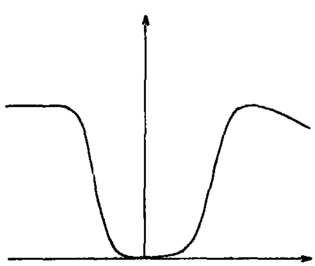

Fig. 9b

Figure 9.b. differs from Figure 9.a. in that the rate of adjustment depends on whether the deviations from the equilibrium inventory

[1]) Mills has shown conditions on which this decision rule comes under the principles of profit maximizaation. See E. S. Mills, Expectations, Uncertainty and Inventory Fluctuations, Review of Economic Studies XXII, 1954—55.

are positive or negative. In constructing the curve it has been assumed that firms are more willing to adjust to reductions than to increases, This assumption can be justified from the point of view of risk evaluation. A firm with low inventories runs the risk of losing good business for lack of production and delivery resources. In the short run however the bankruptcy risk of such behaviour is far less than that involved by keeping large inventories. Consequently it is not unreasonable to assume that firms are more prepared to adjust downwards than upwards as regards the relation between inventories and anticipated production etc.

Assume that γ in fact has the properties indicated by the figure. What results are obtained by testing equation 2.9. on statistical data under the erroneous assumption that factor λ is constant? Clearly this will depend on the interval within which the observed data for ΔL_t lie. If the changes involved are small, the estimate of λ obtained will be of little interest while the corresponding estimate obtained from an observation material with large changes in L_t will probably be of great predictive value. For forecasting purposes the value of the factor can be disregarded where the differences between L^* and L_t are small, while when these differences are large it will be crucial to the precision of the forecast.

If we consider the sum of the firms (the branch) the variation in the factor will be less than the average for individual firms, since for each value of $(L^* - L_{t-1})$ this factor constitutes a weighted average of corresponding factors for the individual firms. Here however there arises a problem of aggregation: Even if γ is a single-valued function of the difference between the equilibrium inventory and the actual inventory of each firm, this does not necessarily imply a single-valued function for the branch. One sufficient condition in this respect is for the γ curve to be the same for every firm and for every inventory increase in the branch to be matched by a definite distribution of the difference between equilibrium inventory and actual inventory between the individual firms. Problems of aggregation will be further discussed in section 4.5.

2.3.3. Problems of interpretation and estimation. Judging by the above, the use of models of the type represented by equation 2.9. to explain inventory variations would appear to be worthwhile, and this procedure is in fact applied frequently[1]). But when the model is directly confronted with data, it involves various more or less latent problems, above all as regards the identification of λ. We are above all concerned here with

- problems arising from other forms of inertia—especially those connected with organization and marketing—than

[1]) Cf. the above-mentioned articles by Fromm and Lovell.

those indicated by λ and which make it possible for L_t to differ from L^{**}_t and

- problems connected with the determination of indicators of L^*

We shall in this section also point to a problem of estimation technique automatically involved in the testing of this model on time series data. These problems will now be considered in the above order.

2.3.3.1. The effect of different kinds of market inertia. Time lags between plans and their realization can arise for many reasons. Here we shall concentrate on two kinds of inertia, namely the time elapsing before a decision is put into effect, e.g. between the observation of a need and the placing of an order, and the time needed by the supplier to fulfil his obligations, i.e. deliver the products ordered. The first kind of lag in the execution of plans will be referred to here as *decision time* (β_1) and the second *delivery time* (β_2). Thus the time between the decision to purchase and the reception of a delivery by firm "i" will be $(\beta_{i1} + \beta_{i2})$. For instance equation 2.9. can now be applied successfully to the study of this firm's inventory policy only if $\beta_{i1} + \beta_{i2} < 1$ period unit during all periods.

$$\Delta L_t = \lambda(L^* - L_{t-1}) \qquad 2.9.$$

At this point however there often arises a conflict between this requirement and the requirement discussed earlier of a constant L^* during every period. The probability of the first requirement being satisfied increases with the length of the period, while the probability of L^* remaining constant decreases accordingly. Of course one cannot be sure that there is any period of the right length to satisfy both requirements—least of all among the few possibilities which reality as represented by statistical data has to offer. We have already emphasised the importance of L^* "behaving itself", and there is therefore reason to select a period which is short enough for the requirement of L^* being constant to be satisfied but which can result in $(\beta_{i1} + \beta_{i2}) > 1$ period unit during certain periods. What are the implications of this? In order to be able to answer this question we must investigate more closely the way in which the products are delivered. Here for the sake of simplicity we shall assume that β_{i1} is equal to zero and that deliveries are made at an even rate throughout the entire period. This means that if $(\beta_{i2}) > 1$ the firm will still receive products ordered during the period[1]). The longer the delay between decision and delivery, the smaller the proportion of plans that can be put into effect during the period and vice versa. This assumption means that if, for instance, it is observed that delivery capacity only amounts to say 75 per cent of the deliveries desired (which can be interpreted in such a way that $\beta_2 = \Sigma w_i \beta_{i2} = 1.33$; w_i is a weight) the delay of deliveries will not necessarily affect certain firms only; if $\beta_{i2} = \beta_2$ for all firms, the loss will be evenly distributed between the firms.

These assumptions simplify an analysis of the effects of delivery time on inventory fluctuations in a group of firms. To simplify matters still further we shall assume for the time being that consumption (C_t) is constant (though period 5 in the example below constitutes an exception). Consider now the following example. At an equilibrium (characterized by $L^{**} = L_t$) there occur at the beginning of a period changes in certain exogenous variables as a result of which firms wish to increase their inventories considerably. This increased demand makes for longer delivery times and the deliveries (J_t) cannot be effected within the period. By the beginning of the next period circumstances have arisen as a result of which firms wish to cut down their inventories. They now order $C_t + L^{**}_t - L_{t-1}$, in which L^{**}_t is the inventory level planned for the end of period t. As a result of the falling-off in orders[2]) the delivery times decrease and the firms' purchasing plans can be realized during the period. In the table below the example has been illustrated in figures and three more periods added. Delivery capacity has been put at 480.

On the basis of this example we shall consider three different ways of allowing for market changes of this kind.

a) According to the first hypothesis

$$\Delta L_t = \pi(L^{**}_t - L_{t-1}) \qquad 2.11.$$

[1]) Another alternative would have been to assume that the entire order was delivered at once. This means that if $(\beta_{i1} + \beta_{i2}) > 1$ but < 2 period units, a time lag of one period unit is observed between order and delivery.

[2]) Order is here taken to mean orders for consumption and increase of the planned inventories together with orders outstanding from the previous period, in other words the involuntary (unplanned) inventory reduction occurring during this period. Thus the order can also be written $C + \Delta L_t^{**}. - {}_u\Delta L_{t-1}$, where $\Delta L_t^{**}.$ is the change in planned inventories, i.e. $L_t^{**}. - L^{**}_{t-1}$, and ${}_u\Delta L_{t-1}$ is the involuntary inventory increase from the preceding period, $L_{t-1} - L^{**}_{t-1}$.

Period	L_{t-1}	L^{**}_t exogenously given	C_t exogenously given	orders $C_t + L^{**}_t - L_{t-1}$	J_t maximized at 480	$L_t = L_{t-1} - C_t + J_t$	ΔL_t	$L^{**}_t - L_{t-1}$	$\frac{\Delta L_t}{L^{**}_t - L_{t-1}}$
							Analysis for estimating γ		
1	200	300	400	500	480	280	+ 80	+ 100	0,8
2	280	230	400	350	350	230	— 50	— 50	1,0
3	230	305	400	475	475	305	+ 75	+ 75	1,0
4	305	393	400	488	480	385	+ 80	+ 88	0,9
5	385	385	500	500	480	354	— 20	0	undef.

We can see from the example that a constant π is difficult to conceive. Not only that it actually fluctuates in the example, but it presupposes a somewhat peculiar behavioural pattern in the market. To that comes that π is undefined when $(L^{**}_t - L_{t-1}) = 0$ and $\Delta L_t \neq 0$, which can happen if, as in period 5 in the example, there occur unexpected changes in consumption.

Equation 2.11., provided with a random term, can nevertheless give a fair description of ΔL_t. It should be noted in this connection that an equation in which the value of π is 0.9. will explain the development of ΔL_t better in terms of correlation than e.g. the equation $\Delta L_t = L^{**}_t - L_{t-1} + \omega_t$ in which ω_t is a random term. There is nothing intrinsically remarkable about this observation, but it is worth remembering when testing equation 2.9., which has been provided with a random term, on empirical material. The tacit assumption in an estimate of this kind is that $E(\pi) = 1$. The result obtained there cannot immediately be interpreted in such a way that the coefficient of L_{t-1} is regarded as an estimate of λ. In fact the result may have been influenced by relations described in equation 2.11., so that the coefficient obtained for L_{t-1} is to be regarded as an estimate of $\pi\lambda$[1]). It is impossible to make any pronouncement concerning the size of λ without a priori knowledge of π.

The practical importance of a π of the kind we have discussed here should increase inversely with the length of the period. If this is reduced by half in the example given, at the same time as plans are changed in the way previously indicated, the re-

[1]) Inserting equation 2.7. with $\phi(L^* - L_{t-1}) = \alpha(L^* - L_{t-1})$ in equation 2.11., we obtain $\Delta L_t = \pi\lambda(L^* - L_{t-1})$.

sultant table will be as follows[1]). Only the columns required for present purposes are included here.

Period		$L_t^{**} - L_{t-1}$	ΔL_t	J_t	$\dfrac{\Delta L_t}{L_t^{**} - L_{t-1}}$
1	200	+ 100	40	240	0,4
2	200	+ 60	40	240	0,66
3	200	— 50	— 50	150	1,0
4	200	0	0	200	undef.
5	200	75	40	240	0,55
6	200	35	35	235	1
7	200	88	40	240	0,45
8	200	48	40	240	0,85
9	250	0	— 10	240	undef.
10	250	0	— 10	240	undef.

As can be seen from the table, the average for π differs markedly from 1 at the same time as the dispersion of π increases. Delays in delivery are more clearly apparent in this example; the shorter the period the greater the delivery time in period units. This can be compared with happens to quantity $(1 - e^{-iK})$ if "i" is reduced in the continuous model. As is evident from the formula and from figure 8, this depends on the value of K. The larger K is the smaller the effect of a change in "i" on $(1 - e^{-iK})$.

b) According to the second hypothesis the mathematical expectation of the involuntary inventory increases is assumed to be zero, and the increases of different periods should be independent of one another, i.e. $E({}_u\Delta L_t) = E({}_u\Delta L_t \cdot {}_u\Delta L_{t-1}) = = 0$. This hypothesis is not satisfied in the above example. If for instance the delivery time is an endogenous variable and is determined simultaneously with ΔL_t the hypothesis is not theoretically satisfactory except in the trivial case of $(\beta_1 + \beta_2) < 1$. This is nonetheless a very common hypothesis in literature on the subject. It is justifiable here if e.g. changes in delivery times are exogenously determined and occur at random. Generally however it is based on the assumption that discrepancies between planned and realized consumption tend to cancel one another out; in order to do so they ought rather to be mutually dependent. One way of avoiding the issue is to assume that in drawing up their purchasing plans firms make allowance for the possibilities of obtaining deliveries within an estimated time.

[1]) It is assumed here for the sake of simplicity that consumption, purchasing etc. are evenly distributed over a period.

c) A third way of attempting to tackle and if possible eliminate the effect of various kinds of market inertia in the study of inventory equations such as equation 2.9. is to give the inertia-creating factors an explicit expression. Consider a single-product market which is closed in the sense that the product cannot be obtained from outside, so that delivery capacity can be estimated. Assume that the price elasticity of demand is zero within a wide interval, that the price is pegged at $\bar{p}$ and that the marginal cost of production to the suppliers of the product in question working at full capacity is $< \bar{p}$[1]). The quantity produced will then be equal to delivery capacity (CAP). Thus the equations of supply and demand will appear as follows. Consumption (C_t) is assumed as previously to be constant.

$$^{d}J = {}^{d}\Delta L_t + C_t; \; {}^{d}\Delta L_t = L^{**}{}_t - L_{t-1} \qquad 2.12.a$$

$$^{s}J = CAP \qquad 2.12.b$$

In these equations ^{d}J denotes the demanded and ^{s}J the supplied quantity.

If both 2.12.a and 2.12.b are reduced by C_t we obtain

$$^{d}\Delta L_t = {}^{d}J_t - C_t \qquad 2.13.a$$

$$^{s}\Delta L_t = {}^{s}J_t - C_t = CAP - C_t \qquad 2.13.b$$

The realized inventory increase will here be equal to the required inventory increase when capacity is greater than total demand and equal to the inventory increase supplied when capacity is less than total demand, i.e.

$$(CAP - C_t) > {}^{d}\Delta L_t \rightarrow \Delta L_t = {}^{d}\Delta L_t \qquad 2.14.a$$

$$(CAP - C_t) < {}^{d}\Delta L_t \rightarrow \Delta L_t = {}^{s}\Delta L_t \qquad 2.14.b$$

A system such as 2.14.a and 2.14.b works well as a forecast model if the structure is known. But if one wishes to obtain an estimate of it from time series data the system gives rise to problems, since it implies that ΔL_t are equal to $^{d}\Delta L_t$ for all observations. Thus, if 2.14. is a correct model $\hat{\lambda}$ the estimate of λ, will probably be biased in a direct estimate of 2.9. How then should one proceed? One way is to limit the regression to periods with large excess capacity. The probability of ΔL_t being equal to $^{d}\Delta L_t$ is greater in these periods than others; this method is probably reliable if CAP is constant all the time, since variations in $(CAP-C)$ are entirely determined by

[1]) These assumptions do not seem to deviate from reality to any great extent as far as the Swedish steel market is concerned.

${}^{d}\Delta L_t$. Alternatively one can, given an estimate of L^* ($\hat{L}^*$) make the regression for periods when

$$CAP_t - C_t > \mu\,(\hat{L}^* - L_{t-1})$$

where μ is a guestimate of λ derived e.g. from similar studies.

It seems natural to enquire whether there is any variable that my conceivably describe the imperfections of the market discussed here. The prospect does not seem very encouraging, since it is a question about restrictions which in practice are not readily discernible.

$$\Delta L_t = \lambda(L^* - L_{t-1}) \qquad 2.9.$$

The right-hand side of equation 2.9. will however be augmented with a term $(a_0 + a_1 z)$ describing the market situation. High values for z_t indicate that the market is strained, i.e. ${}^{d}J > CAP$ and purchasers' requirments are not met. When z falls there are better possibilities of satisfying demand. When $z < z_0$ supply will exceed demand (see figure 10). If we retain the behavioural assumption from equation 2.14. realized demand (J) will be equal to "real" demand (${}^{d}J$). This is illustrated in figure 10 e.g. by the fact that the curve I—I is deflected at z_0 and follows the z axis to the origin.

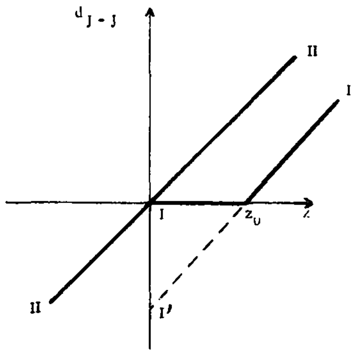

Fig. 10

Here however we shall concentrate our attention on the model behind the I—I' curve, which from the point of view of estimation seems more attractive than 2.14. According to curve I—I' different values of z uniquely determine (positive and negative) values for the difference between demand and realized purchases (${}^{d}J - J$). At a given value for consumption this difference is equal to the involuntary inventory reduction (${}^{d}\Delta L_t - \Delta L_t$). This means that the properties of the indicator do not change if the levels of ${}^{d}J$ vary. The choice of indicator will be dealt with more closely in a later section. We can note at this point that intuitively speaking it seems very difficult to obtain a satisfactory gauge.[1])

The model assumes a behaviour on the part of purchasers different from that described on page 23, where purchasers adjusted their orders according to what old orders they expected to be delivered. Here by contrast individual firms are assumed to be incapable of making assessments of this kind. When they wish to reduce their inventories they will order too much, e.g. because they are tied to old delivery times. For if all firms wish to reduce their inventory investments total demand at a

[1]) If both CAP and ${}^{d}J$ are known and producers maintain a full utilization of capacity so that purchasers receive larger deliveries than they desire during certain periods, $z = {}^{d}J - CAP$ is a direct gauge of involuntary inventory reductions (see curve II—II).

given consumption will decline, so that delivery times are reduced and purchasers acquire more inventories than they had bargained for.

It does not however seem completely unrealistic to assume that firms pay regard to the attainable when determining their purchases. At a given value of C this means that variables of a market-descriptive nature are included as arguments in the L^{**} function. As will be shown later, it is immaterial in the actual formulation of the theory in a regression equation which of the two last hypotheses for z's role are used: the importance of this decision commences with the interpretation of the estimate obtained.[1]

2.3.3.2. The effect of the choice of indicator on equilibrium inventories. The occurrence of market imperfections of various kinds can thus make it difficult to estimate the coefficients in equation 2.9. How important is the choice of indicator for L^* in this connection? Assume that we wish to test the hypothesis that λ differs significantly from 1. Assume moreover that we choose $\Sigma a_i x_i$ as indicator for L^*, in which the different x variables are assumed to describe variables incorporated in the firm's repertoire of rules of thumb. Assume finally that we obtain from the time series data the estimates $\hat{a}_1$, $\hat{a}_2$ ... $\hat{a}_n$ and $\hat{\lambda}$, where $\hat{\lambda}$ is significantly < 1. Can we draw any conclusion from this concerning the plausbility of the hypothesis? Using traditional testing procedure we decide not to reject the hypothesis but to consider it true for the time being. If instead we had tested another indicator, $\Sigma a'_i x'_i$ and obtained $\hat{\lambda} > 1$, the hypothesis would probably have been rejected pending further investigation. Both estimates can equally well be biased for similar reasons, i.e. because $\Sigma a_i x_i$ and $\Sigma a'_i x'_i$ both entail systematically incorrect measurements of the variations of L^*. In the former case ($\Sigma a_i x_i$) we are faced with an overestimate[2])

[1]) There are of course other methods of treating various kinds of market inertia apart from those discussed here. Thus Schoenman (An Analog of Short-Period Economic Change, Stockholm 1966, pp. 64—71) discusses the problem in terms of "changing lags". If one is interested e.g. in how a firm's demand for raw materials (x_1) reacts to changes in the demand for its own product (x_2), one will be concerned with the time lag between order and production and the size of raw material inventories (x_3). The approach chosen here has been to study the relation $x_{1t} = f(x_{2(t-i)}, x_{3(t-j)}, x_{4(t-k)})$ in which x_4 denotes the sellers' delivery capacity and i, j and k are constants. Schoenman studies the relation $x_{2t} \rightarrow x_{1(t+j)}$ where $j = g(x_{3t}, x_{4t})$. The latter method seems however to give rise to problems of estimation and it is difficult to find relevant testing procedures.

[2]) i.e. if $\lambda > \hat{\lambda}$.

and in the latter ($\Sigma a'_i x'_i$) with an underestimate. This can b expressed

$$L^* - L_{t-1} = b(\hat{L}^* - L_{t-1}) \qquad 2.1$$

where $\hat{L}^*$ is the estimate of L^*, i.e. $\Sigma a_i x_i$ or $\Sigma a'_i x'_i$. b is constant.

The coefficient of L_{t-1} in a direct estimate of equation 2.9 is consequently ($\lambda \hat{\cdot} b$). Clearly knowledge of λ can only b obtained from ($\lambda \hat{\cdot} b$) via a priori knowledge of b. It shoul however be pointed out that in choosing one indicator c several possible one generally also assumes that $b = 1$.

For the sake of completeness it should also be noted that λ can als be biased as a result of $\hat{L}^*$ systematically over or underestimatin L^*, i.e. $\hat{L}^* - L^* =$ constant. This is the case if one first calculate $\hat{L}^*$ and then performs the regression

$\Delta L_t = a \cdot \Delta^* \hat{L}_t$ where $\Delta^* \hat{L}_t = L^*_{t-1} - L_{t-1}$

If $\hat{L}^* > L^*$ then $a < \lambda$ and vice versa. This estimation procedur would seem the obvious course if e.g. $\hat{L}^*$ is obtained from interview of the purchasers at the beginning of each period.

2.3.3.3. A problem of estimation technique. Finally it can b noted that tests of the inventory model described by equatio 2.9. generally lead to problems of multicollinearity whicl produce uncertain estimates of little analytical value. Sinc L_t is generally autocorrelated, $\hat{L}^*$ will also, if it is a goo gauge of L^*, be correlated with L_{t-1}. This problem can b avoided if the hypothesis is tested in stages, i.e. $\hat{L}^*_{t-1}$ i estimated first and the analysis then performed in the manne specified above[1]).

2.4. Summary

The basic or working hypothesis of this study is, as was state by way of introduction in section 2, that inventory fluctuation are caused by a gap arising between an inventory level dictate by some decision rule (equilibrium inventory) and the curren inventory level. From this hypothesis a continuous inventor model (2.2.) was deduced via assumptions concerning be

[1]) The point here is that the regression analysis can do little to illustrat the effect of individual variables in the model. Given an unchange structure the model can nonetheless be useful as a forecasting instrumen namely if the exogenous variables will be correlated to each other in th same way in the future as in the past. We shall return to this estimatio problem in later sections.

$$\frac{dL}{d\tau} = K(L^*_\tau - L_\tau) \qquad 2.2.$$

havioural patterns in individual firms (the consumers). This was specified and integrated over an interval of time, giving an expression for inventory increases according to which they were a constant part of the difference between the equilibrium inventory and the actual inventory at the beginning of the interval (Equation 2.6.). The basis for an analysis of time series data is the availability of data referring to consecutive time intervals of the same size. The possibility of carrying out a meaningful test on the basis of such data was shown to depend on the development of the equilibrium inventory.

Starting from the basic assumption that firms act according to simple policy rules (rules of thumb) but that for reasons of safety and on account of the costs they consciously delay in adjusting to the levels indicated by these rules, we devised a general inventory model, the linear version of which (the flexible accelerator model, equation 2.9.) was discussed. Our final verdict on this model was that, although the assumption of a constant λ did not seem entirely realistic, there was a great deal to suggest that the model was usable in the context of forecasting, especially with regard to large inventory movements.

$$\Delta L_t = \lambda(L^* - L_{t-1}) \qquad 2.9.$$

The structural parameters of a model (or the parameters of its reduced forms) must be know before it can be used as a forecasting instrument. Particular attention was devoted to two circumstances impeding the estimation of λ, namely the influence of other forms of inertia besides those which λ is meant to reflect and the choice of an incicator for the equilibrium inventory. As a result of these circumstances, a test of 2.9. on time series data may yield an estimate of the product $(\lambda\pi b)$ instead of an estimate of λ[1]).

Some solutions to this problem of identification were advanced, particular interest being devoted to the addition of a supply equation to the model. It was found that this could be done quite simply. The model (2.14.) seemed moreover a priori to be realistic. We adopted a somewhat evasive attitude regarding the choice of an indicator for L^*: in adopting an indicator for L^*, b was given the "subjective" mathematical expectation of 1.

[1]) Since by combining 2.7., where $\phi = \alpha$, with 2.15. and 2.11. we obtain the equation $\Delta L_t = \lambda\pi b(\hat{L}^* - L_{t-1})$.

3. Determinants of inventory demand

3.1. The functions of raw material inventories

According to the approach described earlier, equilibrium inventories are determined by the rules of thumb applied by purchasers. The concept of a rule of thumb is generally used to describe a crude and simple principle of policy. The fact that it is crude and simple need not imply that it is unjustifiable from the point of view of profitability; more refined and exact estimates may (and probably often do) entail such prohibitive information costs that they are not worth using. This is probably particularly the case where inventory costs are mostly determined by a handful of dominant factors. A situation of this kind is also particularly favourable to the econometrician endeavouring with the aid of statistical observations to study the determinants of inventories and inventory movements.

In order to arrive at a meaningful knowledge of the determinants of steel inventories, the natural course would seem to be to start with the functions which these inventories are meant to discharge. These may comprise

1. facilitating the desired degree of regularity in production
2. permitting the cost savings resulting from large purchases per purchasing occasion
3. providing a buffer against a possible shortage of raw materials leading to so-called deficiency costs
4. allowing purchases to be governed by price expectations and thus reducing raw material costs.

Inventories performing the first two functions will, using what is now traditional nomenclature, be referred to as transaction inventories. These may be said to comprise a technically necessary and an economically justifiable part.

The other functions are performed by safety inventories (3) and speculative inventories (4). The last of these may be < 0, but the sum of speculative, safety and "economy" inventories must not be < 0, since the technical inventory is to be regarded as a minimum inventory.

3.2. Transaction inventories

Transaction inventories are often due to the fact that it is practically impossible to synchronize the deliveries of raw materials to the firm with the input of raw materials into process. An inventory below this minimum leads to an undesirable fall in production. Even in a completely smooth running but time-consuming production process, however, there will be a certain minimum inventory of goods in process, the importance of which we have already observed. There may however be reasons of profitability for keeping inventories above this minimum. On the one hand high average inventories entail high storage costs (interest on the capital tied up in the inventory, cost of premises, servicing and maintenance of the inventories), but on the other hand high inventories imply large purchase quantities at any one time, which in turn can mean a saving of costs in the form of discounts, reduced freight costs etc. Quantity rebates, increasing in proportion to the quantity of each single purchase, are very common in the steel market. Thus the optimum inventory depend not only on the relation between size of inventory and storage costs but also on how purchase costs vary with the quantity per procurement. Thus an increase in the interest rate employed by firms in their cost accounts, all other things being equal, will cause the optimum inventory to decline, while it will rise in the event of rises in the purchase cost per purchase (e.g. through reduced quantity rebates).

A series of decision models have been constructed during the last 10—15 years dealing with optimum inventory size in a firm.[1]) We have no cause to study these more closely in the present context, but it is interesting from the point of view of empirical analysis to note that they often result in the optimum inventory changing less than proportionally to production (cf. the so-called square root formula on which Whitin's inventory

[1]) A classical work on this subject is Arrow, Karlin and Scarf, Studies in the Mathematical Theory of Inventory and Production, Stanford Cal, 1958.

model is based, among others[1]). Thus a 10 per cent rise in the output of the engineering industry would, if the transaction motive alone were considered according to these models, lead to an increase of less than 10 per cent in steel inventories, thus implying a fall in their relative inventories (inventories/consumption).

3.3. Safety (precautionary) inventories

If we take into account the *precautionary motive* the relation between inventories and production becomes more equivocal. This motive for holding inventories is based on the uncertainty of economic assessment. Uncertainty in itself is of course no motive for holding inventories: the real reason lies in the risk of the firm losing money by suddenly finding itself bereft of inventories. The loss a firm sustains when it is unable to complete an order owing to lack of inventories is generally known as the deficiency cost. This definiency cost comprises the net profit the firm loses through the loss of sales and any loss of goodwill etc. Thus all other things being equal, precautionary inventories probably vary according to deficiency costs, which in turn reflect cost structure and profitability.

"Availability" fluctuations would appear to be particularly important in this connection. If the raw material supplies of a firm seem to be in jeopardy for one reason or another, this ought reasonably to induce the firm to endeavour to guarantee its supplies in good time by increasing its raw material inventories. The Korean War and the Suez crisis are two examples of events stimulating extraordinary inventory investments among the industries of the western world. Similarly notice of strikes generally gives rise to livelier purchasing activity than is warranted by current consumption. Thus the effect of constantly recurring strike threats in the American steel industry on inventory developments has been very much in evidence during the last decades. In this perspective an "improvement" in raw material supplies has of course the contrary effect. If the capacity utilization of the firms producing raw materials declines, this generally means a reduction of delivery times. Thus the risk of a steel consumer being prevented by shortage

[1]) See the classification of inventory models made by Holt, C. and Modigliani, F., Firm Cost Structures and the dynamic response of Inventories, Production, Work Force and Orders to Sales Fluctuations, in Inventory Fluctuations and Economic Stabilization, Part II, Washington 1961 (p. 13).

of steel from meeting a sudden rise in the demand for his product will decrease so that his need for steel inventories declines[1]).

3.4. Speculative inventories

Speculative inventories increase when purchasers, on account of anticipated price rises, acquire larger quantities of a raw material than are justified by planned consumption together with purchasing, storage and definciency costs[2]). Since these commodities will be consumed sooner or later, price speculation implies that purchasers either put forward or postpone their purchases. Price speculation is of course no independent part of the inventory policy of a firm, for the profits expected from it are balanced against increased storage costs if prices are expected to rise and against the risk of loss of output and sales if they are expected to fall.

Thus in order for an increase of inventories to be remunerative, the advantages of this increase, i.e. lower prices and possibly lower specific purchasing costs, must exceed the costs involved. Assume for instance that a purchaser expects a price rise of say 5 per cent during a period. This leads him to adjust his inventories up to the level where marginal revenues and marginal costs are the same. Assume that these expectations are fulfilled and that in planning the next period's purchases the purchaser anticipates a further price rise of the same order. This will not, ceteris paribus, cause him to increase his inventories still further. If he were to do this the additional cost would exceed the additional receipts. Thus inventory level is dependent on changes in price expectations.

Although price speculation really belongs to the domain of dynamic analysis, we can use methods from comparative statics to illustrate

[1]) In a study of inventory fluctuations in the American economy 1946—58, Thomas M. Stanback emphasized the relation between purchased materials and the availability of materials: Th. M. Stanback, Postwar Fluctuations in Business Inventories, in Inventory Fluctuations and Economic Stabilization, Part I, Washington 1961. This work seems to have had considerable influence on the formulation of the inventory equations in the so-called Brookings model: cf. The Brookings Econometric Model of the United States, Amsterdam, 1965, cap. II: 4, Factors influencing investment in inventories, by P. G. Darling and Michel C. Lovell, pp. 131 ff.

[2]) Speculation can of course concern any of the items included in the estimate of inventory profitability. However speculation of this kind can often be analysed in the same way as price speculation.

the relation between inventory and price expectations. To simplify this relation we shall employ a very simple decision model based on the following assumptions.

- Consumption of raw materials is constant over time
- The firm can obtain deliveries at certain minimum intervals, e.g. one month
- Delivery times and consumption can be foreseen in such a way that deliveries can be received for the instant stocks are exhausted
- Storage and purchasing costs are such that it is not worthwile to purchase for more than a month at a time

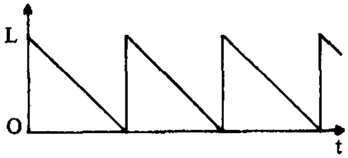

Figure 11.

It follows from these assumptions that the inventory curve will appear as in the accompanying figure and that the optimum average inventory (${}_aL_{opt}$) is equal to half a month's consumption. If now when planning purchases for month 1 we are certain that the price of the raw material, which has hitherto been stable, will rise from p to $(p + \Delta p)$ at the end of the month, it ought to be worth investigating whether we should not transfer part of our purchase for month 2 to month 1: this would imply an increase of the same size in the average inventory. (We assume that the prices of the day of delivery will apply). The situation is illustrated in figure 12, in which Δp is regarded as a marginal revenue, i.e. as the increase in the alternative or opportunity revenues resulting from a rise of one unit in the surplus inventory $({}_aL - {}_aL_{opt})$[1]. *mc* denotes the additonal costs involved, i.e. the marginal cost. Figure 12 indicates that it is worhwhile increasing inventories to $({}_aL' - {}_aL_{opt})$. It also shows that the anticipated price rise must attain a certain minimum level in order for speculative purchases to materialize at all. If when planning purchases for month 2 one is sure that the price level will again rise by Δp at the end of that month, stocks will not be increased any further because this would raise storage costs in excess of the savings effected by purchasing more cheaply. Thus no speculative inventory increase occurs, even though the outward circumstances are apparently the same as in period 1. If on the other hand one were to expect the level of prices to remain at $(p + \Delta p)$ during month 3, it would be profitable to reduce inventories to their original level, in this case the marginal receipt curve has fallen to zero.[2]

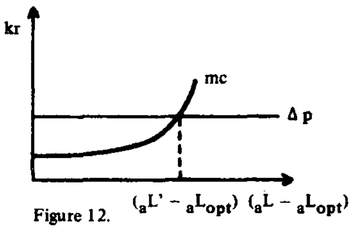

Figure 12.

One interesting question is whether firms react as vigorously to anticipated falls in prices as to anticipated price rises. Assume that the firm initially bargained for a price reduction of Δp. If the consumption of raw materials were combined with profitable output it would, according to our assumptions, not be profitable to reduce stocks, for this would entail a fall in output, the cost of which cannot be made up for during a subsequent period. If on the other hand one

[1]) During the next period one can if one wishes sell the surplus inventory for a net receipt of $\Delta p({}_aL - {}_aL_{opt})$.

[2]) In a somewhat more "interesting" model where the optimum average inventory is larger than is "technically necessary" owing e.g. to savings on large purchases, stocks will not revert entirely their previous level after the price rise, for the price rise results in increased interest charges.

could distribute the purchases between shorter delivery intervals, an inventory reduction of this kind would be worthwhile as long as the marginal yield of the resultant savings (through cheaper purchases and lower storage costs) exceeded the marginal cost, more particularly the increased purchase and deficiency costs resulting from an inventory reduction. In practice however a speculative reduction of this kind is often very much dependent on the initial situation. If stocks are very close to the level that is technically necessary, there is little possibility of speculative abstention from purchasing, while no similar restriction need apply to a speculative inventory increase. Thus with accelerating price rises foreseen by purchasers, inventory speculation continues for as long as output capacity permits: with accelerating falls in prices on the other hand, speculative inventory reductions will be curtailed when the technically necessary inventory level is reached.

Now price speculation need not refer to current inventories. In a market where the prices on the day of ordering are the prices which are charged on delivery, it should be more attractive to purchasers if possible to speculate in orders. To have orders outstanding should entail less costs than having the corresponding quantity in stock. This has led Ruth P. Mack[1]) among others to use the sum of orders outstanding and inventories ("ownership") as a dependent variable in the study of price speculation. This idea cannot however be followed in the present study, among other things for the simple and common reason that we do not have access to the relevant data[2]). There are however certain weighty objections to this procedure from the analytical point of view—apart from the fact that in our introduction we declared ourselves to be interested in fluctuations in actual inventories.

- Speculative purchases cannot be studied alone, they have to be studied together with inventory increases of other kinds, and outstanding orders would seem to be a poor substitute for transaction and precautionary inventories.
- Purchasers on the steel market have had no opportunity of fixing delivery times, they have generally had to accept the delivery times which are current. This means quite simply that inventory increases lag behind speculative orders to a certain extent. This also means that orders and inventories are not perfect substitutes for each other as regards price speculation, so that an analysis of their sum would not appear to serve any useful purpose.

The incidence of price speculation in a market probably depends on the attendant possibilities of profit and risks of loss respectively. Seen from this point of view willingness to speculate is connected with factors such as the strength of price fluctuations, the proportion of the raw material to total

[1]) Information, Expectations and Inventory Fluctuation, New York and London, 1967. See especially cap. 13.

[2]) Among other things we lack data concerning Swedish orders with foreign steelworks.

costs and the relation between the price of the raw material and that of the ultimate product. The following factors probably indicate a ready disposition to speculate, especially as regards steel consumers' steel inventories.

- As can be seen from Figure 13, prices have varied considerably. The curve referring to steel merchant's inventory prices for ordinary bars is significant of the movement of prices for ordinary steels. Thus during the periods July 1954—February 1955, March 1959—November 1959 and January 1969—September 1969 prices rose by 30, 28 and 50 per cent respectively. Prices also fell very rapidly after the peaks of 1952 and 1957. Between June 1952 and March 1953 they fell by 30 per cent. During the period July 1957—April 1958 there was a fall of 22 per cent. Downward adjust ment following the peaks of 1960 and 1964 however proceeded far more slowly.

  The prices of certain other products than steel bars have fluctuated still more violently. Ordinary plates (over 9 mm thick) are a case in point. Thus the price in January 1955 was Skr. 55 per 100 kg. By April 1957 this had risen to Skr. 110, staying at this level up to and including September the same year. By December 1958 it had fallen again to Skr. 55. The rate of increase during the boom period 1968—69 was 70 per cent in ten months.

- Steel costs probably constitute such a large proportion of the total costs of the engineering industry as a rule that successful speculative purchases have a considerable effect on profits. It is difficult to illustrate statistically the proportion of steel costs defined in this way. The interesting figures in this connection concern the relative size of steel costs to the steel-purchasing producers, i.e. the direct steel consumers. The information provided by the available statistics refers to the value of steel purchases in relation to the sales value of the output of a wide range of enterprises. An average of this kind is of limited value if its distribution is wide and skew[1]). But the average for the engineering

[1]) The importance of distribution can be illustrated by the following example: Two branches both exhibit a steel cost proportion of 5 per cent. The distribution of this proportion in one is normal with a standard deviation of 0.2 per cent. The distribution in the other is such that for 20 per cent of the firms steel costs amount to 25 per cent of total costs while the other firms do not use any steel. If the hypothesis that the proportion of steel costs is positively correlated to willingness to speculate is correct, then the incidence of speculation, all other things being equal, will be greater in the latter branch than in the former.

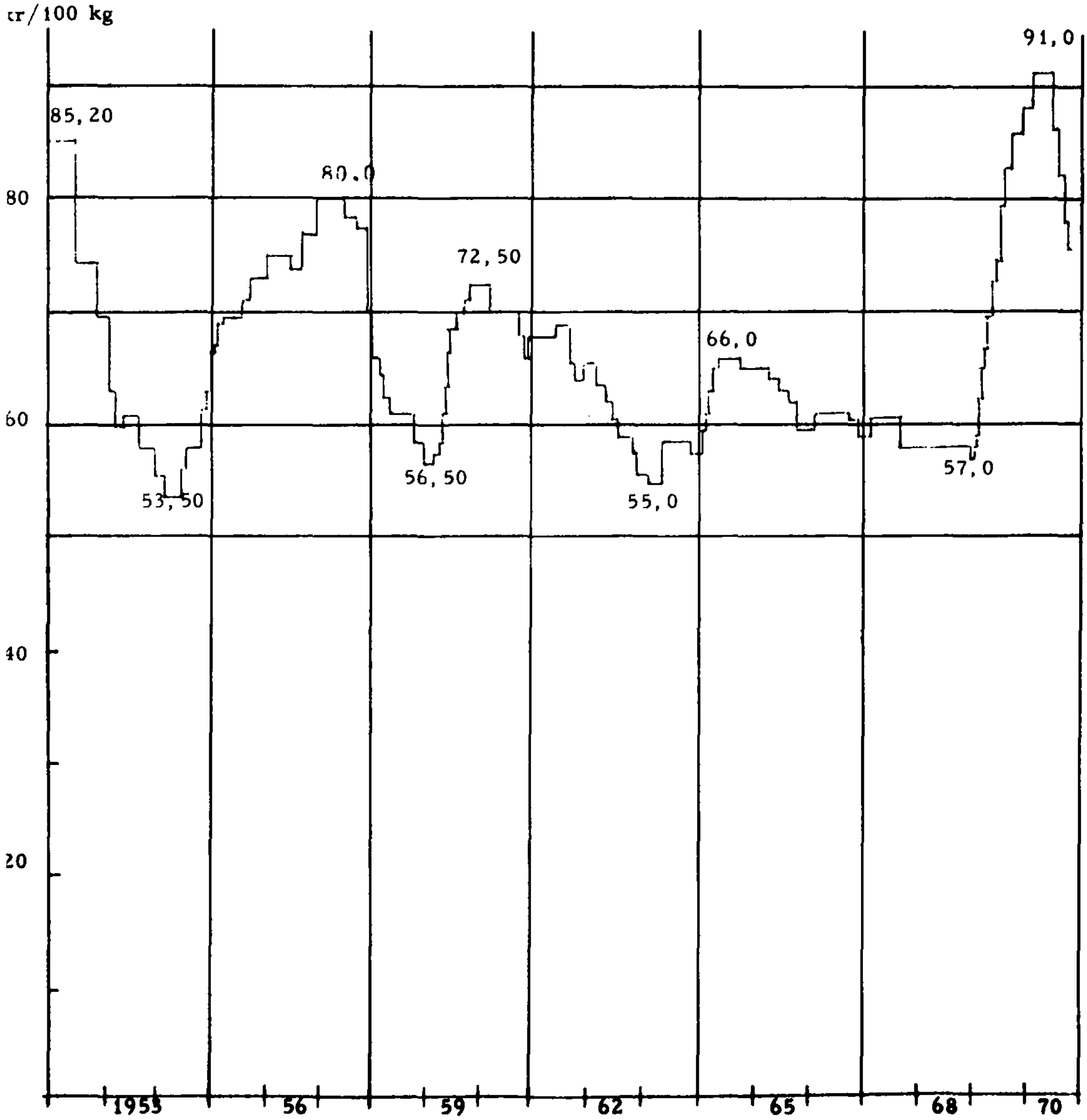

Fig. 13

industry is so large as to render the effect of steel costs on profitability obvious. A steel costs fraction for the sub-branches of iron and steel manufacturing, transport production (excluding shipbuilding) and other engineering industries between 1965 and 1967, weighted according to the proportion of purchases of steel to total steel purchases, amounted to 10.5. per cent Average gross profits calculated in the same way for the same period in relation to turnover were just over 8 per cent[2]).

The pricing of the products of the engineering industry is probably important in this connection. Thus if firms apply a flexible markup pricing whereby changes in raw material prices are rapidly transferred to the prices of the finished products, the potential profits of price speculation are reduced considerably. This is however probably not the case in the Swedish engineering industry. Judging by the price indices for various kinds of engineering products, which are admittedly not altogether relevant in this context, prices would seem to be fairly rigid. Thus variations in the prices of raw materials are not evened out by means of corresponding changes in the prices of engeineering products but are allowed to express themselves in the profit margins.

As regards engineering products where Swedish firms are competing within narrow limits against foreign firms, it is important to note that the amplitude of variations in steel prices is far greater in Sweden than e.g. in Western Germany, Great Britain and the USA[3]).

The ability to foresee price rises in time would therefore appear to be an important precondition of competitivness.

- Price variations have followed a strikingly even pattern, i.e. trends in price movements have been relatively uniform. Thus once a price rise has got underway following a low it has lasted for at least a year, thus making price speculation a comparatively safe pursuit.

There are however certain factors that inhibit speculation as regards steel inventories. One of these is the risk of corrosion, which is determined among other things by climatic conditions. The fact that steel is bulky and the consumers' storage space is limited means that many firms soon reach the stage where marginal storage costs begin to rise fast. Finally it is worth mentioning that no small proportion of steel demand concerns special qualities and dimensions, which in turn are connected with tailor-made engineering products. This sector of the steel market cannot readily be made the subject of price speculation unless future consumption is known far in advance.

[2]) The figures for steel cost proportions have been calculated from tables 1 and 5 respectively in the Annual Statistics on Industry. The gross profits proportion is derived from the Corporation Statistics (»vinststatistiken»). The numerator shows profits before depreciation, the denominator shows gross turnover, i.e. the sixth row in table 6 divided by row 3 in the same table. See Industry 1965, 1966 and 1967 and Företagen for the same years (Swedish Official Statistics).

[3]) See L. Fridén, op. cit.

3.5. Summary

In this section we have really discussed four groups of determinants of steel consumers' equilibrium inventories under three headings, namely the size of consumption, direct and indirect (via the size of purchases) costs attaching to different inventory levels, the state of the market (delivery times) and price expectations. The optimum raw material inventory is determined simultaneously with production and consumption, which in turn are affected by demand and delivery conditions, etc. One can therefore appreciate that optimum inventory accounts tend to be very complicated. Here however we have at an early stage advanced the working hypothesis that firms apply simple rules of policy in determining their inventories. Consequently we shall assume that according to the *primary* rule of decision firms endeavour to adjust their inventories to anticipated consumption. We shall however assume that this primary rule is modified by factors indicating the market situation and price expectations[1]).

[1]) These general hypotheses can be expressed

a. ${}_TL^* = f_1(C^*)$; $f'_1 > 0$
b. ${}_PL^* = f_2(\chi)$; $f'_2 > 0$
c. ${}_SL^* = f_3(P^* - P)$; $f'_3 > 0$
d. ${}_TL^* + {}_PL^* + {}_SL^* = L^*$; ${}_TL \geqslant \Gamma$

in which ${}_TL$ denotes transaction inventories
${}_PL$ » precautionary »
${}_SL$ » speculative »

and where χ is a quantity descriptive of the business situation and where Γ is the technically necessary inventory level.

4. Models for investments in steel inventories by steel consumers

4.1. Recapitulation

In our analysis of variations in finished steel inventories we took as our starting point the idea of an equilibrium inventory (L^*). This equilibrium inventory can be attributed to a decision rule and is determined by the level of the quantities incorporated in the rule. In the event of a discrepancy between equilibrium and actual inventories the decision rule will lead to an inventory change. In chapter 2 we discussed some important factors determining the speed at which this difference is reduced, in other words the speed of inventory adjustment. Here we began by noting that this adjustment was conditioned by costs entailed by varying purchases and by the risk attitudes of steel consumers. In this connection we also remarked on circumstances which could cause actual purchases to deviate from what had been planned, resulting in involuntary inventory holding. Inventories of this kind can however also arise as a result of consumption during a given period differing from what had been planned for that period. The consideration (explicit or implicit) of involuntary inventory increases is of great importance in statistical studies of inventory equations in general and has, as we shall see, dominated the disposition of the statistical analysis of steel consumers' steel inventory fluctuations put forward in the present work.

4.2. The general approach

The equations estimated in the statistical study described later on are based on the equation

$$L_t = L^*_{t-1} + (J_t - J^*_t) - (C_t - C^*_t) \qquad 4.1$$

where L^*_{t-1} is the equilibrium inventory indicated by the firms' estimates (rules of policy or thumb) at the end of period $(t-1)$. We shall assume that the equilibrium level is constant throughout the period. J^*_t is the purchase required in view of the planned consumption (C^*_t) in order for L^*_{t-1} to be attained by the end of period t.

The expression $(J_t - J^*_t) - (C_t - C^*_t)$ can be described as unplanned inventory holding, i.e. the result of purchases and consumption not proceeding according to plan. The unplanned inventories may be < 0[1]).

It is worth emphasizing that the significance of planned purchases and unplanned inventories is directly related to the quantity L^*. If for instance $L^*_t \neq L^{**}_t = L_t$ then an unplanned inventory exists at time t even though the inventory level actually attained is equal to the level required at the beginning of the period for the end of the period (L^{**}_t). Thus unplanned inventories are not identical to involuntary inventories as previously defined by us, namely ${}_uL_t = L^{**}_t - L_t$, The reason for equation 4.1. not being written in terms of L^{**} is that it is far more difficult in certain cases to find measures of L^{**} than of L^*, e.g. when L^{**} is determined in the way described in equation 2.7. When $\phi(L^* - L_{t-1})$ has the expectation of 0, i.e. when inventories are to be completely adjusted to the equilibrium level in a period, both approaches coincide. Since we shall be keeping to the definition given in 4.1, "involuntary" will in what follows be used as a synonym of "unplanned".

$L^{**}_t = L^* - \phi\,(L^* - L_{t-1})$

One can obtain $\Delta L_t = L_t - L_{t-1}$ from equation 4.1. either by taking the first difference of all the terms or by subtracting L_{t-1} from both terms. If these operations are effected we obtain.

$$\Delta L_t = \underbrace{\Delta L^*_{t-1}}_{\substack{\text{change in}\\ \text{equilibrium}\\ \text{inventory}}} + \underbrace{\Delta[(J_t - J^*_t) - (C_t - C^*_t)]}_{\substack{\text{change in}\\ \text{involuntary}\\ \text{inventory}}} \qquad 4.2.$$

[1]) According to these definitions unplanned inventories at the end of period t are equal to the unplanned inventory increase occuring during the period, which in turn accordingly is not the same concept as that of the increase of unplanned inventories. The latter concept is the first difference of unplanned inventories with respect to time.

and

$$\Delta L_t = \underbrace{L^*_{t-1} - L_{t-1}}_{\begin{array}{l}\text{Initial difference}\\ \text{between equilibrium}\\ \text{inventory and actual}\\ \text{inventory}\end{array}} + \underbrace{(J_t - J^*_t) - (C_t - C^*_t)}_{\begin{array}{l}\text{terminal}\\ \text{involuntary}\\ \text{inventory}\end{array}} \qquad 4.3.$$

These two equations express the same thing in different terms, so that it might appear superfluous to state both definitions. They will however each provide the platform for a group of hypotheses divided with regard to the treatment of involuntary inventories.

The general hypotheses which will be considered here are:

1. Involuntary inventories vary stochastically around zero, as do each of their two components, $(J - J^*)$ and $-(C - C^*)$.
2. Unplanned consumption $(C - C^*)$ varies stochastically around zero while the difference between actual and planned purchases $(J - J^*)$ varies systematically.
3. Involuntary purchases vary stochastically around zero while unplanned consumption varies systematically.
4. Both involuntary purchases and unplanned consumption vary systematically.

According to the first hypothesis concerning involuntary inventories, which more exactly can be formulated $E\,({}_uL_t) = E\,({}_uL_t \cdot {}_uL_{t-j}) = 0$, 4.2. can be written[1])

$$\Delta L_t = \Delta L^*_{t-1} + \epsilon_{at}; \qquad 4.4.a$$
$$E\,(\epsilon_{at}) = E\,(\epsilon_{at} \cdot \epsilon_{a(t-1)}) = 0$$

Concerning the three remaining hypothesis we shall distinguish between *two cases*, namely the case where the systematically varying quantities can be described as a function of some exogenous variable and the case where systematic variation causes actual inventory changes during a period to be proportional to the difference between equilibrium inventory and the actual inventory at the beginning of the period.

In the former of these cases, as in hypothesis 1, equation 4.2. is the natural point of departure. Applying the second hypothesis we can now express this equation

$$\Delta L_t = \Delta L^*_{t-1} + \phi\,(\Delta \zeta_t) + \epsilon_{bt} \qquad 4.4.b$$

[1]) $E({}_uL_t) = E({}_uL_t \cdot {}_uL_{t-1}) = 0 \Rightarrow E(\Delta_u L_t) = E(\Delta_u L_t \cdot \Delta_u L_{t-1}) = 0$

where $\phi\ (\Delta\xi_t)$ is an indicator of $\Delta(J_t - J^*_t)$ — cf. p. 168 — and where ϵ_{bt} is a random variable with the same properties as ϵ_{at}.

If we apply hypothesis 4, equation 4.4.b will be augmented by a quantity which is assumed to comprise an approximation of $\Delta(C_t - C^*_t)$.

The second case can perhaps best be illustrated by re-writing equation 4.3. as

$$\Delta L_t = A\,(L^*_{t-1} - L_{t-1}) + \omega_t \qquad 4.5.$$

where $A = 1 + \dfrac{(J_t - J^*_t) - (C_t - C^*_t)}{L^*_{t-1} - L_{t-1}}$, which is presumed to be constant. ω_t is a random variable.

Systematic variations in the adjustment process can be entirely attributed to the term $(J_t - J^*_t)$, if $(C_t - C^*_t)$ is a random variable. In this context we can choose between three sub-hypotheses.

$\Delta L^{**} = \lambda\,(L^*_{t-1} - L_{t-1})$

- The systematics in $(J_t - J^*_t)$ are of the kind described in equation 2.9., such that $E(A) = \lambda$.

$\Delta L_t = \pi\,(L^{**}_t - L_{t-1})$

- The systematics are of the kind indicated by equation 2.11., such that $E(A) = \pi$.

$\Delta L_t = \pi\lambda\,(L^*_{t-1} - L_{t-1})$

- The systematics due to both the above described forms of adjustment inertia. In this case $E(A) = \pi\lambda$.

4.3. Two methods of approach

4.3.1. The initial situation. In the previous section two equations for inventory increases or inventory investments were derived from the basic model for inventory level (4.1.). These equations formed the starting point for two main groups of models for steel inventory investments. The groups were divided up in terms of hypotheses concerning involuntary inventories.

There is however a special reason for effecting a further division of approach in this context. This division is occasioned by the statistical background, there being no data concerning steel inventories in the engineering industry for periods of less than one year during the period covered by this study.

The observation interval of one year probably comprises too great an aggregation over time to permit a closer illustration of the cyclical phenomena[1]) which have prompted this study.

[1]) Cyclical variations in a variable x_t are taken here to mean systematic non-seasonal variations around a trend for this variable. This trend is considered here as being arithmetically or logaritmically linear, i.e. $\hat{x}_t = a + b \cdot t$ or $\hat{x}_t = Ae^{B \cdot t}$; $t = 0, 1, 2, \ldots n$.

If one wishes to a acquire knowledge of speculative purchase or precautionary inventory increases, events in many market the steel market included, are probably too fast-moving to b described annual data which indeed may even travesty then To this it might be objected that events of this kind ar irrelevant from the point of view of firms and society alik In fact however a speculative cycle can be important fc considerably longer periods of time although it is apparentl filtered off completely or very nearly in annual data[2]). Thu a speculative rise in demand can stimulate investment b steelworks and so have the effect of raising capacity. Th course of events on the continental steel market during th boom period of 1968—69 lends itself to such an interpretatio

Although we do not have access to quarterly or half-yearl data for steel consumption and inventory investments b consumers, the statistical situation is by no means hopeless for we have statistics of the sum of these components, namel deliveries to the engineering industry or—keeping to th terminology we introduced earlier—the realized purchases o the engineering industry. This gives us reason to conduct ou analysis in two ways, referred to here as the *direct* and *indirec* methods respectively.

4.3.2. Direct method. The direct method entails the calculatio via the construction of a quarterly series for consumptio (^cC_t) of the steel inventory investments of the engineerin industry as the difference between realized purchases an estimated consumption. (See definition 1.5.). The quantit thus obtained ($^c\Delta L_t$) is used as a dependent variable in th testing of different inventory models. Thus we begin by cal culating

$J_t = C_t + \Delta_c L_t$ 1.5.

$$^c\Delta L_t = J_t - {}^cC_t;\ \text{unit period} = 1\ \text{quarter}. \qquad 4.6$$

Next we study relations of the type

$$(L^*_{t-1} - {}^cL_{t-1}) \rightarrow {}^c\Delta L_t$$

$\Delta L_t = \Delta L^*_{t-1} + \epsilon_{at}$

$\Delta L_t = A\,(L^*_{t-1} - L_{t-1}) + \omega_t$

where we shall base our estimate on equations 4.4. and 4. respectively. The index c in 4.6. denotes that the variables i question are calculated and not directly observed.

The calculation of quarterly steel consumption is describe in the appendix. Here it will suffice to mention that annua

[2]) The problems connected with time aggregation are dealt with i section 4.4.

figures for steel consumption have been divided into quarters on the basis of employment figures. Thus the calculation method entails the assumption that steel consumption for brief periods can be described as a function of employment. Other bases of division are also considered in the appendix.

Apart from giving an acceptable explanation of the estimated inventory increases, a meaningful analysis of inventory variations by the direct method should also contain a meaningful description of the estimated consumption. Otherwise one cannot be sure as regards fluctuations in inventory investments of having obtained a good agreement between model and "reality" at the cost of a puzzling consumption series.

4.3.3. Indirect method. The term indirect method alludes to the fact that we are analyzing inventory investments via a study of purchases. In applying this method we proceed more explicitly than in the preceding case from definition 1.5., according to which realized purchases are equal to the sum of consumption and inventory increase. Here different inventory models—each coupled with the assumption that steel consumption is proportional to the steel consumers' (the engineering industry's) production—are confronted with data on realized purchases.

Steel inventory investments by consumus is indirect method conseventy studied from the following relation.

$$J_t = bQ_t + \varDelta L^*_{t-1} + \varDelta\,(J_t - J^*_t) - \varDelta\,(C_t - C^*_t) + \omega_t \quad 4.7.$$

in which Q_t is an indicator of production within the engineering industry and where ω_t is a non autocorrelated stochastic variable with zero mean.

This equation can be modified and reformulated in many ways according to one's assumptions regarding the increase in involuntary inventories, i.e. $\varDelta\,(J_t - J^*_t) - \varDelta\,(C_t - C^*_t)$.

$\varDelta L_t = AL^*_{t-1} + \epsilon_{at}$

$L_t = \varDelta L^*_{t-1} + \phi\,(\varDelta\zeta_t) + \epsilon_{bt}$

Equation 4.7. combined with equations 4.4.a and 4.4.b gives us

$$J_t = bQ_t + \varDelta L^*_{t-1} + \omega_{1t} \quad 4.8.$$

and

$$J_t = bQ_t + \varDelta L^*_{t-1} + \phi\,(\varDelta\zeta_t) + \omega_{2t} \quad 4.9.$$

However equations 4.8. and 4.9. do not include all the variants that will be tested in applying the indirect method.

Thus we shall be devoting attention to a model in which speci regard is paid in the estimation of the parameters to an systematic difference between actual and unplanned consump tion $(C_t - C^*_t)$. We shall quite simply try to measure thi with $b\,(Q_t - Q^*_t)$. This means that we shall make a close examination of the relation.

$$J_t = bQ_t + \Delta L^*_{t-1} + b\Delta\,(Q_t - Q^*_t) + \eta_t \qquad 4.1($$

This and other equations will be described at length in chap 6 and 8[1]).

Thus the test procedure for the indirect method consist in studying how ΔL determinants together with Q_t explain J with a view to drawing conclusions concerning the explanator value of the built-in inventory model. The success of this metho depends entirely on the correctness of our hypothesis regardin consumption. The more nearly bQ_t describes C_t the mor closely the results of the indirect method resemble the result that would have been obtained if the direct method had bee applied. (We here disregard any correlation between Q_t an the inventory investment determinant variables.)

There is one reason in favour of using the indirect metho even when there are quaterly observations of ΔL_t available These are almost invariably calculated in such a way that e.g in the case of raw materials the identity $C_t + \Delta L_t = J_t$ alway applies. This means that the errors of measurement are no independent. Assume that ΔL_t is formed from observations o L_t while C_t is "observed" as a residual between J_t and ΔL In this case an underrestimate of ΔL_t is bound to lead to a overestimate of C_t and an estimate of a relation $\Delta L_t = a\Delta C$ or of a relation $\Delta L_t = a\Delta C_{t+1}$ can give totally misleadin values for a. In both cases the parameter value will (probabl have a negative bias[2]).

[1]) In this approach it will be assumed that the equilibrium inventory the end of $(t - 1)$ also is the inventory level firms want to have at th end of period t, i.e. $L^*_{t-1} = L_t^{**}$.

[2]) J_t and L_t are observed. ΔL_t and C_t are formed by taking the fir difference of L_t and by subtracting ΔL_t from J_t. In the observation L_t there occur measuring errors such that $L_t = L^s_t + \mu_t$, where L is the true value and μ_t a non-autocorrelated error of measureme with a mean value of zero. According to the assumptions the errors measurement in $\Delta L_t + C_t$ and ΔC_t will be $\Delta\mu_t$, $-\Delta\mu_t$ and $-\Delta^2\mu$ Thus the simultanous inventory model should be written

$$\Delta L_t = a\Delta C_t + \omega_t$$

$$\omega_t = \Delta\mu_t + a\Delta^2\mu_t$$

4.4. Summary

The equations which are to be tested on statistical material have two main characteristics, namely the choice of dependent variable (ΔL_t or J_t) and the choice of hypotheses regarding involuntary inventories. In the latter case the fundamental distinction is whether the difference ($L_t - L^*_t$) can be regarded as a non-autocorrelated random variable with a mean value of zero or whether it is characterized by systematic (and considerable) variations. The problem of systematic variations in involuntary inventories has in turn been given two alternative principal solutions; it has been assumed that this phenomenon can be described with variables or as a constant multiple of the difference between equilibrium and actual inventories. Thus the equations can be organized as shown below.

General model $(L^*-L_t)\rightarrow\frac{dL}{dt}$	Direct method	non-systematic	$^{c}\Delta L_t = \Delta L^*_{t-1} + \epsilon_{at}$	(4.4.a.)
		systematic	$^{c}\Delta L_t = \Delta L^*_{t-1} + \phi(\Delta\zeta_t) + \epsilon_{bt}$	(4.4.b.)
			$^{c}\Delta L_t = A(L^*_{t-1} - L_{t-1}) + \omega_{at}$	(4.5.a.)
			$^{c}\Delta L_t = A(L^*_{t-1} - L_{t-1}) + \phi(\Delta\zeta_t) + \omega_{bt}$	(4.5.b.)
	Indirect method	non-systematic	$J = bQ_t + \Delta L^*_{t-1} + \eta_{at}$	(4.8.)
		Systematic	$J = bQ_t + \Delta L^*_{t-1} + \phi(\Delta\zeta_t) + \eta_{bt}$	(4.9.)
			$J = bQ_t + \Delta L^*_{t-1} + b(\Delta Q_{t-1} - \Delta Q^*_{t-1}) + \eta_{ct}$	(4.10.)

It can be demonstrated that a least square estimate of "a" is biased and inconsistent (see e.g. J. Johnston, Econometric Methods, New York 1963, cap. 6). By the latter is meant that the bias cannot be avoided by increasing the size of the sample. A least square estimate of a based on T observations gives, if the errors of measurement are presumed independent of the true values:

$$\hat{a}_T = \frac{\sum_{t=1}^{T}(\Delta L_t - \overline{\Delta L})(\Delta C^s_t - \Delta\bar{C}^s) + \sum_{t=1}^{T}(\Delta\mu_t - \Delta\bar{\mu})(-\Delta^2\mu_t + \overline{\Delta^2\mu_t})}{\sum_{t=1}^{T}(\Delta C^s_t - \Delta\bar{C}^s) + \sum(-\Delta^2\mu_t + \overline{\Delta\mu 2_t})} =$$

$$= \frac{a}{1 + \mathrm{var}(\Delta^2\mu_t)/\mathrm{var}(\Delta C^s_t)} + \frac{\mathrm{cov}(\Delta\mu_t, (-)\Delta^2\mu_t)/\mathrm{var}(\Delta C^s_t)}{1 + \mathrm{var}(\Delta^2\mu_t)/\mathrm{var}(\Delta C^s_t)}$$

If the random variables are independent of each other $\hat{a}$ is an underestimate of a. The size of the bias increases with the variance in the error in the measurement of ΔC^s. If the random terms $\Delta\mu_t$ and $-\Delta^2\mu_t$ are correlated, which does not appear unlikely in the present context, the bias increases still further.

The general hypothesis is that the inventory fluctuations studied are mainly brought about by fluctuations in demand. Four of the equations are in fact pure demand equations. Equations 4.4.b., 4.5.b. and 4.9. constitute exceptions to the general hypothesis in that they contain "supply elements". They can be regarded as reduced forms of demand and supply models in which the supply equation is of the very simple variety described in section 2.10.

In chapters 2 and 3, ΔL^* was given a "theoretical content". In order to be able to test the model the theoretical quantities discussed there must be replaced with available statistical indicators. In the following chapter we shall deal briefly with such indicators and their relation to corresponding theoretical quantities. First however we shall digress somewhat to deal with some of the problems that arise when a theory is applied to data which in one sense or another refer to sums of the variables in which the theories are originally formulated.

4.5. Some points concerning aggregation

We began by a summary of observations of annual changes in consumers' inventories of finished steel. Our observations prompted the question: What has determined these inventory fluctuations? The observations and the primary question concern a sum of products (finished steel of all qualities and forms), a sum of firms (all manufacturing firms) and a certain length of period (one year). These properties can be said to characterize the aggregation or system level of the observations and the inquiry respectively.

Although this question may be highly relevant to both firms (e.g. steel producers and mining companies) and authorities this does not necessarily mean that it can be analyzed at the same system level as it is put. In order for an analysis at a certain system level to be meaningful one must be able to find relations that are stable in the sense that they have a certain minimum duration and fulfil certain minimum requirements of precision.

Our aim with this excursus is among other things to demonstrate the implications of the requirement of stability in this particular context. We shall also briefly explain our choice of system level so as finally to draw attention to what in this connection is the important relation between model formulation and aggregation level with respect to time.[1])

[1]) The classical work in the field of aggregation is Theil, H., Linear Aggregation of Economic Relations, Amsterdam, 1954. This book treats

The usual procedure when constructing aggregated models or macromodels is to start with a micromodel and then give the macromodel a similar form. This analogy formation generally proceeds on an intuitive basis[1]) without any logical transformation from micro to macro theory. A simple example will serve to illustrate the implications of this procedure. Assume that we believe in a theory of the raw material consumption of the individual firm, y_i, (micromodel). On the basis of this we formulate a "similar" theory of the raw material consumption of the branch, y, (macromodel). The production of the firm and branch respectively is included as the sole dependent variable (x_i and x respectively). The analysis can be described in the table and figure on the following page[2]).

In the table the aggregation procedure has been given a general and a specified version, of which we shall concentrate our attention on the latter, where a_i and a are treated as constant parameters. Clearly—if the micro-theory is true—the macro-relation formulated can only apply in special cases. The interesting question is what result an estimate of the macro-relation will give. Theil has shown that an estimate of the macro-equation using the least square method for the period ($t = 1, 2, \ldots T$) results in "macro-parameters" which are not only dependent on corresponding micro-parameters.

[1]) See Bentzel, op.cit., p. 2.
[2]) Cf. Malinvaud, op.cit., p. 77.

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the problems of aggregation from both its economic and statistical aspects. Theil's work has been lucidly presented in R.C.D. Allen, Mathematical Economics, chapt. 20, 2nd,. ed., London 1959. A general outline of aggregation problems is given in E. Malinvaud, L'aggregation dans les modèles économiques, Cahiers de Seminaire d'Econométrie, No. 4, Paris 1956. Malinvaud's outline is rather abstract and predominantly a work of scientific theory but ought nonetheless to be of great use to empirical students. Swedish works on aggregation include R. Bentzel, Om aggregation av produktionsfunktioner, in 25 Economic Essays in Honour of Erik Lindahl, Stockholm, 1956, Bengt Höglund, Modell och Observationer, Lund, 1966 and H. Lütjohann, Om en typ av aggregation vid linjär regressionsansats, stencil, Stockholm University, 1965. Chapt. 14 of the last-mentioned work is an introductory outline of different hints of aggregation in regression.
The few pages of the present work devoted to the problem of aggregation are based principally on the works by Allen and Malinvaud, Reference is also made to H. A. J. Green, Aggregation in Economic Analyses, chapt. 12 (Aggregation and Estimation), N. J. 1964.

	general model	linear model with simple summation of micro-variables
micro-model	$f_i\colon x_i \to y_i$	$y_i = a_i x_i + k_i; \quad i = 1, 2, \dots n$
aggregation principle	$g_i\colon x_i \to x$ $h_i\colon y_i \to y$	$x = \sum x_i$ $y = \sum y_i$
applied macro-theory	$f\colon\ x \to y$	$y = ax + k$

$$
\begin{tikzcd}
x_i \arrow[r, "f_i"] \arrow[d, "g_i"'] & y_i \arrow[d, "h_i"] \\
x \arrow[r, "f"'] & y
\end{tikzcd}
\qquad
\begin{tikzcd}
x_i \arrow[r, "a_i x_i + k_i"] \arrow[d, "\sum x_i"'] & y_i \arrow[d, "\sum y_i"] \\
x \arrow[r, "ax + k"'] & y
\end{tikzcd}
$$

In fact

$E(a) = \sum a_i \alpha_i$ and

$E(k) = \sum k_i \kappa_i + \sum k_i$

where $\quad \alpha_i = \dfrac{\sum (y_{it} - \bar{y}_i)(y_t - \bar{y})}{\sum (y_t - \bar{y})^2}$ and $\kappa_i = y_i - \alpha_i \bar{y}$;

$\sum \alpha_i = 1$ and $\sum \kappa_i = 0$

The expressions of the macro-parameters can be re-written as[1])

$E(a) = \bar{a} + n \operatorname{cov} (a_i \alpha_i)$ and

$E(k) = \sum k_i + n \operatorname{cov} (a_i \kappa_i)$

The estimates of both a and k are normally dependent on the length of the observation period and k also depends on the non-corresponding a_i. If the model is enlarged to include more variables so that $y_i = \Sigma a_j x_j + k$; $j = 1, 2, \dots$ m, $E(a_j)$ would be dependent on all—corresponding and non-corresponding—micro-parameters.

What is the practical significance of this aggregation bias? More exactly, what significance does it have in the context of forecasting—i.e. when we wish to determine y at givent values of x or x_j? In the above example the question concerns the stability of a and k.

[1]) Cf. Allen, op.cit. p. 700. $\bar{y}_i$, $\bar{y}$ and $\bar{a}$ denote the artithmetical averages of the variables y_{it}, y_t and a_i respectively.

We have already observed that, since a_i is the regression coefficient in a simple regression between y_{it} and y_t which refers to observations for the periods $1, 2, \ldots T$, an estimate of a_i and consequently of a for another period, say $(T+1, T+2, \ldots T+s)$ will give different results, unless

- all firms have the same marginal propensity to consumption, i.e. $a_i = a$ or
- the distribution of production between different firms is constant or—speaking in rather more general terms—is described by a stable stochastic model, i.e. $y_{it} = a_i y_t + k_i + \epsilon_t$ where a_i and k_i are real parameters and ϵ_t is a random variable with the mean value 0.

Thus in a forecasting situation the predictive value of the macro-model estimated on time series data is dependent among other things on the dispersion of a_i and on how much the distribution of production will be changed[1]). The smaller the dispersion in a_i the better—all other things being equal—the macro-model will work as a forecasting model. Its forecasting value also improves the more similarity there is between the growth rates of the individual firms, i.e. when the production of each and every one of them tends to develop in proportion to total production. If the model is enlarged to include several independent variables it will become more difficult to interpret the relations between the coefficients of the micro and macro-relation, but these relations are in principle the same as those described above[2]).

[1]) As will be seen from the appendix, we have in fact tried in practice to arrive at this situation by using another aggregation principle for x_i instead of a simple summation namely weighting the production of groups of firms with their average steel consumption per product unit, This can be said to constitute an approximation of the aggregation principle which makes the macro-model an exact relation for steel consumption, i.e. according to which $x = (1/\bar{a})\Sigma a_i x_i$; $\bar{a} = (1/n)\Sigma a_i$, (cf. Allen, op.cit., p. 698); the production of the various firms is weighted with their marginal propensity to consume.

[2]) Thus if the micro-model is $y_i = \Sigma_j a_{ij} x_{ij}$ and the macro-model $y = \Sigma a_j x_j$, where $i = 1, 2, \ldots n$ and $j = 1, 2, \ldots m$ then the coefficient for x_p will be the arithmetical mean of the micro-coefficients a_{ip} plus an aggregation bias:

$$a_p = \frac{1}{n} \Sigma_j a_{ij} + n\Sigma_j \operatorname{cov}(a_{ij}, a_{ij.p}); \ \Sigma_i \, a_{ij} = 1$$

These variances only disappear when $a_{i1} = a_{i2} = \ldots = a_{im}$ for all i, The aggregation can however be consistent when the variables x_{ij} can be described for each j with a stable stochastic model of the corresponding macro-variable x_j.

In this study the aggregation level for firms is a branch, namely the engineering industry. This does not mean that we have found it useful to construct a behavioural model with a branch as acting subject. The general models outlined in the preceding section (4.4.) are intended to be tested on data for the engineering industry but they are based on ideas concerning the behaviour of the individual firms. So far we have confined ourselves to obtaining a few factors of importance in the inventory planning of firms on the basis of economic theory and experiences from other empirical studies[1]).

Thus the micro-functions for equilibrium inventories have not been exactly defined but describe L^* as an unknown function of variables representing transaction, precautionary and speculative motives for inventory holding. Aggregation consists as a rule of a simple summation[1]). The macro or branch function for the equilibrium inventory describes this as a function of variables corresponding to the independent variables of the micro-function. Thus this aggregation simply means that if a variable occurs in a micro-function it is also included, unchanged or aggregated in the macro-function.

Thus in spite of what was said earlier concerning the prejudicial effects of aggregation, the statistical analysis is carried out at branch level. The main reason for this is that not enough data are available for a more refined analysis and that to obtain micro-data would entail very great difficulties and considerable costs. The natural procedure would therefore seem to be to begin by trying to improve our knowledge of the market in question by using available aggregated data. If a study of this kind enables us to define stable relations, these can be used as a basis for both forecasting and the formation of hypotheses in a more penetrating study.

We do however have certain possibilities of improving our initial situation by making use of available external information. We are interested in relations of the type

$$\Sigma_i J_{it} = \Sigma_i(a_{i1} Q^*_{it} + a_{i1} a_{i2} \Delta Q^*_{i(t+1)} + a_{i3} \Delta^2 p_t);$$
$$i = 1, 2, \ldots \mathrm{m}$$

In estimating the corresponding macro relation from aggregated data one can probably improve the situation by weighting

1) The occurrence of a few predominant determinants is in fact crucial in practically all econometric studies where the availability of observations puts severe limits on the number of variables in an equation.

the production of different groups of firms with steel consumption per product unit in each group, instead of forming a simple sum of Q_{it} ($i = 1, 2, \ldots$ m). Also, when forming a weighted sum of the $\Delta Q_{i(t+1)}$, allowance can be made for the group's relative inventory of steel, i.e. ${}_aL_{jt}/C_{jt}$ where $j = 1, 2, \ldots k$ denotes a group of firms (sub-branch). Finally we may note that the constancy of a macro-parameter a_3 corresponding to the parameters a_{i3} is entirely dependent on the degree of constancy of the individual micro-parameters. If we apply the above-mentioned principles of aggregation we obtain the following macro-relation

$$J_t - \tilde{Q}_t - \Delta\tilde{\tilde{Q}}_{t+1} = a_3 \Delta^2 p_t$$

where $\tilde{Q}_t = \sum \bar{a}_{j1} Q_{it}$

$$\tilde{\tilde{Q}}_t = \sum \bar{a}_{j2} a_{j1} Q_{it}$$

$$\bar{a}_{j1} = \frac{\sum_t C_{jt}}{\sum Q_{jt}}$$

$$\bar{a}_{j2} = \frac{\sum L_{jt}}{\sum C_{jt}}$$

Aggregation over *time* can give rise to the same kind of problems as aggregation over firms. On the one hand certain theories (e.g. of production and inventory policy etc.) are more or less explicitly geared to certain periods, while on the other hand periods of a certain length cannot be used for studies of certain behaviour. Thus price speculation models concerning the stock market can hardly be tested on annual data, since a great deal of very important information on this market is filtered off when daily or weekly data are aggregated to annual data[1]).

To illustrate the effect of aggregation over time we shall consider two models of which one is originally static (single-periodic) and the other dynamic (multi-periodic) containing lags. The first describes a variable $y_{t,k}$ as a function of $x_{t,k}$. We can imagine the same concrete example as before, namely steel consumption as a function of the output of steel-consuming industries. We regard a linear version:

$$y_{t,k} = a x_{t,k}$$

[1]) It may be objected that economic phenomena of such brief duration as a week or a day are of no interest. But the important consideration is often not the duration of the observed phenomenon but the duration of its consequences.

a is constant over time, $t = 1, 2, \ldots$ denotes a particular year and $k = 1, 2, \ldots n$ a fraction of a year. Thus if $n = 12$, k denotes a particular month. An aggregation to annual data entails aggregation over k for each t, i.e.

$$\sum_{k=1}^{n} y_{t,k} = \sum_{k=1}^{n} ax_{t,k} = a \sum x_{t,k}$$

which we write

$$y_t = ax_t$$

Clearly the aggregation has not affected the functional relation. Thus in the dynamic case with lags we can write

$$y_{t,k} = a_1 x_{t,k-1} + a_2 x_{t,k-2} + a_3 x_{t,k-3}$$

An aggregation over time will now give

$$\sum y_{t,k} = a_1 \sum x_{t,k-1} + a_2 \sum x_{t,k-2} + a_3 \sum x_{t,k-3} \text{ or}$$

$$y_t = a_1 x_{t-\frac{1}{n}} + a_2 x_{t-\frac{2}{n}} + a_3 x_{t-\frac{3}{n}}$$

The symbol $(t - \frac{i}{n})$ here denotes that the variable in question is observed for the first $(n - i)$ sub-periods (months) of year t plus the last i sub-periods of year $t - 1$. The aggregation does not appear to have affected the relations here either. This analysis of annual data requires access to sub-period data for the dependent variables. If such data is lacking one can no longer be sure of obtaining a relation between y and x as described by the parameters a_1, a_2 and a_3. If we assume the normal desire in econometrics to find a stable relation between y and x with annual data, this can only exceptionally be completely met. But satisfactory solutions can be found to the problem. Thus if the sub-period is very short, i.e. n is large, the equation

$$y_t = ax_t + \epsilon_t; \; E(\epsilon_t) = 0; \; a = a_1 + a_2 + a_3$$

is generally a very useful approximation in the sense that ϵ_t has a small variance[1]). Consequently it can well be used as a forecasting model for forecast periods of one year and over. On the other hand it does little to enhance our understanding of quarterly or monthly developments of y—unless we know the internal relation of the micro-parameters (a_1, a_2 and a_3).

[1]) Note that an aggregation of this kind conceals the causality between x and y. Cf. R. Bentzel and B. Hansen, Om simultanitet i ekonomiska modeller, Ekonomisk Tidskrift.

If for instance $n = 4$, i.e. the sub-period is a quarter, the above equation may entail an unacceptably large dispersion of ϵ_t. It is natural in this case to add x_{t-1} as independent variable. We then examine the relation

$$y_t = A_1 x_t + A_2 x_{t-1} + \epsilon_t$$

A_1 and A_2 are not really parameters in the true sense any more than the macro-parameters in the aggregation of firms. Thus they cannot be obtained as unique combinations of the parameters of the original model, i.e. a_1, a_2 and a_3, which means that they are devoid of theoretic content. But this does not prevent them being of good predictive value by virtue of the stable development pattern of x_t.

In models with large time lags between variables, time aggregation may entail a loss of information in the sense that it prevents us from being able to estimate the correct structure. Conversely, however, working with data for short periods makes heavy demands on precise specification of the lag structure[1]).

We shall study another type of information loss which has already been touched on. Consider the model

$$y_{t,k} = AX'_{t,k} + BZ'_{t,k}$$

where $A = [A_1, A_2 \dots A_r]$, $X = [X_1, X_2 \dots X_r]$

$$B = [B_1, B_2 \dots B_s] \text{ and } Z = [Z_1, Z_2 \dots Z_s]$$

Let the X variables determine the more longterm changes in Y while the Z variables describe stationary time series with brief cycles. Thus the latter determine the more short-term variations of y.—They can for instance comprise seasonal variables. If we aggregate over time and obtain the relation for annual data, the effect of certain variables will be wholly or partially filtered off. Sometimes this filtration is an advantage, —seasonal variables are often a case in point—but sometimes it deprives one of important information. Thus certain of the variables that are filtered off may be of great importance at so-called turning points in y's trade cycle. In other cases one is particularly anxious to study the effect of certain z-variables on y.

As regards the time dimension of the variables, and unlike

[1]) Sometimes such an exact specification can entail an unnecessary amount of work for forecasting purposes. Aggregation can also simplify forecasting work at the cost of a negligible loss of information.

the procedure followed with products and firms, deviations have been made from the aggregation level at which the data giving rise to the original question were presented. The question concerned annual data. The statistical anlysis is principally based on quarterly data[1]).

There are many reasons in favour of "descending to quarterly level", although as has already been remarked this is bound to entail certain data problems. In this way there is better possibility of a trade cycle analysis, which in turn is important for providing a basis for short-term forecasts. Furthermore the planning periods of firms are probably shorter than a year as far as inventories are concerned—cf. the discussion in section 2.3. concerning the desirability of a constant L^* during the unit period. Also there seems to be a considerable risk of the discovery and analysis of such phenomena as price speculation becoming far more difficult if one adheres to annual data. The fact that we stopped at quarters instead of aiming for shorter periods was not merely due to data difficulties. The engineering sector is distinguished by the close interdependence of its constituent enterprises, as witness its intricate network of sub-contractors. This means that one firm's planning is often influenced by another's. The effect of fluctuations in the demand for the end products of the branch spreads via orders for tools and intermediate goods through the sub-contractor network, resulting in changes in output and raw material consumption. In view of the complicated lag pattern involved here, a study and identification of this process on the basis of monthly data applying to the entire sector would be practically impossible. At the aggregation level of a quarter we can probably include the important aspects of the relations which interest us in a static model or a model which has a relatively simple lag structure[2]).

[1]) In the final chapter, however, which is designed to illustrate more longterm trends, the observations consist of annual data.

[2]) See R. Bentzel and B. Hansen, op.cit.

5. Choice of indicators; Data

5.1. Directly measurable quantities and proxy variables

In chapter 3 we discussed the determination of an equilibrium inventory, following the traditional procedure of dividing the determinants into three groups. Our general model for the equilibrium inventory according to the discussion in the above-mentioned chapter can be written

$$L^* = L^*({}_TX, {}_PX, {}_SX) \qquad 5.1.$$

where ${}_TX$, ${}_PX$ and ${}_SX$ are to be regarded as vectors of variables determining transaction, precautionary and speculative inventories. These quantities were generally concerned with expectations, e.g. regarding future output and price development and other "psychological states" such as purchasers' view of the market situation. Quantities of this kind are not generally directly observable. In order to be able to pursue our study further we must therefore try to obtain observable variables which describe these quantities in one way or another. We need not of course be exclusively concerned with whether a particular theoretical quantity is assumed to be approximated by a registered variable (proxy variable). It is equally common to make use of a theory including observable variables of how a particular psychological variable, e.g. anticipated price, is formed. In both cases the statistical analysis will apply to a group or combination of hypotheses. This can be illustrated by a simple example. Assume that we wish to test the hypothesis

$$y_t = bx_t + \epsilon_t \quad \sigma(\epsilon_t) < \theta \qquad 5.2.$$

x_t is not observable but we believe it to have the following relation to an observable variable x_t^0

$$x_t = cx^0_{t-1} + d\Delta x^0_{t-1} + \omega_t \qquad 5.3.$$

Consequently the tested relation will be

$$y_t = bcx^0_{t-1} + bd\Delta x^0_t + b\omega_t + \epsilon_t \qquad 5.4.$$

ω_t and ϵ_t are random variables with the mean value 0.

Clearly we are here testing two hypotheses together, namely the hypothesis that y_t is proportional to x_t and the hypothesis that x_t can be fairly well described by $(cx^0_{t-1} + d\Delta x^0_{t-1})$[1].

Consequently the estimate of 5.4. can give an unacceptable result—even if equation 5.2. is true—because we have used a poor indicator of x_t. Since the indicator used for expectation variables and other unobservable entities can be crucial in determining how well a particular model describes reality, we have considered it important to give a somewhat more detailed account of the "solution" of the "problems of measurement" that have arisen in this study. In this connection we shall also have occasion to consider some important properties of the observable variables. Headings such as production and orders can conceal a multiplicity of measurement principles which as a rule give the variable in question different contents and consequently also have different results when used in a regression study. It is however not our intention to give a detailed account of the statistical material but rather to illustrate properties of the indicators used which are of importance in the interpretation of the results obtained. A more detailed summary of the data is given in supplement 1 and in the appendix.

5.2. Transaction inventories ($_TX$)

In chapter 3 the transaction inventory or the technical inventory was regarded as a function of steel consumers' anticipated consumption only. We shall assume in this connection that the total effect on the inventory level of interest charges, quantity discounts and similar factors within a relevant interval can be approximated by a constant factor plus a stochastic variable with zero mean and small variance. Concerning the relation between inventory changes and changes in consumption we shall adhere strictly to an assumption of proportionality. Thus,

[1] Cf. Carl F. Christ, Econometric Models and Methods, New York, 1966, p. 250.

disregarding the precautionary and speculative motives for holding inventories, the equilibrium inventory can be written

$$L^*_{t-1} = a_{10} + a_{11} C^*_t \qquad 5.5.$$

where C^*_t denotes anticipated or planned consumption during period t[1]). Now since we have already introduced the assumption that steel consumption is proportional to production in the steel consuming industries equation 5.5. can be written.

$$L^*_{t-1} = a_{10} + a_{11} b Q^*_t \qquad 5.5.a.$$

Thus a production plan implies a consumption plan. Consequently what is here said concerning production will be equally applicable to consumption. Later on in this study however the hypothesis of the relation between production and consumption will be modified with regard inter alia to available indicators.

5.2.1. Anticipated production. Our consideration of the production plans in our inventory models is based on three alternative hypotheses:

- The production plans are realized on average. Accordingly they can be observed post facto in the form of realized production. Thus the relation between ex ante and ex post quantities can be expressed: $Q_t = Q^*_t + \epsilon_t$, where ϵ_t is a random variable with a mean value of zero and small variance.
- The production plans can be measured with the aid of so-called expectation variables.
- The production plans can be described with the aid of a model.

The first of these should hardly require any further comment. The remaining two on the other hand call for a more detailed account.

5.2.2. Expectation data. There are no quantitative measurements available which state directly the production plans of firms for a coming period. The short term indicators which seem most appropriate are the figures of the Business Tendency Survey or the barometer survey performed by the National Institute of Economic Research. These consist of qualitative assessments

[1]) In the following a_{1i}, a_{2j} and a_{3k} will be used as coefficients of variables representing transaction, precautionary and speculative motives for inventory holding respectively.

published quarterly and covering among other things outp for the next quarter[1]). Although these are only concerned wi the direction of a change, they have often been found aggregated levels (branches) to give a very good picture quantitative development. This is particularly true of industri comprising a large number of firms. This in turn is very muc the case with the engineering industry, so that we have goo cause in the present context to investigate what the baromete data have to offer. A natural estimate of anticipated productio in view of the method used for quantifying barometer dat is

$$\text{BAR } Q^*_t = Q_{t-1}(1 + \delta_t) \qquad 5.($$

$\delta_t = \dfrac{\text{BAR } Q^*_t - Q_{t-1}}{Q_{t-1}}$ is the anticipated percentage output ir crease transformed from barometer data.[1]

[1]) The calculation method is described in the appendix.

5.2.3. Production planning models. Production is a variable c decision or control. According to static micro-theory th production level of the profit-maximizing firm is determine by the intersection of the marginal cost and marginal revenu curves. This aspect disappears in earlier dynamic productio models. Instead inventories were introduced in these model as a natural component, since the production decision take in one period had implications for the initial situation in subsequent period. A typical example of such a model is tha formulated by Erik Lundberg, which later formed the basi approach in Metzler's classical inventory model[2]). In the latte production plans are described by the equation

$$Q^*_t = S_{t-1} + (1 - c)\,(S_{t-1} - S_{t-2})$$

S_{t-1} here denotes deliveries during the period $t - 1$, whicl according to Metzler's assumption indicate delivery expectation for period t. The second term of the right hand side denote planned inventory increase $(H^*_t - H_{t-1})$, where $H^*_t = cS_{t-1}$ H_t denotes the stock of finished goods inventories. Withou

[1]) At the end of each quarter every firm states whether its output durin the coming quarter will be greater or smaller than or the same as durin the past quarter.

[2]) See Erik Lundberg, Studies in the Theory of Economic Expansion London, 1937, and Lloyd A. Metzler, The Nature and Stability c Inventory Cycles, The Review of Economic Statistics, August 1941

going into the details of this decision model any further we can note that production is completely flexible. This is turn implies that output fluctuations do not entail any costs. More recent literature on the subject has put production costs back into the picture. We refer here to costs directly associated with a certain output level or changes in the same, together with costs indirectly connected with output changes, such as storage costs.

An interesting approach is presented in a work by Holt, Modigliani, Muth and Simon. The combined production and inventory models presented there are based on traditional assumptions of rationality whereby firms are taken to determine production and inventories so as to maximize the anticipated value of future net revenues[1]). They however assume that the revenues of each firm are exogenously determined, so that the optimization process is limited to a minimization of the present value of future costs. Costs are expressed as quadratic functions of decision variables and exogenous variables. The decision rules derived from these assumptions are linear in exogenous variables and in lagged decision variables. Thus they have very attractive qualities from the point of view of both model technique and estimation.

Here we shall devote attention to two "rules" for optimal production which come entirely within the linear decision models constructed by Holt et al., namely

$$Q^*_t = a_0 + a_1 Q_{t-1} + a_2 H_{t-1} + a_3 NO^*_t \qquad 5.7.$$

and

$$Q^*_t = b_0 + b_1 Q_{t-1} + b_2 UO_{t-1} + b_3 NO^*_t \qquad 5.8.$$

Symbols:

NO^*_t = anticipated demand (incoming or new orders) during period t

UO_{t-1} = stock of unfilled orders at the end of period $t-1$.

Of these equations 5.7. refers to an "inventory-producing" and 5.8. to an "orderproducing" firm[2]). In an intuitive assessment of the parameter values, all except a_2 are >0 (a_0 and b_0

[1]) Planning Production, Inventories and Work Force, N. J., 1960. See too the above-mentioned works by Holt and Modigliani as well as Theil, Optimal Decision Rules for Government and Industry, Amsterdam, 1960, especially section 3.2.

[2]) A more detailed account of the implications of these concepts will be given further on in this chapter.

are of no interest in this connection). For reasons of costs the firms are expected to even out their producton in relation to demand, which means that planned production is a positive function of the current output level. For the same reasons the level of planned production should vary inversely to the size of stocks of finished products. The cost relation is perhaps less clear as regards the coefficient of orders in hand. A large volume of orders in relation to output implies a long delivery time, which can lead to costs in the form of cancelled contracts and difficulties experienced by the firms in obtaining new profitable orders. The sign of a_3 and b_3 should not require any further comment.

These models have been used by D. A. Belsley in an empirical study of the determination of production in American industry[1]). Following the traditional practice, Belsley has built up his production model from specific assumptions concerning cost relations and optimization process together with the linear restrictions applying between decision variables and exogenous variables. We shall follow the derivation of equation 5.7.

Costs are assumed to consist of three components, which can be written within a relevant interval as quadratic functions of the level of production, of changes in the same and of the inventory level:

$$_{Q}V_t = V_{10} + V_{11}Q_t + V_{12}Q_t^2;\ V_{12} > 0$$

$$_{\Delta Q}V_t = V_{20} + V_{21}\Delta Q_t + V_{22}(\Delta Q_t)^2;\ V_{22} > 0$$

$$_{H}V_t = V_{30} + V_{31}H_t + V_{32}H_t^2;\ V_{32} > 0$$

The first equation is designed to describe the short-run cost curve of the enterprise. The second is intended to capture the costs arising when firms have to put in overtime, recruit and train new labour, etc. in order to change their output. The third is designed to reflect the indirect costs attaching to a certain level of production. In the present case these consist of the costs involved in maintaining inventories[2]).

Both the ex post and the ex ante quantities are mutually connected by the restrictions[3])

[1]) D. A. Belsley, Industry Production Behavior: the order-stock distinction, Amsterdam, 1969.

[2]) Belsley allows H_t to assume values < 0. A negative inventory here corresponds to a positive stock of orders.

[3]) The order inflow is assumed to be equal to deliveries, thus implying that $Q_t + H_{t-1} > NO_t$.
Our argument differs in this respect from Belsley's, where H_t is regarded as a net inventory.

$$H_t = H_{t-1} + Q_t - NO_t \quad \text{and}$$
$$H^*_t = H_{t-1} + Q^*_t - NO^*_t$$

The time for which the firm's production is planned is assumed to consist of T periods ($t = 1, 2, \ldots T$) and its optimization process is assumed according to the above to consist in minimizing the anticipated costs during the interval of time $(1, T)$.

Thus we look for the minimum of the function

$$V_T = \Sigma_Q V_t + \Sigma_{\Delta Q} V_t + \Sigma_H V_t + \mu (H_T - H_0 - \Sigma Q^*_t + \Sigma NO^*_t)$$

In this equation μ is a Lagrange multiplier. Summation proceeds over $t = 1, 2, \ldots T$. Necessary conditions for a minimum are

$$\frac{\partial V_T}{\partial Q_t} = 0; \; t = 1, 2, \ldots T$$

The vector $[Q_1, Q_2, \ldots Q_T]$ can be solved from these equations and the production planned for the first period written

$$Q^*_1 = a_0 + a_1 Q_0 + a_2 H_0 + \Sigma_{t=1}^{T} a_{3+t} NO^*_t$$

Now Belsley, like Theil, assumes that each production decision is a first-period decision, the basic premise here being that the firm successively pushes its planning horizon forward in time. Thus at the beginning of period 2 this horizon extends as far as $(T + 1)$. Accordingly the production planned for each of the following periods is described by equations entirely equivalent with the above decision rule. It can be shown that $0 \leqslant a_1 \leqslant 1$, where $V_{22} = 0 \Rightarrow a_1 = 0$, and that $a_2 = - a_{3+1}$.[1]) To make the above equation equal to 5.7., the last term must be capable of being written as a linear function of NO^*_1. This is possible if NO^*_t ($t = 1, 2, \ldots T$) is perfectly autocorrelated.

$$Q^*_t = a_0 + a_1 Q_{t-1} + a_2 H_{t-1} + a_3 NO^*_t$$

This procedure may seem unnecessarily complicated for our purpose, which is to find indicators of Q^*. We have admittedly been able to define this variable as a function of among other things known ex post quantities but instead we have come up against the problem of finding indicators for

[1]) See Belsley, op.cit. pp. 42—43.

anticipated demand. We shall however attempt explicity to make use of these decision models. Moreover, in view of their being based on an acceptable micro-theory, we shall use them as frames of reference in dealing with other indicators of planned production[2]).

5.2.3.1. Production to order and to stock. There is reason to believe that domand, expectations and production plans are formed differently in different types of enterprise. In recent years importance has come to be attached in this respect to distinguishing between those enterprises producing to order and those producing to stocks. As has already been observed, equations 5.7. and 5.8. are based on this distinction. In firms producing to order, production is part of the sequence

$$\begin{array}{ccr} \text{order (demand)} & \longrightarrow & \text{production} \\ & & \downarrow \\ & & \text{deliveries} \\ \multicolumn{3}{c}{\xrightarrow{\hspace{8cm}}} \\ & & \text{time} \end{array}$$

The time lag between orders and deliveries is reflected by the orders in hand, which in this type of enterprise serve as buffers between production and demand. Deliveries are assumed to take place as soon as the product ordered is produced. Consequently the stock of finished products will be confined to pure friction inventories and will not have the buffer properties of the unfilled orders.

In inventory producing firms, production is decided upon first, and the chain of events corresponding to the above sequence is as follows:

[2]) It should however be emphasized that this approach is not to be regarded as general. For one thing, the assumption that demand is beyond the control of firms is sometimes completely unrealistic, for a firm anticipating a decline in demand can be expected to try to counteract this trend by increased sales activity. To this it may be objected that such an action only leads on the whole to a re-allocation of demand between firms. This is true when one is dealing with a closed market. The objection is probably irrelevant to an open market, where firms can e.g. move into new geographical markets. The problem can however be "solved" within the theoretical framework specified above. One such solution is to divide up the expected sales into an autonomous and a controlled part UNO^*_t and CNO^*_t. The latter of these affects costs, which—if we confine ourselves to the version referred to here—will thus acquire a fourth component:

$${}_{CNO}V_t = V_{40} + V_{41}\, CNO_t + V_{42}\, CNO_t^2.$$

production
↓
increase of stocks of finished goods → order
↓
delivery
——————————————————→
time

In this case delivery comes immediately after an order. To make this possible, the product in demand must be available in stock.

As regards the choice of indicators of anticipated sales and planned production we are of course concerned to know whether the firm in question belongs to the first or the second group of producers. But it is seldom that individual firms or branches can be unequivocally classified as one or the other. Thus a firm may produce one and the same commodity both to order and to stock. It is still more common for a firm to have a mixed production including both typical "order goods" and distinctive "inventory goods". It is nonetheless interesting to know whether one of these two characteristics predominates within a group of firms.

Judging by the available statistics, the Swedish engineering industry is clearly dominated by production to order. The accompanying table shows stocks of finished goods and unfilled orders in the sub-branches of the engineering industry. The figures indicate the average of stocks on 31.12 1967 and 31.12 1968 respectively. If we use the ratio unfilled orders/inventory level as indicator and like Zarnowitz[1]) take the value 1 as the dividing line between order and inventory producing industries, the engineering industry is beyond all doubt to be classified under the former category. It is therefore reasonable to assume that backlog of orders and new orders play an important part in the formation of expectation and planning and that equation 5.8. therefore constitutes a more representative frame of reference than equation 5.7.

	1 unfilled orders*	2 stocks of finished goods*	(1)/(2)
I	1.146	411	2.81
II	3.161	1.146	2.76
III	3.749	513	7.31
IV	3.128	475	6.59

I Manufacturing of metal products
II Manufacturing of machinery
III Manufacturing of electrical machinery etc.
IV Manufacturing of transport equipment (excluding shipbuilding)
* Million Skr.

$$Q^*_t = b_0 + b_1 Q_{t-1} + b_2 UO_{t-1} + b_3 NO^*_t \quad 5.8.$$

5.2.3.2. Applied indicators. There are two objections to using decision models 5.7. and 5.8. in their entirety. Firstly certain important data are lacking, among them figures concerning firms' stocks of finished goods, and other data are not defined in such a way that the restrictions specified previously will apply. Secondly, the use of these models would give rise to

[1]) V. Zarnowitz, Unfilled Orders, Price Changes and Business Fluctuations, N. Y. 1962 (NBER occ. p.p. 84).

considerable problems of estimation owing among other things to the fact that this would cause the multicollinearity between the "independent" variables in the regression equations to rise steeply.

Now this can be avoided if we first calculate Q^* with the aid of a regression analysis carried out on time series data. There are however no data for Q^*_t on which to base such an analysis. If there had been, the whole of this discussion concerning our limited objectives would have been unnecessary. However, although it is not altogether meaningful, we shall carry out an analysis of this kind on the assumption that the difference $Q^*_t - Q_t$ is small and not autocorrelated.

The equation which we can test in this connection is 5.8. As was pointed out earlier, it is in all probability more interesting here than equation 5.7. In order to carry out the calculations we must however define NO^*_t. We have confined ourselves to three traditional criteria according to which NO^*. is determined in such a way that $NO^*_t = NO_t$, $NO^*_t = NO_{t-1}$ or $NO^*_t = NO_{t-1} + a\,(NO_{t-1} - NO_{t-2})$ where a is a constant factor. In the former case the equation 5.8. is specified as

$$Q^*_t = b_0 + b_1 Q_{t-1} + b_2 UO_{t-1} + b_3 NO_t \qquad 5.8.a.$$

However we shall also test a somewhat simplified approach which in principle evades the problem by measuring expected demand. This procedure is based on the assumption that the production plans for the decision periods under consideration are based on previous production and order trends.

Production plans based on previous production trends. This principle implies that firms extrapolate historical development when planning their production. This procedure, which of course is taken to be confined to inventory producing firms, is probably not uncommon in practice and is often motivated by the fact that no radical changes in the demand trend are expected in the short run. Here we shall devote special attention to one version of this kind of output adjustment:

$$Q^*_{t+1} = Q_t + \Sigma^n_{k=0}\, v_k \Delta Q_{t-k} \qquad 5.9.$$

An adjustment of this kind need not imply that firms disregard inventory planning. On the contrary it may imply an anti-cyclical inventory policy. Assume that production plan adjustment is permitted during a period e.g. such that $Q_t = Q^*_t + \delta\,(NO_t - Q^*_t)$ where $0 < \delta < 1$. If demand falls off, production plans and actual production will be adjusted accordingly, subject to a certain lag, and the production cycle will have a smaller amplitude than the demand cycle. Thus stocks of finished goods will act as a buffer between demand and production. Contrary to what was the case in equation 5.7., storage costs are ignored in the above equation while on the other hand explicit allowance is made for costs caused by changes in production.

$$Q^*_t = a_0 + a_1 Q_{t-1} + a_2 H_{t-1} + a_3 NO^*_t \qquad 5.7.$$

Production plans based on previous order trends. A far more reasonable assumption in this connection is that production plans are determined by the previous order trend. For the reasons of costs noted earlier, an immediate order adjustment of the type $Q^*_{t+i} = NO_{t-1}$ on account of the normal irregular pattern of incoming orders would not seem to be a particularly realistic assumption, at least as far as quarterly or monthly data are concerned. On the other hand it may be reasonable to assume that firms plan their production in the light of what they consider to be more long term trends in demand. A general statement of such a rule of production planning is

$$Q^*_{t+i} = Q^*_{t+i}(NO_t,\ NO_{t-1} \ldots) \qquad 5.10.$$

One example of such a decision rule is

$$Q^*_{t+i} = \Sigma^n_{j=0} w_j NO_{t-j} \qquad 5.10.a.$$

With cyclical variations in NO_t production planning of this kind will lead to cyclical variations in Q^*_t, which however are lagged and evened out in relation to the former. Here the volume of unfilled orders will be the shock absorber between demand and production. Like equation 5.8. the above equations make allowance for the costs of production changes, but unlike 5.8. they make no explicit allowances for the costs connected with the actual volume of orders on hand. If Q^*_{t+1} is also to be regarded as a demand forecast, the production evening mechanism in these equations can be said to lie in the way in which demand forecasts are made.

$$Q^*_t = b_0 + b_1 Q_{t-1} + b_2 UO_{t-1} + b_3 NO^*_t \qquad 5.8.$$

Production plans based on current level of production and order trends. If the costs of production changes are a rapidly increasing function of the size of these changes, it would seem natural to assume that firms base their production planning on current output and adjust their production plans upwards or downwards in relation to output at a slow rate in relation to the demand situation. Here again we have an adjustment mechanism that is governed by costs. One general linear version of such a short term production planning model is

$$Q^*_{t+k} = Q_t + \delta(UO_t - Q_t - G);\ 0 < \delta \leqslant 1 \qquad 5.11$$

G is a constant indicating the normal difference between the stock of orders and production during a period of a certain length. With $k = 1$ this equation can be regarded as a special variant of equation 5.8., where $b_0 = G . \delta$, $b_1 = 1 - \delta$, $b_2 = \delta$ and $b_3 = 0$. Thus here production plans are based solely on orders already received, while order expectations are immaterial to short-term planning.

$$Q^*_t = b_0 + b_1 Q_{t-1} + b_2 UO_{t-1} + b_3 NO^*_t \qquad 5.8.$$

We shall use a special approximation to this model, namely

$$Q^*_{t+k} = Q_t + d\Sigma^n_{i=0} w_i \Delta NO_{t-i};\ 0 < d < 1; \Sigma w_i = 1 \qquad 5.11.a.$$

This will be used since data concerning backlog of orders has not been available for the entire period in question and has not had such a unit of measurement that the difference $(UO_t - Q^*_t)$ can be given a reasonable significance. The term $\Sigma_i \Delta NO_{t-i}$ will not be interpreted here as an order forecast but as a description of the current order situation. In this model too the volume of orders on hand will serve to even out production relative to the inflow of orders.

5.2.4. Data. In the previous section we used the concept of production in the sense of quantity produced, so that e.g. the difference between deliveries and production could be designated as an increase in stocks of finished goods. At the same time we have assumed that consumption is proportional to production. In order to reconcile these assumptions, production time must be short enough in proportion to the length of the observed periods. But this is not the case as regards the Swedish engineering industry, where production (process) times of several months can occur. It is therefore important to know the properties of available production indicators. In section 1.4. it was shown that the more output-oriented a measure of production is the less interesting it is as an indicator of steel consumption. At the same time, however, we introduced a new measure of consumption, ${}_0C$, which denoted the steel leaving the production process in the form of finished engineering products or as scrap. The difference between purchases and consumption in the latter sense consisted of changes in steel inventories and steel in process. If in applying the indirect method we use a measure of production based on output we shall thus be studying variations in the sum of the increase in steel in raw material inventories and the increase in steel in process.

The official production index of the Central Bureau of Statistics (SCB) is based on the sales value of production, which is deflated by a price index and multiplied by a constant value added factor derived from value added data for 1959. The annual figure of the index is obtained in this way. Quarterly figures are calculated on the basis of the annual index and employment figures[1]). The value of such a measure as an indicator of steel consumption will of course depend among other things on the flexibility of employment.

Employment however is generally a rather slow indicator of activity changes within an industrial sector. This coupled with an industrial sector. This coupled with the construction of the index probably combine to make the production index a rather insensitive gauge of the cyclical variations of the steel industry. On the other hand it is probably better fitted as a gauge of ${}_0C$, i.e. the consumption variable excluding variations in steel in process. This means that the difference between purchases and consumption calculated on the basis of this gauge is to be seen as an indicator of the increase in the total amount of steel in the raw material inventories of the engineering industry and steel in process.

There is reason to test gauges of the production of the engeneering industry which describe consumption better than the gauge employed in the production index. It has been shown that consumption can be very well described by a weighted index of "final demand"[2]). It is also possible to obtain quarterly data for this variable. The use of these however involves considerable difficulties: not only are the quarterly figures of the stocks of finished goods and stocks of goods in process of the engineering industry, which are of great interest in this connection, considerably "worse" than the annual figures, short-term statistics of this kind also occasion certain problems of periodisation. The most striking problem of periodisation in this connection concerns investment statistics. The figures for investments are a mixture of "payments" connected with machinery delivered and payments concerned

[1]) See appendix.

[2]) See Part II, chapt. 2. It should however be noted that this chapter is concerned with total steel consumption. Thus in the final demand index presented there, the export of ships and industrial plant are more important than in the index we shall be using here.

with machinery under construction, installations in progress and so forth.

A third production indicator which may be used is that which can be obtained from the business tendency surveys of the National Institute of Economic Research mentioned earlier. We have already considered the preconditions for the use of such an index. However it is worth emphasizing that it is a far more sensitive cyclical indicator than the corresponding quantitative gauges, in relation to which it generally also has a certain lead. These are interesting qualities for our purposes and should make the gauge in question a suitable consumption indicator.

Finally it should be noted that in using the production index and barometer data we have employed figures from sub-branches. These data were then weighted together with the share of total steel consumption of each sub-branch (C_j/C) as weights.

5.3. Precautionary inventories ($_pX$)

In chapter 3 precautionary inventories were assumed to be a function of the market condition: the more easily obtainable steel is the less reason the consumer has to maintain an inventory exceeding what is justified by anticipated consumption, and vice versa. In other words, steel consumers are assumed to adjust the duration of their steel inventories to current or anticipated delivery times. If we denote the latter quantity by $_pX_t$ and assume that $a_{10} = 0$ (see equation 5.5.) the linear version of this relation can be written[1])

$$L^*_{t-1} = a_{10} + a_{11} C^*_t \qquad 5.5.$$

$$\frac{L^*_{t-1}}{C^*_t} = a_{11} + a_{21\,p}X_{t-1} \qquad 5.12$$

The question now arises what possibilities there are of measuring the market situation or delivery times. In a market where there are no imports of steel, the ratio between unfilled orders and deliveries of steelworks is a good indicator of delivery times. Thus the hypothesis given above can be more specifically expressed: The greather the volume of unfilled orders with

[1]) Equation 5.12. differs from the formulation given by Darling and Lovell. Their model translated to our problem context can be written $L^*_{t-1} = a_{11} C^*_t$, where $a_{11} = a_{20} + a_{21\ p}X_{t-1}$. However the content of this formulation is identical to equation 5.12.: in both instances L^*_{t-1} is a linear function of C^*_t and $_pX_{t-1} \cdot C^*_t$.

given deliveries, the longer steel consumers will want their inventories to last.

Probably the most relevant concept of the volume of unfilled orders in this connection is the difference between orders in hand and the stock of finished products at the steelworks. The delivery time will then be indicated by the variable

$$\frac{{}_wUO_{t-1} - {}_wL_{t-1}}{{}_wS_t}$$

where ${}_wS$ denotes deliveries by the steelworks[1]).

But the Swedish steel market is very much an open market. Thus during the 1960s on average over one third of Swedish steel demand was met through imports. The delivery time gauge given above would not therefore seem entirely relevant but ought to be combined with a similar gauge of import delivery times. Unfortunately it is difficult to obtain figures of this kind corresponding to those that can be obtained from Swedish statistics. Available indicators suggest however that delivery times in Sweden and the ECSC (the Common Market) from where the overwhelming majority of Swedish steel imports are taken, are strongly correlated. Variations in the delivery times of Swedish steelworks ought therefore still to be able to give a fair picture of variations in the time Swedish buyers have to wait for their orders to be effected[2]).

But it is not necessarily the absolute length of the delivery time that causes the purchaser to maintain a higher inventory level than is necessary with regard to current production plans. The need to maintain extra inventories may be due to the *changes* in the delivery time. In this case the relation

$$\frac{L^*_{t-1}}{C^*_t} = a_{11} + a_{21} \Delta_P X_{t-1} \qquad 5.12.a.$$

will apply. A relation of this kind can be justified in much the same way as the effect of price changes on speculative inventories (see chap. 3, pp. 175–176).

In Lars Jacobsson's econometric model of the Swedish economy[1]) the capacity utilization of steelworks is used as an

[1]) A more general approach is of course to define the market situation as a function of ${}_wUO_{t-1}/S_t$ and ${}_wL_{t-1}/S_t$. An increase of 1000 tons in the volume of orders in hand need not after all have the same effect on the equilibrium inventory as a corresponding reduction in the steelworks' stocks of finished products.

[2]) See note 1, p. 25.

[1]) Cf. Lars Jacobsson, An Econometric Model of Sweden. Beckmans Förlag, Stockholm, 1972.

indicator of the delivery situation. This variable is fairly wel correlated with the ratio of unfilled orders/deliveries. Sinc however, unlike delivery time, it is not observed by the individua buyers it is not a quantity that can be included in purchasers decision rules. Probably the reason for it being used in Ja cobsson's model is quite simply that orders and volumes o orders in hand do not figure there as endogenous or exogenou variables.

One factor which definitively reflects the market situatio in an unregulated market is the price. Prices on the internationa market have been sensitive to changes in excess deman (unfilled orders minus available delivery capacity). Thus high price has reflected a large excess demand, which has als left its mark in the form of long delivery times. It has als implied a shortage of steel throughout western Europe. Ac cordingly price is perhaps a variable which reflects Swedis purchasers' opinion of steel supplies more faithfully than th delivery times of Swedish steelworks.[1])

Apart from the current market situation, the size of pre cautionary inventories may also be modified by purchasers medium term expectations concerning demand for thei products. Thus a heavy accession of orders may lead to purchasing activity exceeding that which corresponds t planned consumption and the current market situation.

The incrase in the inflow of orders may only slowly lead t an upward adjustment of production and consumption plans while inventory adjustment is more flexible. A purchasin policy of this kind is justifiable in terms of profitability i storage costs are low in proportion to deficiency costs and th costs attaching to a flexible output. In order to take int account the last-mentioned circumstance, equation 5.12. wil be augmented with a variable showing how production an consumption are expected to develop subsequent to th current planning period.

We thus obtain:

$$\frac{L^*_{t-1}}{C^*_t} = a_{11} + a_{21\;P}X_{t-1} + a_{22}\frac{\sum v_i C^*_{t+i}}{C^*t} \qquad \text{5.12.b}$$

$$\sum v_i = i$$

[1]) Steel inventories are assumed here to be positively correlated with th price. However a high price with a given rate of interest also implie a high interest charge per ton of stored steel, which reduce the dispositio to maintain inventories. We shall assume that the former effect is great than the latter, i.e. that $\left|\frac{\partial_P L}{\partial P}\right| > \left|\frac{\partial_T L}{\partial P}\right|$

If $\Sigma v_t C^*_{t+i}$ is indicated by NO_{t-1} and this quantity, as seems most probable, is strongly correlated with the Q^*_t indicator it is appropriate for purposes of estimation to write L^*_{t-1} as a linear function of NO_{t-1} and ${}_pX_{t-1} \cdot NO_{t-1}$. The regression coefffcient of NO_{t-1} will thus be an estimate of $(a_{11} + a_{22})$.

5.4. Speculative inventories (${}_sX$)

As was remarked in chapter 3, the steel market seems to have the characteristics of a speculative market. The price movements that have occurred during the postwar period have undoubtedly provided scope for speculative profits. Speculative purchases however are difficult to identify from statistical data and it is a hazardous undertaking to distinguish them from the changes in demand which we have chosen to attribute to precautionary purchases: although the motives behind these two kind of purchase are clearly distinguishable, the factors which prompt them may be fundamentally identical.

We showed earlier that speculative inventories are a function of the difference between expected price and current price. According to this hypothesis speculative purchases or speculative abstention from purchases is a function of changes in this difference. Here again we are faced with the problem of indicating an entity of expectation. Lovell and others assume that price expectations are realized and use ΔP_{t+1} and $\Delta^2 P_{t+1}$ as variables indicative of price speculation for period t[1].) Even if we accept this or any other hypothesis concerning price expectations, there still remains a major problem, namely the choice of a price index. It is important when studying price speculation in the Swedish steel market to distinguish between quoted prices and delivery prices and again between Swedish delivery prices and import prices.

Price quotations refer to the prices applying at the moment of ordering. Delivery prices are the prices registred at delivery (delivery value/tonnage delivered). Given the delivery times applying on the steel market it is reasonable to assume that there is an observable lag between changes in price quotations and realized speculative inventory adjustment. Even if we

[1]) In those studies these variables are of little significance so that Lowell draws the conclusion as regards American industry that "Price speculation is not important". See M. Lovell, Factors Determining Manufacturing Inventory Investment, in Inventory Fluctuations and Economic Stabilization, Washington, 1961.

accept the hypothesis of successful inventory speculation it is reasonable to give the change in quoted prices a lead in relation to the level of inventories, i.e. $\Delta P_{t-i} \rightarrow L_t$ or $\Delta^2 P_{t-i} \rightarrow \Delta L_t$. If we use a delivery price index instead it may be realistic to assume the reverse lead-lag relationship.

Whether we use the price quotation or the delivery price index as price variable in a regression analysis we must as a rule assume that the time between the change in the rate at which the price increases and realized speculative purchases is subject to small variations[1]). As has already been remarked, this is not the case. The variations in delivery time have been considerable and they are not aggregated out in quarterly data; moreover, as we have seen, they are correlated with price variations. If we consider a price cycle of the kind presented in chapter 3, then, given our assumption, speculative purchases will be greatest at the commencement of a price rise when delivery times are short, while speculative stock depletion at the beginning of a fall in prices can be delayed by involuntary inventory increases caused by a reduction in delivery times.

This means that the time lag between changes in the rate of the price rise and speculative inventory fluctuations varies. The problems of estimation arising in situations of this kind were discussed in general terms in chapter 2 and will be given further consideration in the next section. It is however questionable whether the method of studying or measuring price speculation described above is relevant. Price expectations need not be realized, nor need they be derived from historical price movements. Purchasers may to a very great extent be moved by other events, e.g. advance warnings of purchases tax increases, rumours of strikes in the American steel industry, which generally leave their mark on prices, and other signs that there is a risk of a steel shortage.

One way of attempting to solve this problem of calculation is to mark explicitly the periods when price speculation "ought" to have influenced demand. In this way one can construct a price speculation variable, D_0. This is given positive values in periods of speculative inventory increase and negative values in periods of speculative inventory depletion. Another variant is to introduce two dummy variables—D_1 and D_2—in the equation. D_1 and D_2 are given the

[1]) This is a necessary assumption if we are considering a pure demand model.

value 1[1]) in periods when speculative purchases and speculative inventory depletion respectively are presumed to have occurred and the value 0 in other periods[2]). This is justified e.g. if one believes that speculative purchases can be traced better than speculative inventory reductions. In this way one avoids letting the estimate of the former become uncertain as a result of an incorrect specification of the latter.

This method can be said to entail a combination of quantitative and traditional historical analysis. The problem now is to decide what events should occasion price speculation and then determine when such events occur during the period we are studying. Thus the object of such an analysis is somewhat more limited. We do not attempt to explain a phenomenon, only to investigate whether it exists. The method involves certain statistical problems of estimation. Among other things one has to assume that a period of speculative purchasing is not immediately followed by a heavy reduction of inventories but that most of the inventory accumulated through speculation is consumed during D_2-indexed periods.

5.5. Variables of supply

In chapter 2 we discussed a variable z which described the supply of or rather the availability of steel, in such a way that with high values for z it was a seller's market, i.e. purchasers had little chance of getting their entire steel demand satisfied within a certain time. At low values of z by contrast steel was easily available and purchasers could not only get their demand satisfied but could also obtain deliveries quicker than they had bargained for as a result of delivery times having been shortened. Here a variable of this kind is used with one object in mind, namely to make the estimate of the demand relations more reliable.

We have confined ourselves here to the use of two indices which are fairly well negatively correlated, namely changes in the duration of the volume of unfilled orders (measured as unfilled orders/production) and changes in the excess capacity of Swedish steelworks. We shall assume here that an increase in the duration of the volume of unfilled orders indicates increased delivery times and shows that consumers have not obtained deliveries to the extent desired, and that a drastic fall in this ratio implies that they have received larger deliveries

[1]) If realized demand has been a rising function of time and if the extent of speculative purchasing is believed to stand in a certain proportion to total purchases, it is appropriate to add $D_1 \cdot t$ and $D_2 \cdot t$ as speculation indicators.

[2]) Of course the restriction that D_k only can take the values 1 and 0 is not necessary: dummy variables can in principle assume all real values.

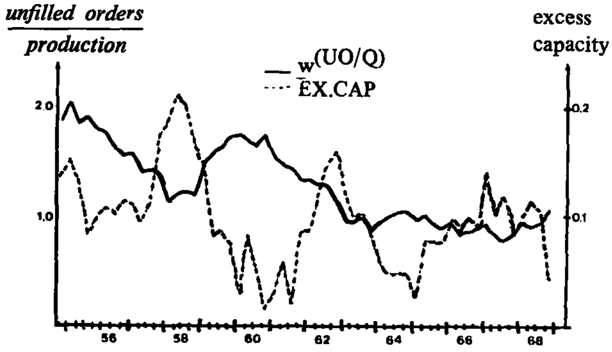


Figure 14.

than they had bargained for. Decreases and increases in surplu capacity will be interpreted in the same way. Thus an increas in excess capacity is assumed to indicate that firms have reduce their delivery times. However the latter index does not bea the same self-evident relation to delivery time as the duratio of the volume of unfilled orders. We have nonetheless als chosen to use excess capacity as a proxy variable for th variable z discussed in chapter 2 since, dealing as we are wit uncertain indicators, we have tried as regards registration an measurement to use several independent variables which ca be assumed to show different sides of one and the same thing Thus if both the duration of the volume of unfilled orders an surplus capacity show the anticipated effect on purchases w shall consider our hypothesis of the occurrence of a z variabl affecting purchases more conclusively substantiated than i only one of these indicators shows such a relation.

6. Explicit formulation of the regression equations

6.1. Linear versions of different inventory models: an exemplification

In chapter 4 we presented different basic models and methods of approach. No explicit account was given of the functional form and variable content of the models. Concerning the functional form we shall confine ourselves to arithmetically linear models, mainly for the sake of simplicity of handling and interpretation and in view of the fact that we have not found any important theoretical reasons for using other functional forms. It should also be noted that the inventory models based on the division of purchases into two components or on the assumption that adjustment to an equilibrium inventory can be described by a constant factor preclude — for reasons of estimation technique—the use of logarithmically linear versions.

If we allow transaction, precautionary and speculative motives for maintaining inventories to be described e.g. by anticipated consumption according to the barometer data ($BARC^*$), the delivery time from the steelworks (${}_wUO/{}_wQ$) and changes in an index of merchants quotations of different kinds of finished steel ($\Delta_m P$) respectively, equations 4.4.a., 4.5. and 4.8.[1]) can be specified as follows:

$$\text{direct method}\begin{cases} \Delta^c L_t = a_1 \cdot \Delta\ \mathrm{BAR}C^*_t + a_2 \Delta[{}_w(UO/Q)_{t-1} \cdot C^*_t] + \\ \qquad + a_3 \Delta^2{}_m P_t \\ \Delta^c L_t = Aa_1 \mathrm{BAR}C^*_t + Aa_2[{}_w(UO/Q)_{t-1} \cdot C^*_t] + \\ \qquad + Aa_3 \Delta_m P_t - AL_{t-1} \end{cases}$$

$$\text{indirect method}\begin{cases} J_t = bQ_t + a_1 \Delta\ \mathrm{BAR}\ C^*_t + a_2 \Delta[{}_w(UO/Q)_{t-1} \cdot C^*_t] + \\ \qquad + a_3 \Delta^2{}_m P_t \end{cases}$$

[1]) See p. 189.

$$J_t = bQ_t + \Delta L^*_{t-1} + b\Delta (Q_t - Q^*_t) + \eta_t = bQ_t - Q^*_t + \eta_t$$
$$\Delta L^*_{t-1} = \Delta L^{**}_t \qquad 4.10$$

There is no reason here to continue the exemplification of these equations. On the other hand equation 4.10. calls for further explanation and scrutiny. Starting from the general approach which it indicates, namely that of making explicit allowance for discrepancies between realized and desired purchases in the estimate, we shall build up a species of inventory model which differs in its construction from the other models dealt with in this work. These models will be referred to as *QJ*-models. Thus their dynamic structure differs from that of the others since production and purchasing planning are not—as is generally the case—presumed to occur simultaneously: The production plans for period t are drawn up at the end of period $(t - 2)$, while purchasing plans and with them inventory investment plans for period t are decided at the end of period $(t - 1)$. The conditions and implications of this behaviour should be apparent from the subsequent argument. Before examining the construction of the *QJ* models more closely it should be pointed out that they have been constructed with two special aims in mind. Firstly they are designed to avoid the use of proxy variables which are difficult to interpret.—The basic data for the independent variables are of two kinds only, namely production and incoming orders. Secondly they constitute an attempt to combine the transaction and precautionary motives in one, increases in transaction and precautionary inventories both being regarded as a function of changes in the inflow of orders.

6.2. The QJ-models

6.2.1. Basic hypotheses and basic model. The purchasing models we shall derive here are based on two conditions:

- Firms plan their inventories for the end of period t at the end of period $(t - 1)$ and endeavour in so doing to keep their inventories in a certain relation to the consumption planned for period $(t + 1)$:

$$L^*_{t-1}(t) = L^*_t = a_1 C^*_{t+1} + a_0 \qquad 6.1.$$

- The difference between actual and planned inventory level at the end of t is equal to the difference between planned and actual consumption during t[1].

[1]) The symbol for the inventory level which it is desired to attain by a certain point in time should in accordance with previous symbols be L^{**}. Since however $L^{**} = L^*$ here, we have for the sake of convenience chosen to use L^*.

$$L_t - L^*_t = C^*_t - C_t \tag{6.2.}$$

The first assumption implies that the production and consumption plans for $(t + 1)$ are fixed by the end of $t - 1$. Thus the least possible theoretical time lag between production decision and production is 1 period unit. We shall assume here that this applies, so that we can write analogously to equation 6.1.

$$C^*_{t-2}(t) = Q^*_t \tag{6.3.}$$

It also follows from the first assumption that purchases for period t are planned at the end of $(t - 1)$ and the purchasing plans are realized. The equation for the inventory change desired during t can be solved from 6.1. and 6.2., from which we obtain

$$\begin{aligned} L^*_t - L_{t-1} &= L^*_t - (L^*_{t-1} + L_{t-1} - L^*_{t-1}) = \\ &= a_1 C^*_{t+1} - a_1 C^*_t + C_{t-1} - C^*_{t-1} \end{aligned} \tag{6.4.}$$

Planned purchases are by definition the sum of planned consumption and planned inventory increase. From this definition and equation 6.4. one can form the following expression of purchase plans (and realized purchases)[1].

$$\begin{aligned} J^*_t = J_t = C^*_t + \Delta^* L_t = C^*_t + a_1 \Delta C^*_{t+1} + C_{t-1} - C^*_{t-1} = \\ = C_{t-1} + \Delta C^*_t + a_1 \Delta C^*_{t+1} \end{aligned} \tag{6.5.}$$

If we wish to add to the above equation the assumption that steel consumption is proportional to the production of the steel-consuming firms, i.e. that

$$C_t = b \,.\, Q_t$$

we obtain the following relation for purchases

$$J_t = b\,(Q_{t-1} + \Delta Q^*_t) + a_t b \Delta Q^*_{t+1} \tag{6.6.}$$

This equation contains two unknown parameters b and a_1, of which the latter is of particular interest. It will be recalled that this analytical method for inventory demand is prompted by the lack of reliable data concerning inventories and consumption. The difference between this model and the other version of the indirect method (see e.g. the definition of equation

[1]) $\Delta^* x_t$ will be used to symbolize $x^*_t - x_{t-1}$. Thus in equation 6.5. $\Delta^* L_t$ denotes the difference between desired inventories at the end of t and actual inventories at the end of $(t - 1)$, while ΔC^*_t is the first difference of C^*_t i.e. $C^*_t - C^*_{t-1}$.

4.8. on p. 219) lies both in the variable content and in the treatment of involuntary inventory increases. In the estimation of a_1, i.e. the marginal propensity to hold inventories, equation 6.6. makes explicit allowance for these, so that the estimate of a_1 is unbiased even if involuntary inventory increases are systematic—provided of course that the model is realistic.

We shall augment the model with a hypothesis concerning the determination of unplanned increases in consumption. We shall assume here that plans are revised in the light of current trends in demand (orders). According to this assumption an improvement in the volume of orders will lead to an upwards adjustment of production plans. In this connection we shall study the revision functions

$$C_t - C^*_t = b\,(Q_t - Q^*_t) = c[\alpha NO_t + (1 - \alpha)\,NO_{t-1} - \\ - \Sigma w_i NO_{t-i}] = cN_t \qquad 6.7.$$

$$\Sigma w_i = 1;\ 0 \leqslant \alpha < 1$$

The purchases equation will now be:

$$J_t = bQ^*_t + a_t b\Delta Q^*_{t+1} + c\,N_{t-1} \qquad 6.8.$$

6.2.2. Indicators. Following the argument in section 5.2.3.2. we shall define different indicators of Q^*_t. First we shall specify two gauges, of which the first is based solely on order data and the second solely on production data. These indicators are

$$u_{t-2} = 0.6NO_{t-2} + 0.3NO_{t-3} + 0.1NO_{t-4} \qquad 6.9.$$

and

$$q_{t-2} = Q_{t-2} + 0.6\Delta Q_{t-2} + 0.3\Delta Q_{t-3} + 0.1\Delta Q_{t-4} \qquad 6.10.$$

The weight vectors in the two equations are identical. The basic principle in determining them has been that firms base their production planning on historical delevopments but are sensitive to current trends. In practice the selected distribution of the weighted averages should have essentially the same results as an exponential distribution thereof. In equation 6.10. the choice of weighted average implies the assumption that firms when planning reduce the forecast increase to half the historical increase; planning proceeds two periods ahead.

Applying definitions 6.9. and 6.10. to equations 6.6. and 6.8. respectively we obtain[1])

[1]) In the measure of N_{t-1}, α has been given the value 0.3.

$$J_t = b\,(Q_{t-1} + \Delta u_{t-2}) + a_1 b \Delta u_{t-1} \qquad 6.11.$$

$$J_t = bu_{t-2} + a_1 b \Delta u_{t-1} + cN_{t-1} \qquad 6.12.$$

$$J_t = b\,(Q_{t-1} + \Delta q_{t-2}) + a_1 b \Delta q_{t-1} \qquad 6.13.$$

$$J_t = bq_{t-2} + a_1 b \Delta q_{t-1} + cN_{t-1} \qquad 6.14.$$

These equations (6.11., 6.12., 6.13. and 6.14.) comprise the versions of models 6.6. and 6.8. which are to be tested.

6.2.3. A modified version. Earlier we discussed a third rule of policy for firms' production, according to which production plans are based on the current output level and current order trends. We shall modify the first assumption, so that inventory planning becomes less restricted by production plans than in equation 6.1. In this connection the production indicator and inventory function have been formulated as follows:

$$L^*_t = a_1 C^*_{t+1} + a_0 \qquad 6.1.$$

$$Q^*_t = Q_{t-2} + d \Delta u_{t-2} \qquad 6.15.$$

$$L^*_t = a_1 b [Q_{t-2} + e \Delta u_{t-1}] \qquad 6.16.$$

where according to our hypotheses $0 < d \leqslant e < 1$

The assumptions for d and e imply that inventories are more sensitive than production to fluctuations in the inflow of orders. This hypothesis is based on the assumption that precautionary inventories are a function of changes in the inflow of orders. When the increase in order inflow accelerates, then according to this hypothesis firms will increase the difference between the equilibrium inventory level and the inventory level justified by immediate production plans. Thus equation 6.16. can be regarded as being derived from the equation

$$L^*_t = a_1 b [Q_{t-1} + d \Delta u_{t-1}] + a_1 b h \Delta u_{t-1}$$

where $h = e - d$.

If the production indicator described above (6.15) and the modified hypothesis concerning the determination of the equilibrium inventory (6.16) are applied to the identity $J^*_t = C^*_t + \Delta^* L_t$ and the assumption that planned purchases are realized ($J^*_t = J_t$), we obtain

$$J_t = b(Q_{t-1} + \Delta Q_{t-2}) + a_1 b \Delta Q_{t-1} + a_1 b e \Delta^2 u_{t-1} + \\ + b d \Delta^2 u_{t-2} \qquad 6.17.$$

This equation contains four unknown structural parameters, all of which can be identified from regression estimates. We are thus in a position to investigate what, from the point of view of trade cycle analysis, is the interesting hypothesis concerning the relation between d and e.

If we introduce the plan revision function for production, the purchases equation can, all other things being equal, be written

$$J_t = bQ_{t-2} + a_1 b\Delta Q_{t-1} + bd\Delta u_{t-2} + a_1 be\Delta^2 u_{t-1} + cN_{t-1} \quad 6.18.$$

Since an unknown parameter and a new variable have appeared in equation 6.18. compared to equation 6.17., it is possible in this equation too to identify all structure coefficients.

A third alternative is to let short-term production and inventory planning proceed on the basis of different assessments. Thus if production plans are determined according to equation 6.10. while inventory holding is entirely bound to order inflow in sush a way that $L^*_t = e_1 u_t$ we obtain, all other things being equal

$$q_{t-2} = Q_{t-2} + 0.6\Delta Q_{t-2} + 0.3\Delta Q_{t-3} + 0.1\Delta Q_{t-4} \quad 6.10.$$

$$J_t = b(Q_{t-1} + \Delta q_{t-2}) + e_1 \Delta u_{t-1} \quad 6.19$$

and

$$J_t = bq_{t-2} + e_1 \Delta u_{t-1} + cN_{t-1} \quad 6.20.$$

If instead we assume that production plans are determined according to equation 6.9., we obtain purchase equations which are identical to 6.11. and 6.12. Dualism of this kind can arise in short-term planning when production and purchasing decisions are taken by different persons. Nor need it be contrary to rational behaviour. This kind of production adjustment can be regarded as a case where costs of major alterations to output are high while inventory adjustment may be deeply influenced by considerations of safety, e.g. in the sense that deficiency costs are of dominating importance.

$$u_{t-2} = 0.6\,NO_{t-2} + 0.3\,NO_{t-3} + 0.1\,NO_{t-4} \quad 6.9.$$

7. Regression analysis — frame of reference, method of estimation and criteria of significance

7.1. Frame of reference

7.1.1. Theory-data. We began this essay with an account of time series data concerning apparent consumption, actual consumption and inventories of finished steels. These figures demonstrated above all the considerable fluctuations undergone by inventory investments, which called for an explanation, not least from the forecasting point of view. We began our analysis with the general formulation of a theory regarding the determination of steel consumers' steel inventory investments. This theory expressed steel inventory investments as a function of several theoretical variables which were divided into three groups. The statistical data available are often unsatisfactory indicators of the variable which are desirable for analytical purposes. Often one has first to examine the correspondance between available and theoretical variables. Sometimes one is forced to pre-determine these relations. For this reason we have devoted a relatively large amount of space to these problems. The result can be said to have been models which describe the relation between variabels within the statistical picture of reality which our statistical institutions have to offer. Explicit formulations of these models were given in the previous chapter. It is now time for these to be confronted with available data.

This confrontation has three aims, of which the first two can—but need not necessarily—be regarded as consecutive stages in an analysis, namely

- using a method of estimation, to give a structure of the model designed to describe the process which has brought about the observed data of the dependent variable[1]).

- to answer the question whether the model is acceptable from any special point of view; this usually refers to its predictive value.
- to facilitate comparisons between several models, e.g. regarding their predictive value.

Our most convenient course would seem to be to begin with the third point. It is however by no means intended here to provide an exhaustive account of questions of theory of science or problems of inductive inference connected with econometric studies. The sole aim is to outline the writer's attitude to relevant problems and to provide a brief account of the method used and the selected statistical measures of goodness of fit. Interested readers are referred to Christ's and Malinvaud's textbooks and to the extensive works on the subject by Wold.

7.1.2. When is a hypothesis rejected? It should be evident from the preceeding argument that it is practically impossible to find criteria which not only show whether an economic model is to be accepted or rejected but also make it possible to discriminate between different models[2]). One of the reasons for this has been said to be that economic laws, unlike physical laws, seem to be of brief duration and that opportunities of experimentation within the field of economic research are few and far between. Consequently the research student in this field is generally imbued with a host of a priori convictions, often based on logical deductions from unsubstantiated postulates. He therefore assesses the credibility of hypotheses from two angles: their plausibility from the "theoretical" point of view, i.e. in the light of a priori premises, and their congruence with statistical observations. Thus his evaluations

[1]) Structure generally refers to the properties within an area of study which do not change (see Christ, op.cit., p. 11). Here the word is used specially to denote the functional or stochastic relation between dependent and independent variables. In a linear single equation model of the type $y = \Sigma a_j x_{jt} + \epsilon_t$;

$$E(\epsilon_t) = 0; \; \frac{1}{T}\Sigma\epsilon_t^2 = \sigma^2(\epsilon)$$

the structure consists of the coefficient vector $[a_j]$ and $\sigma^2(\epsilon)$.

[2]) A model here is regarded as a single hypothesis or a collection of related hypotheses.

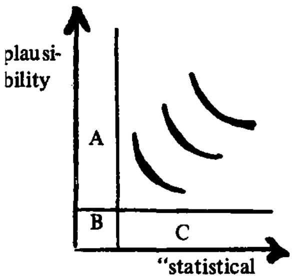


Fig 15

can be described in the accompanying figure, according to which there is a certain minimum level of both theoretical plausibility and agreement with data. Hypotheses coming under either of these limits, i.e. within the area AUBUC, are rejected. Within the acceptance region he may discriminate between hypotheses according to a family of indifference curves reflecting his preference function on the y—x plane. Since the occurrence of an objective or universally accepted gauge of theoretical plausibility can be excluded and since not even agreement with data can be unassailably expressed by a single number, the choice of a model e.g. for purposes of prediction is a higly subjective business.

Let us illustrate this problem with an example connected with our own subject: We are testing on time series data the hypothesis that steel consumption is a proportional function of a production index in which the various sectors are weighted with their specific steel consumption for a given year. During the sample period the trend in production and steel consumption has been horizontal and the changes that have occurred have been of a stochastic nature. The observations are plotted on a diagram with consumption on the vertical axis and production on the horisontal axis. As can be seen from the figure, a regression analysis indicates that there is no relation between the variables. Thus the hypothesis should be rejected. A conditional value, based on a priory considerations, for the slope $= \alpha$ however gives very small deviations. In view of the latter circumstance, many would feel justified in retaining the hypothesis in a forecasting situation based on a very steep rise in production. The lesson drawn in the present work from this and other similar examples is that one should be generous in the presentation of results and not reserve pride of place for the hypotheses one has accepted oneself.

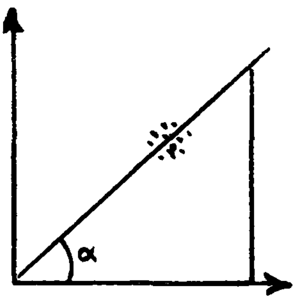


Fig 16 forecast

7.1.3. Several hypotheses in one test. A model will generally include a host of hypotheses of which many are tried out in one test. We touched on this problem in chapter 5. The inventory models tested here contain several hypotheses which cannot be tested separately. Thus the equations

$$\Delta L_t = \lambda(L^* - L_{t-1}) = \lambda(\sum a^*_j x^*_j - L_{t-1}) = \lambda(\sum a^0_j x^0_j - L_{t-1})$$

contains the following hypotheses:

- Inventory investments are exclusively determined by demand.
- The difference between actual inventory increase and that

indicated by the decision rule can be described by a constant factor λ.

- The equilibrium inventory is determined by the levels of the theoretical variables x^*_j.
- The theoretical variables can be described by the observable variables x^0_j.
- The relations are linear.

These hypotheses can if so desired be divided into several sub-hypotheses.

Naturally problems arise here when the intersection of these hypotheses gives a "bad result" when confronted with statistical data. This may after all be due to only one of the hypotheses being incorrect. The question thus arises: which hypotheses are to be retained and which are to be questioned? The procedure here has been in the first instance to "trust" the general hypotheses and endeavour to test different indicators of x^*. Only when we have felt that we have exhausted the possibilities[1]) have the general premises been called into question. As will be evident from the preceding argument, we have not been moved by particular affection for these hypotheses but rather by the desire to give a respected theory a fair chance.

7.1.4. Theoretically distinct but empirically near-inseparable hypotheses. Another problem connected with the choice of hypotheses, and one worth noticing, is that hypotheses which are distinct in theory may partially coincide when it comes to statistical estimation. There are two possible explanations of this phenomenon:

- one and the same proxy variable is used to denote a theoretical entity in hypothesis A and another entity in hypothesis B.
- The exogenous variables are not statistically independent one another; this can have practically the same effects as the previous case.

In the latter case the problem can be hard to discover in a

[1]) Since these are legion, the termination of one's attempts is bound to be a question of physical, mental and financial exhaustion. The second of these factors has in this case put an early limit to the trial and error procedure. The *plausible* indicators of a priori relevant variables are after all few.
Moreover we have been very well aware of the special sampling situation in time series analyses where hypotheses testing very easily changes into mere curve-fitting.

first study of the correlation matrices. Assume that variables Z_1 and Z_2 are included as exogenous variables in one model while Z_3 but not the former is included in another. The correlations $R(Z_1, Z_3)$ and $R(Z_2, Z_3)$ may seem fairly small but the correlation $R[(a_1 Z_1 + a_2 Z_2), Z_3]$ may nonetheless be considerable. In this case the models will give similar results although they purport to be completely separate hypotheses. If for instance a dependent variable is very strongly autocorrelated it is probably pointless to choose a certain lag rather than another with the aid of statistical criteria of significance.

As has already been pointed out on several occasions, the analytical method which will be applied here is that of regression analysis and the statistics refer to time series data. In this connection we are interested in the regression function

$$E(y \mid x_1, x_2 \ldots x_n) = \Sigma_{j=1}^{n} a_j x_j$$

which applies to a population covered by the etimation period and a future bounded by our horizon for purposes of forecasting. The estimation technique which is consistently used is the least square method or the indirect least square method. As has been shown in previous chapters, our basic hypothesis is that the demand for steel, especially inventory demand, can be dealt with in a separate model, i.e. that the problems connected with the estimation of structural coefficients in a simultaneous equation system and which comprise the essence of econometric literature will only exceptionally occasion us any difficulty.

7.2. Method of estimation and criteria of significance

7.2.1. The coefficient estimates of the least square method. Our theoretical discussion has led up to various linear relations between a dependent and one or more independent variables which, seen in causative terms, can be designated explanatory variables. These equations were not considered to apply exactly but were regarded as stochastic. Thus we are studying equations of the type

$$'y_t = a_1' x_{1t} + a_2' x_{2t} + \ldots + a_n' x_{nt} + \epsilon_t$$

The coefficients in these will be determined empirically with the aid of regression analysis. The procedure applied is as follows.

We select from a population T observations of $'y_t$, $'x_{1t} \dots 'x_{nt}$ which can be measured exactly[1]). The T relations are subjec to stochastic shocks, namely the influence of the variable ϵ_t This variable, which is sometimes taken as the net effect on ȷ of other variables than the x variables[2]), is presumed a prior to have an average value of zero and a constant variance Thus for each $t(t = 1, 2 \dots T)$ $'y$ is assumed to be determine by $'x_{it}$ together with a stochastic variable, which thus deter mines the probability distribution of $'y$ given a set of value of the $'x$ variables.

The estimates of the coefficient vector a_i obtained by th least square method are best linear unbiased estimates; if ϵ_t i presumed to be normally distributed they are also maximum likelihood estimates. Thus the least square method results in an estimate of the coefficient values which is at least as likel as any other set of estimates to generate the observed sample

In order to simplify the argument we shall let x_{it} and y be deviations from the means of $'x_{it}$ and $'y_t$ over the T observations. As in previous sections, the estimates of the a coefficients will be designated $\hat{a}_i$. The least square metho minimizes the residual square sum, i.e.

$$\sum_{t=1}^{T} (y_t - \sum_{i=1}^{n} \hat{a}_i x_i)^2 = \text{minimum}$$

From this we obtain n equations

$$\begin{matrix} \hat{a}_1 m_{11} + \dots + \hat{a}_n m_{1n} = \sum x_1 y \\ \vdots \qquad\qquad \vdots \qquad\quad \vdots \\ \hat{a}_1 m_{n1} + \dots + \hat{a}_n m_{nn} = \sum x_n y \end{matrix}$$

where $m_{ij} = \sum x_i x_j$.

From these the coefficient vector $[\hat{a}_i]$ can be solved, whereby

$[\hat{a}_i]' = M^{-1} M'_{xy}$ where

$$M = \begin{bmatrix} M_{11} & \dots & M_{1n} \\ \vdots & & \vdots \\ M_{m1} & & M_{mn} \end{bmatrix} \text{ och } M_{xy} = [\sum x_1 y, \dots, \sum x_n y]$$

We should lose little or nothing by making $n = 2$ which makes both the argument and intuitive understanding easier[3])

[1]) Cf. however the preceding discussion of the effect of errors in variables.

[2]) See e.g. Haavelmo, T., Teknikk og Metoder ved Oppstilling av Teore tiske-Økonomiske Modeller (Lectures given at the University of Oslo 1951 and 1964, Institute of Economics).

[3]) Those requiring a complete and general presentation of these question are referred to current textbooks such as those by Johnston, Malinvau and Christ.

We shall designate the partial regression coefficients a_1 and a_2 $b_{y1.2}$ and $b_{y2.1}$ respectively, while b_{y1} and b_{y2} will denote the simple regression coefficients $\Sigma x_1 y/\Sigma x_1^2$ and $\Sigma x_2 y/\Sigma x_2^2$.
By solving the system thus reduced we obtain the following expressions of the coefficient of x_1

$$b_{y1.2} = \frac{(\sum x_1 y)(\sum x_2^2) - \sum (x_2 y)(\sum x_1 x_2)}{(\sum x_1^2)(\sum x_2^2) + (\sum x_1 x_2)^2}$$

This expression can be written in terms of simple regression coefficients, whereupon

$$b_{y1\,2} = \frac{b_{y1} - b_{y2} b_{21}}{1 - b_{12} b_{21}} = \frac{b_{y1} - b_{y2} b_{21}}{1 - R_{12}^2}$$

Corresponding formulae can be obtained for $b_{y2.1}$. If we solve for the simple regression coefficient of x_1 we obtain

$b_{y1} = b_{y1.1} + b_{21} b_{y2.1}$.

The effect of a *specification error* is clearly evident from this expression. If y is erroneously specified as a function of x_1 only, the estimate of the coefficient of this variable will be biased unless x_1 and x_2 are uncorrelated ($b_{21} = 0$).

7.2.2. Significance tests. In statistical studies of economic relations it is not enough to find regression coefficients calculated for certain periods of time. Generally one also wishes to find answers to the general questions: How relevant are the coefficients? How well has the estimated model as a whole described reality?

Firstly it should be noted concerning specification errors that, subjectively speaking, no errors occur since one is testing a theory in which one has great confidence for a priori reasons. If we believe in the relation $y = b_{y1} x_1$ as the true relation, b_{y1} is the estimate of both the partial and total derivates of y with respect to x_1.

As regards the importance of the regression coefficients, we shall distinguish here between *theoretical* and *practical* (or empirical) relevance. The first of these terms refers to the degree of reliability attaching to a certain coefficient according to certain standard tests. The second concerns the importance of a certain independent variable, according to the regression analysis, to the observed variations of the dependent variable.

Theoretical relevance can apply to both the mean value and the dispersion of the coefficients. The standard deviation in $b_{y1.2}$ is

$\left[\frac{\text{var } \epsilon}{\sum x_1^2(1 - R_{12}^2)}\right]^{\frac{1}{2}}$ or if we consider the estimate of this expression and make allowance for the loss of degrees of freedom in calculating the mean value and coefficients

$$s(b_{y\,1.2}) = \left[\frac{\sum e_t^2}{(n-3)x_1^2(1 - R_{12}^2)}\right]^{\frac{1}{2}}$$

where $e_t = y_t - \hat{y}_t$.

7.2.2.1. The t-test. The quantity, $s(b_{y\,1.2})$, can be used to test the hypothesis whether an estimate significantly differs from an a priori value a_1. If the distribution of ϵ is normal it can be shown that

$$\mathbf{t} = \frac{b_{y\,1.2} - a_1}{s}$$

is a t-distributed variable with $(T - n - 1)$, in this case $(T - 3)$, degrees of freedom.

Often one wishes to know whether a certain variable has any predictive value at all, i.e. whether its coefficients will differ from zero in other samples (forecast periods) as well. Generally one will only accept that it differs either positively or negatively from zero. In the former case the hypothesis: $b_{y\,1.2} > 0$ is tested against the null hypothesis: $b_{y\,1.2} \leqslant 0$. If we accept a 5 per cent risk of rejecting the null hypothesis when it is true, then, if e.g. $T - 3 = 30$, we will accept the first hypothesis when

$$b_{y\,1.2} > 1.697 \cdot s(b_{y\,1.2})$$

We shall not specify in this connection any significance level in this study. As has already been remarked, it is generally not only the result of a statistical study that decides whether one wishes to retain a hypothesis or not: the a priori basis of the hypothesis is also decisive. When—as is so often the case here—hypotheses of similar a priori validity are being tried out, the t test can be of great value. This applies e.g. if one believes in the general formulation of a model and chooses between several indicators of a theoretical variable included in the model.

7.2.2.2. Multicollinearity. Attention will be drawn here to two circumstances which are greatly emphasized in literature and which influence the estimation of coefficients, namely multicollinearity and autocorrelation in the residuals. Multicollinearity occurs when a group of indpendent variables are so strongly correlated with one another as to make it extremely difficult to distinguish the effect of each variables. This cannot be unequivocally established by an either-or test, rather it is a phenomenon which always exists to a greater or lesser degree. The effect of a statistical dependence between the exogenous variables should be evident from the expressions for regression coefficients and their standard deviations. When R_{12}^2 approaches 1 it is easy to understand that the estimates become uncertain[1]).

$$b_{y1.2} = \frac{b_{y1} - b_{y2}b_{21}}{1 - R_{12}^2}$$

Multicollinearity in a sample creates a risk of specification error, which from the point of wiev of forecasting can be unfortunate, for the co-variation of the independent variables can deviate considerably during the forecast period from their intercorrelation during the estimation period[2]). To avoid this dilemma we shall from time to time estimate the parameters from the first differences of the variables instead of estimating on the basis of their levels. This will be of little avail if the variables can be described as linear functions of time. As has been shown from previously presented series, this is not the case in the data sphere under consideration.

7.2.2.3. The DW test. It can be shown that the least square method does not give efficient estimates where autocorrelation occurs in the random variable ϵ_t, hence the importance attached to tracing the occurrence of such correlation in regression studies based on time series. Here we have followed what is by now the traditional procedure of showing the so-called von Neumann ratio, which is the basis of the Durbin-Watson test. Applied to the observed residuals, this ratio can be written

$$DW = \frac{\sum (e_t - e_{t-1})^2}{\sum e_t^2}$$

This ratio, which can assume values between 0 and 4, denotes the degree of autocorrelation in the residuals. A value of 2

[1]) From the expression for $b_{y1.2}$ given section 7.2.1. it is seen that the regression coefficient will be indeterminate in the case when $R_{12}^2 = 1$. And clearly small changes in R_{12}^2 when it is close to unity will affect the denominator drastically. Thus the value of $b_{y1.2}$ is likely to fluctuate from sample to sample.

[2]) See Malinvaud's discussion in Statistical Methods ... pp. 187—192.

indicates that these are not autocorrelated. Durbin and Watson have tabulated upper (DWU) and lower (DWL) limits to DW at different values of T and n:

If DW < DWL the hypothesis of independence is rejected
» DW > DWU the hypothesis of independence is not rejected
» DWL ⩽ DW ⩽ DWU the hypothesis of independence can be either rejected or accepted.

	$k' = 3$		$k' = 4$	
T	DWL	DWU	DWL	DWU
30	1.21	1.65	1.14	1.74
40	1.34	1.66	1.29	1.72
45	1.38	1.67	1.34	1.72
50	1.42	1.67	1.38	1.72

NB. k' denotes the number of independent variables + 1

The accompanying table, which is an extract from table 4 in Durbin-Watson's article in Biometrica, vol. 38, parts 1 & 2, June 1951, shows the values of DWL and DWU at a level of significance of 0.05.

7.2.2.4. Coefficients of multiple correlation. As a measure of the total adjustment of $\hat{y}_t$ to y_t we shall use the coefficient of multiple correlation, which is defined as
$R = | 1 - \sigma^2_{\hat{y}}/\sigma^2_{\bar{y}} |$, where $\sigma^2_{\hat{y}}$ is the variance in y unexplained by the regression plane, i.e. $(1/T-3)\,\Sigma e^2$ and $\sigma^2_{\bar{y}}$ the total variance in y_t, i.e. $\Sigma(y_t - \bar{y})^2/T - 1$. Since this statistic is calculated here with regard to the number of degrees of freedom lost, the addition of another variable will not necessarily raise the value of R even if it were to reduce the residual square sum somewhat It is important to make allowances of this kind for the loss of degrees of freedom when T is small, while the difference between this R and an R in which Σe^2 is divided by T is negligible when T is large.

It should be noted that R can be a misleading characteristic in comparisons of different kinds of regression approaches. It is well known that a least square estimate of the relation $y_t = ax_t + \epsilon_t$ often gives a higher R value than an estimate of the relation $\Delta y_t = a\Delta x_t + \eta_t$. This is the case e.g. if y is total private consumption and x GNP. If out of two competing hypotheses one has been tested on the first differences and the other on the levels of the variables in question, a larger R for the latter alternative does not necessarily mean that it is the better of the two[1]).

We shall however consider a case where a relation between first differences gives a higher R value than the corresponding relation for the undifferentiated variables.

[1]) The correlation between log (private consumption) and log (GNP) is not at least in the case of Sweden appreciably greater than the correlation between time and each of these variables, a fact which can make an estimate from first differences desirable.

7.2.2.5. Beta coefficients. The practical relevance of a variable can easily be illustrated in a diagram showing the contribution of each observation of the variables to the value of the dependent variable. On the other hand the values of the coefficients do not give a clear picture of the importance of the independent variables. They do not even necessarily do so when the picture is augmented with their respective standard deviations. This is because the coefficient values depend on how the variables in question are measured, in addition to which significant values can be obtained for variables which exhibited small variations during the observation period and thus have not contributed much to the variations in the dependent variable. It is possible however to calculate the regression coefficients so that they express the practical relevance of the corresponding variables. This can be done by standardizing these coefficients, multiplying each of them by the ratio of the standard deviation of the appurtenant independent variable and the standard deviation of the dependent variable. In this way we obtain so-called beta coefficients:

$$\beta_t = b_{yt.1.2 \cdots (t-1).(t+1) \cdots n} \frac{\sigma_t}{\sigma_y}$$

These coefficients would have been obtained directly if the variables in the equation had been standardized from the beginning so that $x_t = 0$ and $\sigma(x_t) = 1$.

8. Results of the regression analysis

The content of this section has been arranged as follows. First an account is given under the headings direct method and indirect method respectively of the results of regression studies of appurtenant models. In this connection the effect of various groups of determinants of inventory demand is discussed. Next we shall try to summarize the results of the various model tests in order finally to embark on a brief historical analysis of cyclical fluctuations in inventory demand during the last fifteen year. In this connection we shall also devote some consideration to developments outside the sample period.

A few general observations can be made before presenting the results.

- The sample period comprises 1956: 1—1967: 2 i.e. 46 quarters. By using time lags and differences (up to the third order) we have sometimes been obliged to reduce the number of observations to 42. For obvious reasons this curtailment of the observation period has been done at the expense of the first observations
- The retrospective limit, i.e. the decision to start the sample period in 1956, is dictated by considerations of both data and economic theory. As regards the former, it is above all order data that hinder or preclude a further extension of the sample period. The theoretical reasons for the limitation in question is due to the assumption of a constant economic structure. Since it has not been asserted here that economic structures are un changeable, a "fresher" sample period is more interesting than an old one fore forecasting purposes.
- Steel inventories, steel consumption and steel purchases are measured in thousands of tons. Orders to and output of the steel consumers are generally indicated by an index. In order to be able to form sums of and differences between variables we must give them the same unit of measurement. Here we have let orders and output assume the same sample period average a

consumption. This kind of standardization is dealt with in more detail in a later section. To prevent misunderstandings arising out of the accounting principle as regards data we shall state the units of measurement of these variables when this is necessary for interpretation of the estimates of the different coefficients. As was mentioned earlier, we shall also make use of beta coefficients in comparisons of equations and coefficients.

8.1. Direct method

In applying the direct method described previously, we begin by estimating a quarterly series for steel inventory fluctuations in the engineering industry. The entity ${}^{c}\Delta L_t$ thus obtained is used as dependent variable in two groups of models, generally formulated in equations 4.4. and 4.5.

Of these equations, the former is a special instance of the latter, nameley when $A = 1$. It is natural therefore to begin the statement of results by showing estimates of different variants of equation 4.5., which thus constitutes a more general approach than equation 4.4. We shall also consider the former approach in more detail. To complete the account of the direct method, we shall also discuss some statistically examined models for the consumption of steel.

8.1.1. $\Delta L_t = A(L^* - L_{t-1})$. Table 8: 1 shows the result of different variants of equation 4.5., which has been augmented with a special indicator of the market situation. The equilibirum inventory has been regarded here as a function of the order inflow to the engineering industry, changes in the unfilled orders of the steelworks and changes in steel prices, two indicators being shown for the latter two. These variables are taken to represent the transaction, precautionary and speculative motives for holding inventories. Thus order inflow is regarded primarily as an indicator of planned consumption and changes in the volume of unfilled orders as an indicator of purchasers' (consumers') readiness to maintain extra inventories with a view to safeguarding their supplies of steel in the future. It should be noted that price changes have been dated t and $(t - 1)$ respectively. This does not mean that ${}_{\text{imp}}P$ (the import price index for finished steels) and ${}_{m}P$ (Swedish steel merchants' quotations for ordinary steel bars) represent different hypotheses as regards the chronological structure of speculation, for in both cases the fundamental assumption is that price expectations are based on naïve forecasts, i.e. that $\Delta^* p_{t+1} = \Delta p_t$. As was remarked in section 5.4. a delivery price in one period reflects a quoted price in an earlier period.

Table 8: 1 $\Delta L_t = A(L^* - L_{t-1}) + bZ_t + \epsilon_t$

L_{t-1}	NO_{t-1}	ΔUO_{t-1}	$\Delta_{imp}P_t$	$\Delta_m P_{t-1}$	$\Delta(UO/Q)_t$	$\Delta EXCAP_t$	$\Delta EXCAP_{t-1}$	$\Delta EXCAP_{t+(t-1)}$	const.	R	DW
—0.2839	1.700	0.07123		0.9782	—61.45				7.39	0.802	1.62
(0.0696)	(0.359)	(0.04723)		(0.6002)	(31.16)						
—0.3137	1.829	0.07767	1.161		—59.15				13.19	0.801	1.62
(0.0655)	(0.333)	(0.04687)	(0.733)		(31.44)						
—0.3018	1.715	0.08276	1.413			93.30			17.95	0.791	2.03
(0.0664)	(0.334)	(0.04814)	(0.740)			(67.42)					
—0.3378	1.929	0.06808	1.464				119.2		18.74	0.797	1.86
(0.0731)	(0.356)	(0.04762)	(0.732)				(71.7)				
—0.3895	1.981	0.0763	1.520					143.2	13.74	0.820	2.04
(0.0733)	(0.329)	(0.0448)	(0.693)					(53.9)			

Symbols:

L_{t-1}	inventories of finished steel in the engineering industry at the end of period $(t - 1)$	thousand of tons
NO_{t-1}	Orders received by the engineering industry during period $(t - 1)$	index 1954 = 100
UO_{t-1}	steelworks' orders in hand at the end of $(t - 1)$	thousands of tons
$_{imp}P_t$	import price index for finished steels for period t	index 1959 = 100
$_mP_{t-1}$	steelmerchants' quotation of ordinary steel bars	Skr. per hundred kg
$(UO/Q)_t$	delivery times from steelworks during period t	number of quarters
$EXCAP_t$	average excess capacity of steelworks during period t	percentage of total capacity

First of all we can say that the explanatory value of the model in terms of R is surprisingly high bearing in mind the apparently highly erratic nature of the dependent variable; in the last equation for the period 1957: 1—67: 2 the "explained" variance amounts to almost 75 per cent of the total variance Nor does the Durbin-Watson statistic (DW) give us any particular cause to suspect autocorrelation in the residuals.

8.1.1.1. Coefficient A. As regards the coefficient of L_{t-1}, i.e. A, it should be pointed out that by introducing special supply variables in the regression equation our aim has been to simplify the interpretation of this coefficient. To speak in the terms used in chapter 2, we have sought to eliminate the influence of a supply-conditioned factor π on the estimate of A. This in turn meant that $\hat{A}$ could be regarded as an estimate of the constant inventory adjustment factor λ, which had earlier been given a purely demand analytical content. However, as is evident from the tables, the value of A varies according to the variable content of the equations.—The range of then estimates shown in the tables is 0.11(0.39—0.28). If we divide the observed material into two sub-periods (1957: 1—61: 4) and (1962: 1—67: 2), this rises to 0.16 (0.41—0.25).

The variations in $\hat{A}$ can be ascribed to three circumstances:

- The different supply variables have not been equally successful in eliminating the effect which variations in the supply of steel can have on A. In more technical terms this means that they have not been equally efficient in preventing a $\pi < 1$. The last three equations provide a certain indication of this: The greater the significance of the supply variable, the higher $\hat{A}$ becomes, which can be interpreted as meaning that π approaches 1.
- Different estimates of L^* can lead to different systematic deviations between $(\hat{L}^* - L_{t-1})$ and $(L^* - L_{t-1})$—To revert to the discussion in chapter 2, different estimates of L^* are due to different values for the coefficient b. This is evident when e.g. actual consumption during t is used instead of NO_{t-1} as a variable to indicate transaction inventories. The former entity has less cyclic fluctuations than the latter. This is reflected by the growth of the value of A. It should however be pointed out that the standard deviation of the coefficient of C_t is fairly large and that R falls to < 0.70 as a result of this exchange of variables.
- The correlation between L_{t-1} and different $\hat{L}^*$ can lead

to considerable problems of multicollinearity and so create a degree of uncertainty in the estimates. As we have already seen, this is hard to verify unequivocally.

8.1.1.2. ${}_{T}X$-entities. We shall for the moment leave the discussion of the value of the adjustment coefficient in order to consider the determination of L^* more closely. As can be seen from the table, according to this approach the equilibrium inventory is primarily determined by the volume of incoming orders. This has been regarded as a determinant of transaction inventories. However, this need not be the only interpretation. As we saw earlier (see section 5.2.) it is absurd to assume that production plans are based implicitly on the current inflow of orders. On the other hand this may be of immediate importance to purchases of raw materials. This would mean that the effect of order inflow is to be classified among the transaction and precautionary motives for holding inventories. We shall return to this idea and enlarge on it in due course.

8.1.1.3. ${}_{p}X$-entities. Concerning the precautionary motive we can say that the a priori assumption of a relation between equilibrium inventories and purchasers' expectations regarding future steel supplies cannot be rejected out of hand if we use fluctuations in the volume of unfilled orders as a proxy variable. According to the table its practical importance has not been negligible. A rise of 100 thousand tons in the volume of orders on hand has on average led to an increase of about 20 thousand tons in equilibrium inventories. (Note that the structural coefficient of ΔUO_{t-1} is obtained by dividing the estimated coefficient by $\hat{A}$, whereupon it must be assumed that $b = 1$.) However, the standard deviation of the coefficient is quite large and it is unacceptable as regards the earlier part of the period studied. It will be recalled here that the use of the order volume indicator can give rise to a problem of identification; a rise in the volume of orders during period $t-1$ may affect not only the equilibrium inventory and via this the demand for steel, it may also affect sellers' ability to meet a rise in demand.

$$L^* - L_{t-1} = b\,(\hat{L}^* - L_{t-1}) \qquad 2.15.$$

In this connection it should be pointed out that indicators $({}_{w}UO/{}_{w}Q \cdot C^*)_{t-1}$, $[({}_{w}UO - {}_{w}L)/{}_{w}Q \cdot C^*]_{t-1}$ and their respective first differences have been tested as proxy variables. Since $C^*/{}_{w}Q$ shows small variations, the first of these indicators is very strongly correlated to ${}_{w}UO$ and thus gives about the same results as that quantity. The use of the second indicator leads to less certain coefficient estimates than those obtained for the coefficient of the steelworks' backlog of orders.

8.1.1.4. *$_S X$-entities.* The results of the regression analysis corroborate the hypothesis of the existence of price speculation, which would seem to be fairly uncommon — cf. the quotation from Lovell in section 5.4. Although it is not evident from the table, the time lag $(t + 1)$ for imp P has been examined and has been found to give distinctly less certain coefficient estimates than that applied here, which one might venture to interpret as meaning that speculation was not entirely successful but was based on naïve extrapolations of historical trends.

The fact that the coefficient for the import price has a slightly smaller standard deviation than the domestic wholesale price of steel should not be taken to confirm the hypothesis that speculation is concerned with imported steel, for merchants' prices are very strongly correlated with continental quotations. There is in fact a more or less institutionalized connection between continental and Swedish prices. The difference in the explanatory values of the two indicators is rather to be attributed to the fact that the import price index applies directly to the prices of products delivered, while the merchants' price quotation has no such immediate connection. Since it is accomplished inventory speculation that has been studied, this result would seem to be fully in order. Matters would probably have taken a very different turn if we had explicitly studied speculation in orders instead.

Now it is not certain that the relation we have obtained reflects price speculation, for price movements are connected with demand fluctuations in the ECSC market. Thus a price rise occurs when the delivery times of the continental steelworks begin to increase and the risk of a steel shortage arises. Thus the variable in question could equllay well be an indicator of the precautionary motive. The question of which emotion — the speculative or the precautionary — lies uppermost in the hearts of purchasers when they increase their inventories beyond what is normal in relation to current production plans can be safely entrusted to the psychologists.

8.1.1.5. *Z-entities.* As has already been seen, we have used fluctuations in delivery time indicated by the duration of the volume of orders and by surplus capacity to indicate the difference between $L^{**}_t - L_{t-1}$ and ΔL_t. The anticipated signs preceding these variables are — and + respectively. According to our assumptions, an increase in delivery times is a sign that sellers are having difficulty in meeting purchasers' demands. Meanwhile surplus capacity generally tends to diminish. The interdependence of these two quantities is illustrated in the accompanying figure. It should be noted that we have not aspired to a complete supply and demand model. Our aim in introducing these variables has simply been to increase the possibilities of identifying the demand relations.

8.1.2. An alternative specification of the »A model». Judging be table 8: 1 the inflow of orders to the engineering industry has played an important part in determining its investments in steel inventories. As we have already seen, this factor can influence the equilibrium inventory in two ways, namely through the transaction and precautionary motives for maintaining inventories. This means that order inflow would affect the equilibrium inventory more than is warranted by its effect on planned consumption. A very steep rise in the volume of unfilled orders with the consumers would, on account of the costs involved, in all probability not lead to an immediate adjustment of production and consumption (cf. section 5.2.2.) On the other hand it does probably influence firms' expectations regarding production trends just beyond the horizon for short-term production planning. Perhaps firms will be anxious to ensure their supplies of the necessary raw materials. Since an engineering firm can usually judge quite well what special qualities of steel it will need as soon as it receives an order, precautionary purchases of this kind are relatively free of risk, i.e. the steel purchased in advance is fairly certain to be used. This kind of precautionary inventory holding will be expressed as a linear function of the difference between order inflow during one period and planned production (consumption) for the next. By excluding all variables except NO_{t-1} and C^*_t we now obtain the following relation for the equilibrium inventory:

$$L^*_{t-1} = a_{11}\, C^*_t + a_{21}\,(NO_{t-1} - C^*_t);\ E\,(a_{21}) > 0 \qquad 8.1.$$

The general theoretical aspects of the determination of C^* have been dealt with at length in chapter 5. Of the two indicators shown in table 8: 2, one is based on barometer data while the other is based on equation 5.8., where consumption of steel has replaced production as dependent variable. In both cases the structure has been obtained by regression analysis, on the assumption that $C^*_t = C_t + \epsilon_t$, where ϵ_t is a non-autocorrelated random variable with a mean value $= O$. This assumption implies that C_t take the place of C^* in these estimates. The

$$Q^*_t = b_0 + b_1 Q_{t-1} + b_{2w}\, UO_{t-1} + b_3 NO^*_t \qquad 5.8.$$

estimates resulted in the following indicators

$$BARC^*_t = \text{antilog}\,[\log C_{t-1} + 0.0003149\,N + 0.00021]$$

$$MODC^*_t = C_{t-1} + 0.3624\Delta C_{t-1} + 0.2274\Delta_c UO_{t-1} + + 0.1837\Delta NO_t + 1.350$$

In these equations N denotes the net tendency or the balance, i.e. the difference between the number of firms expecting an increase and the number expecting a fall in output during the next quarter[1]). The variable ${}_cUO$ stands for the volume of unfilled orders in the engineering industry. The co-variation of these indicators of planned consumption is very high. This applies not only to the correlation between $BARC^*_t$ and $MODC^*_t$ but also to the correlation between $(BARC^*_t - C_{t-1})$ and $(MODC^*_t - C_{t-1})$. The occurrence of a constant in the expression for $MODC^*$ is due to the fact that the order indices are formed from figures referring to the number of hours worked. Owing to the rise in productivity the growth rate of order inflow has been decidedly lower than that of production and steel consumption.

It should be noted in this connection that an estimate of $MODC^*$ according to the above is not without certain problems of interpretation. In the first place C_{t-1} in the expression for $MODC^*_t$ ought to be replaced by $MODC^*_{t-1}$. The reason for our procedure is that, in order to avoid multicollinearity due to the high correlation between UO and the NO terms, we have made the estimate on first differences with ΔC_t as dependent variable. This variable has been regarded as an indicator of $\Delta^* C_t$, i.e. $C^*_t - C_{t-1}$ and not of ΔC^*_t, i.e. $C^*_t - C^*_{t-1}$. Moreover the relevance of the estimate obtained is dependent on the validity of the implicit assumption that production plans or their implementation are not affected by limitations of capacity. Apart from stimulating a high rate of production, a large volume of unfilled orders can also be an indicator that capacity is being fully exploited. In this way it indicates a factor inhibiting production. Thus we are faced with a problem of identification. Probably our procedure, i.e. making the regression on first differences, was a tolerable solution to the problem, for $\Delta_c UO$ should be far less correlated with the degree of capacity utilization than ${}_cUO$. It should also be

[1]) The entrepreneurial unit can be said to be defined in such a way that the total number = 100, the firms being weighted with their volume of production. Firms submit their assessments on the 15th of the last month of each quarter.

noted in this connection that a corresponding regression based on levels, i.e. C_t, UO_{t-1}, etc., results in a negative coefficient of ${}_cUO$[1]). Finally it should be pointed out that we have used the actual volume of incoming orders as an indicator of anticipated demand.

We shall describe an alternative production planning model in which production (consumption) plans for a particular period are determined by the level of production and the volume of incoming orders during the preceding period. One can if one so wishes regard this as a "abbreviated" version of the former model, where the volume of orders received indicated both the order situation and anticipated demand. A regression analysis for the period 1956: 2—1967: 4 gives the following relation

$$C^*_t = \hat{C}_t = \underset{(0.0815)}{0.6650\,C_{t-1}} + \underset{(0.0875)}{0.3601\,NO_{t-1}} + \underset{(0.1816)}{0.6894 \cdot t} - 0.630; \quad R = 0.995; \quad DW = 1.78 \qquad 8.2.$$

It is interesting to find that the coefficients of C_{t-1}, NO_{t-1} and t have received relatively small standard deviations, due probably among other things to the fact that, contrary to expectation, the problem of multicollinearity is small. There is however another interesting aspect to the result obtained, namely that it corroborates the hypothesis that planned consumption is a function of orders received during preceding periods, for the equation shown here can be regarded as derived from[2])

[1]) In order to get an idea of the influence of the volume of unfilled orders on planned consumption, $\partial C^*/\partial_c UO$, the relation discussed here should be tested on periods during which capacity does not impose any restrictions, i.e. when $Q^*_t < CAP$. An investigation of this kind has however not been feasible, owing among other things to the lack of good indicators of capacity in the engineering industry.

[2]) This derivation should be easier to follow in the general case. Consider the equation

$$y_t = \Sigma_j^n a^j a x_{t-j} + b \cdot t + c, \quad \text{where} \quad 0 < a < 1.$$

Form the corresponding expression of (t—1), multiply both terms by a and subtract the equation thus obtained from the original. We thus obtain, where $n \rightarrow \infty$

$$y_t = a y_{t-1} + a a x_{t-1} + b[1 - a] \cdot t + [c - ca - b]$$

This type of approach was first presented by Koyck in Distributed Lags and Investment Analyses, Amsterdam 1954.

$$C^*_t = (0.665)^1 \cdot 0.5415\, NO_{t-1} + (0.665)^2 \cdot \qquad 8.2.a.$$
$$\cdot\, 0.5415\, NO_{t-2} + \ldots + 2.0579 \cdot t =$$
$$= \textstyle\sum_{j=1}^{\infty} (0.665)^j \cdot 0.5415\, NO_{t-j} + 2.0579 \cdot t.$$

It is however obvious that even time lags greater than three quarters are hardly of any practical interest. This indicator is so highly correlated with the C^* indicators mentioned previously that it is immaterial in practice which of them one uses in the inventory model.

Table 8:2 shows that the new specification gives what by traditional criteria of significance is a fully acceptable result. The volume of unfilled orders at steelworks and changes in this variable have not been incorporated in these estimates as independent variables. This is because they have played a comparatively unimportant part in the estimates presented previously and because multicollinearity probably results in any influence they exert on the equilibrium inventory being absorbed by the other independent variables. It should however be added that the correlation between $(\Delta L_t - \Delta \hat{L}_t)$ and ΔUO_{t-1} varies between 0.18 and 0.27. The correlation coefficient could also be raised if we were to insert steelworks' inventories. Although the sign of this variable is theoretically correct it has been excluded from the equations, since it adds to the risk of multicollinearity. We shall however return later on to consider the effect of this variable.

In these estimates too the coefficient of the price speculation variable is positive and in three of the cases significant at the risk level of 0.02. The beta-coefficients vary from 0.14 to 0.34, which suggests that the practical relevance of the variable is only noticeable in certain cases.

The estimates shown in table 2 also suggest that the supply situation has definitely influenced the inventory investments actually effected, even if its influence has not been very great. The relation between actual and calculated inventory increases (the latter according to the last equation in table 8: 2) is shown in figures 17 and 18. The scatter in figure 17 gives a certain support to the hypothesis put forward on page 20, namely that the explanatory value of the flexible accelerator model increases with the value of $|\Delta^* L_t|$

In one respect the difference between the results in the two tables is obvious. We refer here to the estimates obtained for A. Whereas in table 8: 1 these are within the interval 0.28—0.38, the corresponding range of variation in table 8: 2 is

Table 8:2

$\Delta L_t = A(L^* - L_{t-1}) + bZ_t + \epsilon_t$

L_{t-1}	$BARC^*_t$	$MODC^*_t$	$NO_{t-1}-BARC^*_t$	$NO_{t-1}-MODC^*_t$	ΔP_t	$\Delta(UO/Q)_t$	$\Delta EXCAP_{t+(t-1)}$	Const.	R	DW
-0.4009 (0.0731)	0.4826 (0.0820)		0.3086 (0.0928)		1.585 (0.691)	-43.49 (30.59)		33.08	0.813	1.76
-0.4501 (0.0743)	0.4938 (0.0787)		0.3339 (0.0890)		1.722 (0.658)		121.5 (51.5)	59.07	0.831	2.14
-0.5369 (0.0976)		0.7547 (0.1511)		0.3188 (0.0757)	0.8698 (0.6912)	-61.20 (28.67)		-11.82	0.832	1.78
-0.5564 (0.0957)		0.7264 (0.1447)		0.3441 (0.0751)	1.312 (0.666)		130.08 (49.06)	19.29	0.843	2.20
-0.5916 (0.0953		0.7702 (0.1429)		0.3554 (0.0733)	1.092 (0.661)	-48.23 (27.71)	112.25 (48.82)	20.73	0.856	1.97

New symbols: BARC* Planned consumption estimated from business tendency survey data
MODC* Planned consumption according to specified model
P_t Merchants' price quotations

The averages of $BARC^*_t$, $MODC^*_t$ and NO_t are equal to the average of actual consumption

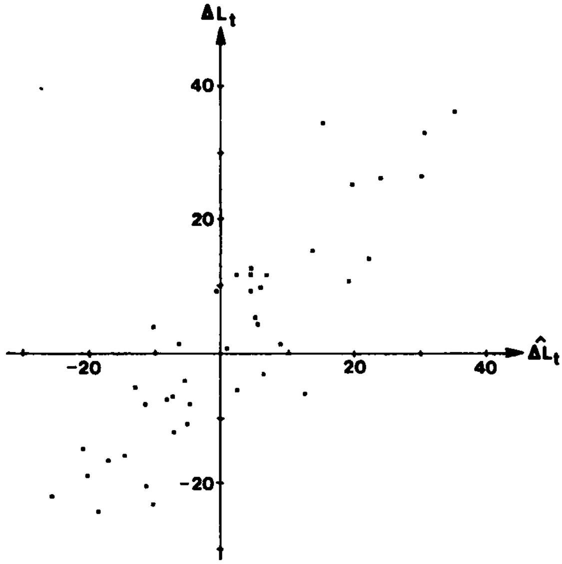


Fig. 17

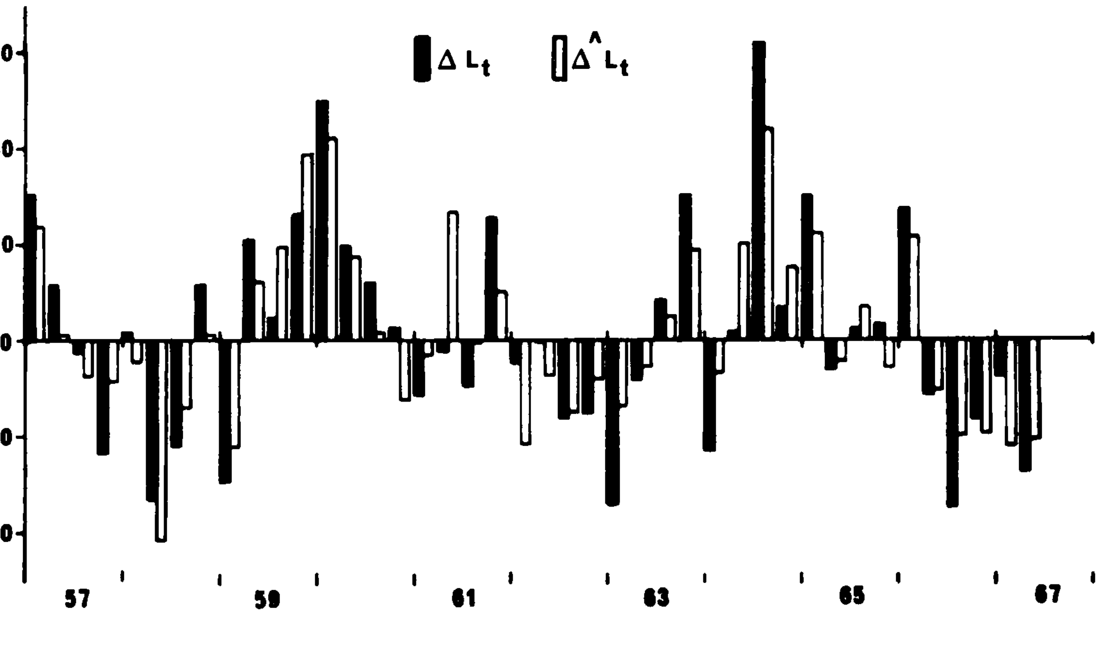


Fig. 18

0.40—0.59. Since the important difference consists in the replacement of NO_{t-1} in table 2 by the variables C^*_t and $(NO_{t-1} - C^*_t)$, the reason for the variation in A is probably largely to be found in this operation, for it seems that NO_{t-1} gives rise to more violent fluctuations in the difference $(L^* - L_{t-1})$ than the variables C^*_t and $(NO_{t-1} - C^*_t)$. At the same time however it should be pointed out that if the correlation between the independent variables is high, a change of specification can easily bring about striking variations in the coefficient estimates.

8.1.3. $\Delta^2 L = A\,(\Delta L^* - \Delta L_{t-1})$. We have already observed that correlation between original time series variables is often greater than correlation between the first differences (with regard to time) of these variables. One way of attempting to avoid problems of multicollinearity is therefore to estimated relations from first differences. Since we have on several occasions emphasized the risk of the detrimental effects of high correlation between the L^* determinants and between L^* and L_{t-1}, there is reason to try out different estimates from the first difference of equation 4.5., i.e.

$$\Delta^2 L_t = A\,(\Delta L^* - \Delta L_{t-1})$$

Table 8: 3 shows results from such estimates which in other respects resemble those presented in the two preceding tables. One important difference becomes apparent on comparing the tables, namely the value of Â. Clearly, this value, which earlier proved sensitive to a change of specification, also reacts to the way in which it is estimated.

Denote for the moment the variables ΔL, L^* and L_{-1} by y, x and z. Let the standard deviation of y and z be $S(y)$ and $S(z)$ respectively. Then the estimate of A will be

$$\hat{A} = -\frac{R(y,z) - R(y,z)\,R(x,z)}{1 - R^2(x,z)} \cdot \frac{S(y)}{S(z)}$$

When we estimate A from the first differences of y, x and z with respect to time, we obtain consistently bigger absolute values than before. In this case this increase is mainly due to the fact that the simple correlation changes from $R(y, z) = -0.246$ to $R(\Delta y, \Delta z) = -0.628$. The correlation between the independent variables and the ratio between the standard deviations in question have decreased. The fact that $R(x, z)$ is lower than $R(\Delta x, \Delta z)$ may make the A estimate in the latter case more accurate than in the former. There are however only small differences between the t-values in question. It might be added that in regarding L^* and ΔL^* as directly observ-

Table 8:3

$\Delta^2 L_t = A(\Delta L^* - \Delta L_{t-1}) + bZ + \epsilon_t$

ΔL_{t-1}	ΔNC_{t-1}	$\Delta MODC^*_t$	$\Delta(NO_{t-1} - MODC^*_t)$	$\Delta_w UO_{t-1}$	$\Delta^2_w UO_{t-1}$	$\Delta_w L_{t-3}$	$\Delta^2 P_t$	$\Delta^2 (w/Q)_t$	const.	R	DW
-0.6163	0.4292				0.05757		1,167	-64.24	1.02	0.832	2.18
(0.1321)	(0.0930)				(0.04703)		(0.738)	(28.88)			
-0.7001	0.3711			0.07883			1.266	-58.42	1.18	0.831	2.14
(0.1352)	(0.0937)			(0.06410)			(1.088)	(31.88)			
-0.7009	0.3609					-0.1948	1.623	-58.40	2.70	0.829	2.14
(0.1347)	(0.0939)					(0.1750)	(1.131)	(31.77)			
-0.7648		0.8055	0.4002				0.9144	-67.48	0.57	0.826	2.08
(0.1563)		(0.3299)	(0.0915)				(0.7540)	(26.50)			
-0.7783		0.6393	0.3955	0.1116		-0.2468	1.096	-79.39	1.48	0.842	2.11
(0.1534)		(0.3720)	(0.0921)	(0.0583)		(0.1613)	(0.748)	(36.38)			

able variables we have simplified too much to be able to analyse the effects of multicollinearity.

One interpretation of the fact that the difference between the change in equilibrium inventories and actual inventory change according to our estimates is evened out more rapidly than the difference between the equilibrium inventory and actual inventory level should not be excluded. This is based on the assumption that $\hat{A}$ in the relation $\Delta\hat{L}_t = A(\hat{L}^* - L_{t-1})$ is more influenced by the variations in the supply of steel than is the case with the corresponding factor in the first difference of this expression. In other words, L^* is taken to be more correlated than ΔL^* with the state of the steel market, so that the estimate of A in the former case is more affected by a factor π (see chapter 2) than in the latter case. This in turn implies that the z variables have not enabled us to eliminate the effect of these variations in the state of the market on $\hat{A}$.

Independent variables \ Dependent variable	$\hat{L}^*$ (8:2)	$\Delta\hat{L}^*$ (8:3)
MODC*	·1.406	
ΔMODC*		1.053
NO_{t-1}-MODC*	·0.594	
ΔNO_{t-1}-ΔMODC*		0.523
ΔP	1.620	
Δ^2P		1.196

The numbers refer to the third relation in table 8:2 and to the fourth in table 8:3 respectively.

The complement of the difference in A value is the differences in the levels of the structure coefficients. As is shown in the accompanying table, these are consistently lower for the variables included in the determination of $\Delta\hat{L}^*$ than for the explanatory variables of $\hat{L}^*$.—Since we are considering one and the same basic model, the former variable vector is the first difference of the latter. Thus an anticipated price rise of 10 kronor per 100 kg results in a speculative increase of 16 thousand tons in L^* according to the $\hat{L}^*$ estimate but of only 2 thousand tons according to the $\Delta\hat{L}^*$ estimate. This difference may be relevant outside the sample period, e.g. in a forecasting situation.

A new independent variable appears in table 8: 3, namely the steelworks' stocks of finished products. This variable has been given a time lag of 3 quarters in relation to the dependent variable. The coefficient estimate obtained has the "right" sign; the standard deviation however is quite large. The specific implication of this result is that, all other things being equal, an increase of just over 30,000 tons in the steelworks' inventories is required in order for the steel inventories of the engineering industry to be reduced by 10,000 tons. Since however the steeelworks' inventories have risen steeply, especially during the 1960s, this variable has probably played an important part in the more structural change in the inventory maintenance of the engineering industry. We shall be returning to this aspect in Part IV.

8.1.4. $\Delta L_t = \Delta L^*_{t-1} + \epsilon_t$. Although tables 8: 1—8: 3 show that factor A varies from one instance to another, it always

Note: The structure coefficient of a variable = the obtained regression coefficient/A.

Table 8:4

$\Delta L_t = \Delta L^*_t + \epsilon_t$

ΔNO_{t-1}	ΔC^*_t	$\Delta(NO_{t-1}-C^*_t)$	$\Delta_w UO_{t-1}$	$\Delta^2{}_w UO_{t-1}$	$\Delta_w L_{t-3}$	$\Delta^2 P_t$	$\Delta(UO/Q)t$	R	DW
0.484			0.430			0.099	-0.226	0.661	1.54
(0.132)			(0.133)			(0.132)	(0.134		
0.479			0.394		-0.165	0.127	-0.249	0.679	1.65
(0.131)			(0.135)		(0.132)	(0.132)	(0.134)		
	0.572	0.535				0.148	-0.219	0.656	1.88
	(0.136)	(0.136)				(0.127)	(0.131)		
	0.452	0.534	0.253			0.105	-0.237	0.690	1.74
	(0.148)	(0.132)	(0.143)			(0.125)	(0.128)		
	0.571	0.576		0.183		0.134	-0.231	0.680	1.84
	(0.134)	(0.137)		(0.126)		(0.124)	(0.130)		
	0.432	0.546	0.243		-0.162	0.115	-0.275	0.710	1.88
	(0.147)	(0.132)	(0.141)		(0.124)	(0.121)	(0.128)		

N.B. All coefficients are beta-coefficients. The regression constants, i.e. the estimates of intercepts, have been omitted in this account.

$$\Delta L_t = \Delta L^*_{t-1} + \epsilon_t; \quad \Delta L^*_{t-1} = \Delta L^{**}_t \qquad 4.4.$$

has a value definitely within the interval (0,1) and not very close to 1. Consequently the hypothesis expressed in 4.4. to the effect that the difference between actual inventory change and change in the equilibrium inventory can be described as a random variable which has a mean value of zero and constant variance and is not autocorrelated no longer seems realistic. We shall however set out the results of estimates of the coefficients in various specifications of this model and make various comparisons with the estimates analysed previously.

It can be said at once that this model approach gives a lower statistical explanatory value than that which was analysed in the preceding section. There is nothing intrinsically remarkable about this. It is quite natural for the correlation to be lower if a certain coefficient has been ascribed a certain value from the beginning than if it is chosen freely, so to speak.

The important question however is whether the difference in R is large enough for us to reject the hypothesis that $\Delta L_t = \Delta L^*_t + \epsilon_t$, i.e. that the level of the equilibrium inventory at the end of period $(t-1)$ is attained at the end of period t. As was pointed out earlier, this is a question of subjective assessment. The view of the alternative hypothesis represented by equation 4.5. which was put forward previously (especially in chapter 2) is that it is difficult to justify the occurrence of a *constant* delay factor of the type λ and that it is natural to assume that firms have such decision rules that they immediately try to adjust inventories to the level indicated by these rules. However the results suggest unequivocally that the decision rules identified are not of the latter kind. Now this may of course be because they describe the behaviour of firms incorrectly. It should be pointed out in this connection that $/A/$ can be raised to 0.90, especially by using stiff indicators of C^*_t. In these cases however R falls drastically. This means that, at least for purposes of forecasting, we are justified for the time being in using models which presuppose a constant delay factor.

All that need be added by way of commentary on table 8: 4 is that the variables are of the same relative importance on the whole as in the models described earlier. The coefficient of the price speculation variable has however become definitely insignificant in some cases, in the sense that its standard deviation is greater than its average.

8.1.5. The determination of consumption. In the introduction to this essay we remarked on the suitability for purposes of analysis of dividing up observed consumption into two components, $\Delta_p L_t$ and ${}_0C_t$, and on a priori premises we found it probable that the first of these had considerable influence on cyclical variations in steel consumption. We noted that its importance increased with relative production time, i.e. the time between input and output divided by the length of the period, $(t_{\text{out}} - t_{\text{in}})/i$; when $(t_{\text{out}} - t_{\text{in}}) \rightarrow O$ then $C_t = {}_0C_t$ even when ${}_0C_t$ varies[1]). As was mentioned in chapter 1, the variation in $\Delta_p L_t$ can also be influenced by the same factors as ΔL_t. Accordingly there is reason to distinguish between the determinants of $\Delta_p L_t$ and those of ${}_0C_t$.

In estimating a model for consumption, the quantity of steel in process has been assumed to depend on current production and on the volume of unfilled orders in the engineering industry. The first component has been assumed to perform a technical function (process inventories), while the second has been taken to indicate a kind of preparedness function (that part of the intermediate inventories which is not to be classed as friction inventories).

$$ {}_pL_t = a_1 Q_t + a_{2c} UO_t \tag{8.3.} $$

This gives

$$ \Delta_p L_t = a_1 \Delta Q_t + a_2 \Delta_c UO_t = a_1 \Delta Q_t + a_2 (NO_t - S_t) \tag{8.4.} $$

where S_t is deliveries of finished products by the engineering industry. If C is then taken as a linear function of S_t we obtain the following equation for observed consumption

$$ C_t = a_1 \Delta Q_t + a_2 NO_t - a_2 S_t + a_3 S_t \tag{8.5.} $$

In the absence of indicators of S making it meaningful to form a variable $(NO_t - S_t)$ the equation has therefore been approximated to

$$ C_t = \mathscr{A} Q_t + a_1 \Delta Q_t + a_2 NO_t \tag{8.6.} $$

where $\mathscr{A} Q_t$ is an approximation of $(a_3 - a_2) S_t$[2]). Tested on quarterly data for the period 1956: 1—1967: 2, this hypothesis gave the following relation, in which the coefficients are standardized units, i.e. so-called beta coefficients.

[1]) If ${}_0C_t$ is constant and the structure remains unaltered, then $\Delta_p L_t = 0$.

[2]) This presupposes that S and Q_t are strongly correlated with one another, a presupposition which does not apply in the case of certain individual engineering enterprises (e.g. manufacturers of paper machines) but which is probably more true of the branch as a whole.

$$C_t = \text{constant} + \underset{(0.026)}{0.821 Q_t} + \underset{(0.026)}{0.235 NO_t}; \; R = 0.993 \qquad 8.6.\text{a.}$$

or

$$C_t = \text{constant} + \underset{(0.102)}{0.457 Q_t} + \underset{(0.023)}{0.251 NO_t} + \underset{(0.099)}{0.356 \cdot t}; \qquad 8.6.\text{b.}$$

$$R = 0.994$$

ΔQ_t has been omitted from the equations on the grounds that the coefficient obtained for this variable, although it has a positive sign, does not contribute significantly to the explanation of the variations in C_t. According to the estimates most of the variations in C_t are due (as seems quite natural) to production an deliveries. The use of the beta ocefficients as indicators is limited however as regards the question of what causes a variable to vary around its trend when the latter is large. In the second estimate the equation has therefore been augmented with a trend variable, which implies a trend elimination of all variables in the equation. Now it is evident that deliveries have played a smaller part in the cyclical variations of consumption than in its trend. If Q_t and S_t are identical the coefficient of the latter variable will be $\hat{a}_3 = 0.457 - 0.251 = 0.206$, i.e. smaller than the coefficient of NO_t. As regards the cyclical variations of C_t, according to this attitude the occurrence of a precuationary steel inventory in the form of goods in process or semi-manufactures between the various production processes has played quite an important part.

We have seen that both production and new orders have a strong influence on the behavior of the quantity which we record as steel consumption. If we will try to answer the question why the rate of increase in steel consumption deviates from that in production, it seems natural to base our analysis on a logarithmically linear relation between the variables in question.

A regression analysis covering the same sample period as above gives the following equation

$$\log (C/Q)_t = -2.7774 + \underset{(0.0620)}{0.41421 \log NO_t} - \underset{(0.000444)}{0.005480 \cdot t}$$

$$R = 0.886; \; R(C, \hat{C}) = 0.991; \; DW = 1.18$$

Here the coefficient of time has got a negative sign. This result is partly due to the value of the coefficient of new orders. The higher the latter, the lower will be the former. If the coefficient of time had become equal to zero this would have implied that the rate of growth of consumption equalled the growth rate of production plus almost half of that of new orders. It should be stressed that the interest of this consumption model is limited to analyses of business cycle fluctuations. It gives us a description of how a fairly stable growth in production (resulting from a concious stabilization policy by firms) can give rise to surprisingly large fluctuations in steel consumption. In the long run the growth rate of production will equal that of new orders (in this case plus the rate of increase in production per man hour) which means that steel consumption can be set as a function of one of those variables and a trend factor.

Now the variatons in C_t "explained" by NO_t are not necessarily due to a precautionary increase in goods in process. They may also be a sign of bottlenecks in production which lead to blockages and cause input to proceed less evenly than output. According to this interpretation, input and the consumption of steel are dependent on the volume of orders. But owing to capacity restrictions during the latter stages of the production process, output is not as flexible as input. Thus in the event of a steep rise in demand output would rise more slowly than input, causing the order backlogs and the inventories of goods in process to increase. When demand stagnates and begins to fall, this affects input, while output continues to rise through a reduction of the amount of goods in process.[1]

8.2. Indirect method

When the *indirect method* is applied, the dependent variable is steel purchases by the engineering industry while the independent variables are indicators of consumption and inventory increase respectively. As we saw earlier, two approaches will be tested here. One of them is based on the assumption that $C_t = C^*_t + \epsilon_{1t}$ and that $J_t = J^*_t + \epsilon_{2t}$, where $E(\epsilon_{1t}) = E(\epsilon_{2t}) = E(\epsilon_{1t}\epsilon_{2t}) = O$ and that either ϵ_{1t} or ϵ_{2t} is autocorrelated. The second is an attempt to make allowance for any systematic variation in ϵ_{1t}.

The first of these models was formulated in equation 4.8.:

$$J_t = bQ_t + \Delta L^*_t + \eta_{1t}$$

[1] This was the approach used in the model for investment in goods in process. Cf. Part II 2.5.3.

To ease the assumption regarding the residual term ϵ_{2t} this equation, like equation 4.9., can be provided with a z term:

$$J_t = bQ_t + \Delta L^*_{t-1} + \phi(z) + \eta_{2t}$$

The second model approach was generally formulated in equation 4.10.

$$J_t = bQ_t + \Delta L^*_{t-1} + b(\Delta Q_{t-1} - \Delta Q^*_{t-1}) + \eta_{3t}$$

Various versions of this approach were presented in chapter 6 under the heading QJ models.

Both imply that the result obtainted from a given inventory model can be dependent on the consumption model and the indication of the variables in it. The coefficient estimates in the consumption model are similarly affected by the specification of the inventory model. Thus if the inventory increase model consists of $\Sigma a_j x_{jt} = AX_t$ and the consumption model of $\Sigma b_i y_{it} = BY_t$ then an estimate will give

$$\hat{J}_t = \hat{A}X_t + \hat{B}Y_t$$

If BY_t is replaced with another model, say CZ_t, no x_j must be correlated with any y_i or any z_k if $\hat{A}$ is to remain unchanged.

In concrete terms this means in the present context that if a production indicator is chosen which is thought to reflect observed consumption (input) rather than consumption corrected by changes in steel in process, ${}_0C_t$ (output), the estimates of the coefficient vector will very likely be affected.

8.2.1. $\hat{\mathbf{J}}_t = \hat{\mathbf{b}}\mathbf{Q}_t + \Delta\hat{\mathbf{L}}^*_t$. It is evident from the above that the difference between equations 4.4.a and 4.4.b on the one hand and equations 4.8. and 4.9. on the other concerns the determination of consumption and its effect on the coefficient estimates. As we have seen, the inventory model is tested separately in the first, while in the second it is tested together with a consumption model, which as was observed in the previous section can lead to different coefficient estimates. As we saw in chapter 5 there are several alternatives available for estimates of consumption using the indirect method. Table 8: 5a illustrates two general cases, namely when real consumption is regarded as a linear function of actual production and, secondly, when real consumption is assumed to equal planned consumption.

The table shows three separate indicators of production, namely the SCB (Swedish Central Bureau of Statistics) pro-

Table 8:5a

$\hat{J} = \hat{C} + \Delta\hat{L}$

Q_t 1)	Q_t 2)	NO_t	ΔNO_{t-1}	C^*_t 3)	ΔC^*_t	$\Delta_w UO_{t-1}$	$\Delta_w L_{t-1}$	$\Delta^2 P_t$	$\Delta_w (UO/Q)_t$	const.	R	DW
0.8119			0.4741			0.1965	-0.6279	0.2992	-132.44	89.03	0.947	1.07
(0.0484)			(0.1757)			(0.1028)	(0.3386)	(1.6001)	(73.37)			
	0.9236		0.3801			0.2127		0.1360	-108.24	37.18	0.971	1.11
	(0.0402)		(0.1407)			(0.0900)		(1.2020)	(55.09)			
0.6703		0.6730	0.4258			0.0874	-0.3170		-115.70	-156.70	0.977	2.30
(0.0392)		(0.0909)	(0.1253)			(0.0696)	(0.2126)		(46.69)			
				1.0623	1.7131	0.1552	-0.3968		- 97.91	-37.94	0.979	1.66
				(0.0393)	(0.4776)	(0.0669)	(0.2183)		(48.52)			

1) Q_t is indicated by $\Sigma w_i Q_{it}$, where Q_{it} is the official production index for a subbranch of the engineering industry. w_i are weights reflecting the average share of each sub-sector in total steel consumption during the period 1961-64.

2) Q_t is a final demand index, i.e. $Q_t = \Sigma b_i Y_{it}$, where Y_i is a final demand sector. N.b. that the investments in goods in process is included amoung those sectors

3) C^*_t = constant $\cdot 0.665^{(t-j)} \cdot NO_{t-j}$; j=1,2,3, ...

duction index for the engineering industry, a linear combination of this index and an index of incoming orders and, thirdly, a final-demand-based index which makes special allowance for the increase of goods in process. The table shows that the coefficient estimate is definitely influenced by the different specifications of consumption[1]). This is above all the case with the coefficients for the steel mills' order stocks and inventories. Both these quantities, which are intended to express precautionary inventory increases, exhibit striking variations of theoretical and practical relevance from case to case. Like the estimates given in tables 8.1., 8.2. and 8.3., changes in planned consumption—whether this quantity be represented by orders received during the preceding period or by orders received during several preceding periods[1])—are of both theoretical and practical consequence to realized inventory changes. The supply term is also of importance. The effect of price speculation on inventory changes is by contrast absolutely negligible according to these estimates.

The value of the correlation coefficient varies above all according to the indication of consumption. When this is expressed as a linear function of the SCB production index, which proved a very insensitive gauge of input changes, R is between two and three percent units lower than when the production index is taken directly (in equation 2) or indirectly (in equation 3)[2]) as a gauge of input.

The constant in the first two equations is positive at the same time as the coefficients for Q are less than 1. This result is due to the fact that specific steel consumption C/Q has diminished in time[3]) *and* that Q and t have been strongly (positively) correlated with each other. If either of these conditions is not satisfied the relation will of course cease to apply. Thus in a forecasting situation where we anticipate a fall in production we can no longer apply the coefficient estimate of Q, for this would imply a reversion by firms faced with

[1]) For the purposes of this table and when comparing it with previous tables, it should be borne in mind that the variables Q, NO and C^* have been standardized in the sense that their respective mean values equal the mean value of J.

[1]) In this case we have employed the specification of planned consumption given on p.

i.e. $C^* = 36.5069 + 2.4638 \cdot (0.665)^j \cdot NO_{t-j} + 0.3634 \cdot t$

[2]) The argument for this specification is given in section 8.1.5.

[3]) This is a consequence of the substitution of other materials for steel and the introduction of better quality steels. Cf. Part. II, sections 2.4. and 6.

Table 8:5 b

$(J-BQ)_t = \Delta\hat{L}_t + \epsilon_t$

	ΔNO_{t-1}	ΔC^*_t	$\Delta_w UO_{t-1}$	$\Delta_w L_{t-3}$	$\Delta^2_m P_t$	$\Delta UO/Q$	t	const.	R	DW
Q=weighted production	0.5050		0.2000	-0.6170	0.738	-120.5	-2.415	33.71	0.776	1.10
index	(0.1964)		(0.1050)	(0.3484)	(1.640)	(75.2)	(0.482)			
- " -		3.434	0.0798	-0.4519	-	179.7	-2.286	7.33	0.869	1.67
		(0.192)	(0.0858)	(0.2758)		(59.9)	(0.379)			
Q=final demand index	0.3593		0.1884	-0.4378	0.440	-97.6	-1.123	12.06	0.714	1.09
	(0.1374)		(0.0758)	(0.2549)	(1.170)	(53.8)	(0.350)			
- " -		2.111	0.1124	-0.3634	-	-123.2	-1.072	-3.35	0.788	1.35
		(0.183)	(0.0697)			(48.0)	(0.309)			

In all equations $\Sigma NO_{t-1}/T$, $\Sigma C^*_t/T$ and $\Sigma Q_t/T$ are equal to 458, 97, i.e. the quaterly average of realized steel purchases over the period 1957:1 - 1967:2.

diminishing output to older techniques of production, thus increasing steel consumption per unit and making the fall in steel consumption less than the fall in production. The fore-caster would most probably be better advised in a situation of this kind to make the coefficient of Q equal to 1.

One means to a better clarification of the effect of the fall in the ratio C/Q on the relation between C and Q is of course explicitly to insert a trend factor in the equation. This can suitably be done by using $J - BQ$ as dependent variable, with B a coefficient transforming the Q index in such a way that its mean value over the period studied equals the mean value of J. In this way the problems of multicollinearity which would otherwise result from a strong correlation between Q and t can be avoided.

According to estimates made in this way the substitution effects referred to above have caused steel production at unchanged production by steel consumers to fall by 1—2.5 thousand tons per quarter.[1]) The higher figure applies if pro-duction is indicated by the SCB production index, while the lower figure was obtained with a production index based on final demand figures. Our interpretation of the quantity $(J - BQ)$ will depend on how we measure production. In the former case (Q is the official production index) the quantity in question is to be regarded as an estimate of the increase in the *sum* of the quantity of steel in the consumers' raw material inventories and the quantity of steel in goods in process. In the latter case (Q is a final demand index) the difference $(J - BQ)$ is an estimate of the rise in consumers' steel in-ventories in the normal sense of the term, so that it is not directly comparable with ΔL_t, i.e. the dependent variable in the estimates given in tables 8: 1—8: 4.

It will be seen from the table that the two specifications given of the inventory model give a higher correlation when Q is indexed with a production index than when it is indexed with a final demand index. Thus the models explain steel inventory changes better when they are made to include steel in process than when they exclude it. It is also evident that ΔC^* functions better than ΔNO_{t-1} as a determinant of transaction invento-ries. Now in the present instance ΔC^* is nothing but a linear function of the rise in order inflow during preceding periods $(\Sigma a_j NO_{t-j})$ and time, where a_j is exponentially distributed

[1]) This fall of 2.5 thousand tons quarterly during the period 1956: 1—1967: 4 corresponds to an annual fall of *c.* $\frac{1}{2}$ per cent in specific steel consumption.

$C^*_t = 36.5 + 2.5\,(0.665)^j \cdot$
$\cdot\, NO_{t-j} + 9.4 \cdot t$

according to the specification in the margin. By using ΔC^*_t instead of ΔNO_{t-1} we increase the uncertainly of the coefficient estimate of $\Delta_w UO_{t-1}$, due probably to the simple correlation between ΔC^*_t and $\Delta_w UO_{t-1}$ being greater than the correlation between ΔNO_{t-1} and $\Delta_w UO_{t-1}$. Thus the increase in planned consumption "soaks up" part of the explanation of inventory variations which theoretically ought to be attributed to other variables. It should also be observed that the introduction of price speculations has not been found to enhance the statistical explanatory value of the models.

Finally we see that the last equation in table 8: 5 describes reality somewhat better in terms of correlation than do the other equations. In this case our basic assumption is that realized consumption equals planned consumption (or that $C_t - C^*_t = \epsilon_t$, where ϵ_t has a zero mean and a small variance). This assumption implies that the difference between planned and real purchases is only reflected in inventories.

8.2.2. **The QJ models.** Table 8: 6 shows the results of a regression analysis of equations 6.11. . . . 6.14. and 6.20. The object of this approach, as has been previously pointed out, is to facilitate an efficient estimate of the structure parameters even when the residuals are systematic and to limit the number of exogenous variables, which should also be both readily accessible and easy to interpret.

The structural parameters which are to be estimated are marginal propensities to consumption and to inventory holding respectively, i.e. $\partial C/\partial Q$ and $\partial L/\partial C^*$. Thus the latter derivative expresses a constant relation between expectation or plan quantities, which means that it can only exceptionally be immediately identified from realized data for L and C. As was shown in chapter 6, we approach the problem in two ways so as to make allowance for any systematic variation in the involuntary inventory increases. First the regression equations have been formulated in such a way as to make allowance for such systematics as arises from discrepancies between actual and planned consumption. Secondly we try, starting with a theory of the revision of consumption plans, to introduce a variable to "explain" involuntary inventory increases. To make the results easier to understand, all original variables, i.e. J, u and Q, have been standardized in such a way that
$\Sigma J_t = \Sigma u_t = \Sigma Q_t = 456.2 \cdot T$. The figure 456.2 is the historical

quarterly average in thousands of tons of steel purchases by the engineering industry.[1])

The estimates obtained exhibit a surprisingly high degree of stability. Except for equation 6.13. neither b nor a_1 changes significantly with changes of specification or changes of indicator of Q. The latter circumstance is perhaps surprising, for the two measures used have very different cyclical properties. The DW figure is rather low in some cases but still far better than those obtained when one tries to estimate a_1 and b on the assumption that discrepancies between actual and planned consumption can be described by a non-autocorrelated random variable with an average value $= O$. In this case we obtain (using the production index described above as a measure of Q)

$$J_t = \underset{(0.037)}{0.754 Q_t} + \underset{(0.422)}{0.631 \Delta Q_{t+1}} + \text{constant} + e_t;$$

$$R = 0.945; \; DW = 0.90$$

Clearly the residual term e_t is autocorrelated here and the estimate of the marginal propensity to holding inventory is more uncertain than the estimates shown in the table—of these, the first and third are the most relevant comparisons.

The results also show that order inflow is a better indicator than the historical production trend for purposes of production planning, at least when steel consumption is taken as the measure of output, for equation 6.12. describes J^*_t entirely as a function of $[NO_{t-1}, NO_{t-2} \ldots NO_{t-5}]$ with the coefficient structure $[0.762, 0.662, -0.254, -0.170, -0.057]$. Thus we have described purchases (J_t) as a function of a weighted average of incoming orders. It has been possible to specify this function by constructing a model of inventory changes and consumption and only by extimating the coefficients in this model has it been possible to determine the weight distribution in this weighted average.

The fifth column of the table, headed "trend", requires a word of explanation. Under this heading is given the inventory investment trend incorporated in the regression constant. A division of the constant in this way is feasible if the regression is conducted by stages. For reasons previously stated (see section 7.2.) this procedure is only meaningful if the independent variables are uncorrelated. In this case the linear relations

[1]) The average refers to the period 1956: 1—1967: 2.

Table 8:6

QJ-Models

Equations	b	a·b	c	const.	trend	R	DW
6.11. A	0.812 (0.036)	0.778 (0.207)		72.07	-6.8	0.964	1,23
6.11. B	0.861 (0.036)	0.831 (0.191)		53.83	-8.4	0.965	1.47
6.13. A	0.707 (0.044)	1.194 (0.392)		105;64	-6.2	0.932	1.15
6.13. B	0.815 (0.047)	0.446 (0.297)		70.16	-2.6	0.938	1.29
6.12.	0.853 (0.031)	0.834 (0.171)	0.572 (0.150)	65.41	-9.8	0.975	1.84
6.14. A	0.793 (0.043)	1.150 (0.355)	0.830 (0.217)	88.29	-10.8	0.949	1.57
6.14. B	0.855 (0.041)	0.732 (0.281)	0.638 (0.215)	59.84	-9.8	0.956	1.67
6.20. A	0.849 (0.040)	0.716 (0.220)	0.752 (0.195)	68.62	-5.3	0.959	1.22
6.20. B	0.869 (0.037)	0.786 (0.202)	0.794 (0.179)	58.81	-6.16	0.964	1,35

Note. In equations indexed A the production indicator is a production index weighted with steelc onsumption per product unit. In equations indexed *B* the production indicator is a final demand index including the changes in stocks of goods in process with the consumer.

included can be identified. In the case of two independent variables (x_1 and x_2) the regression constant $\hat{a}_0$ can be divided into $\hat{a}_{01}$ and $\hat{a}_{02}$. If we first perform the simple regression ($y = \hat{a}_{01} + \hat{a}_1 x_1$) we immediately obtain, if x_1 and x_2 are uncorrelated, the partial regression coefficient and the constant ($\hat{a}_{01}$) obtained thereby is wholly attributable to the partial relation $x_1 \rightarrow y$. Our next step is to insert x_2 to obtain the total regression constant. The difference between this and $\hat{a}_{01}$ is $\hat{a}_{02}$, which is wholly attributable to the relation $x_2 \rightarrow y$.

We have taken this step because the correlation between the dependent variables in this relation is very slight. Thus in this way we can obtain from 6.11.a. the two structural equations

$$C_t = 78.91 + 0.812 Q_t \text{ and}$$

$$\Delta \hat{L}^*_t = -6.84 + 0.958 \Delta C^*_{t+1}$$

This estimate shows that C_t is not proportional to Q_t, a result which is as pointed out earlier due to a tendency for the discrepancy between production and consumption to increase. This trend in specific steel consumption can of course also have affected the parameter estimates in the second equation.

The constant in the second equation is to be interpreted as a trend factor[1]) according to which inventories fall by approximately 27 thousand tons p.a. when consumption remains unchanged.

The coefficients in the plan revision terms of equations 6.12. and 6.14. all differ significantly from zero. According to our assumptions these terms describe the increment over and above planned consumption which is occasioned by order trends. It should be noted that $\hat{c}$ in equation 6.12. is smaller than $\hat{c}$ in the other equations. This is probably connected with the difference in measures of production. Q^* in 6.12. is based on new orders ($Q^*_t = u_{(t-2)}$). u is highly correlated with observed consumption, so that it "traps" a certain portion of the variations of $\Delta_p L$ which are "described" by the third term of the second equation.

$$J_t = b u_{t-2} + a_1 b \Delta u_{t-1} + c N_{t-1} \qquad 6.12.$$

$$J_t = b q_{t-2} + a_1 b \Delta q_{t-1} + c N_{t-1} \qquad 6.14.$$

The statistical explanatory value of the inventory investment models hidden in equations 6.11.—6.14. is between 0.55 and 0.60 if the revision term is not included and between 0.65 and 0.73 if it is included.

[1]) If the indefinite sum of this expression is calculated we obtain

$$\Delta^{-1} (\Delta L^*_t) = L^*_t = 0.958 C^*_{t+1} - 6.84 \cdot t + \text{constant.}$$

In order to connect the direct and indirect methods, we shall see how the model approach comprised by equations 6.11.—6.14. works if we use the same consumption indicator as in the application of the direct method. Analogously with equation 6.10. we obtain as an indicator of C^*_t

$$c_t = C_{t-2} + 0.6\Delta C_{t-2} + 0.3\Delta C_{t-3} + 0.1\Delta C_{t-4}$$

If we insert this variabel instead of q in equation 6.14. and give b a conditional value of 1, an estimation gives us the relation

$$J_t - c_{t-2} = 0.32 + \underset{(0.24)}{0.95\Delta c_{t-1}} + \underset{(0.18)}{0.47 N_{t-1}}$$

$$R = 0.68; \quad DW = 2.07$$

We can conclude that the coefficient estimates have not been significantly affected by this procedure. The correlation is fairly high compared with the correlation coefficients in table 8: 4. Finally we will present the results of an estimate of equation 6.17. according to which order inflow has an extra effect on purchases apart from the effect it has on them through its influence on consumption plans. In this connection we obtained the relation

$$\hat{J}_t = \underset{(0.051)}{0.816}\,(Q_{t-1} + \Delta Q_{t-2}) + \underset{(0.478)}{0.746}\Delta Q_{t-1} +$$

$$+ \underset{(0.242)}{0.365}\Delta^2 u_{(t-1)} + \underset{(0.241)}{0.261}\Delta^2 u_{(t-2)} + 67.56;$$

$$R = 0.935; \quad DW = 1.40$$

If the estimates of the structural coefficients are solved from the coefficient values in the above equation we obtain

$$\hat{b} = 0.816 \qquad \hat{d} = 0.320$$

$$\hat{a}_1 = 0.914 \qquad \hat{h} = \hat{e} - \hat{d} = 0.169$$

As we found in tables 8: 2 and 8: 3, order inflow has an extra effect on purchases of steel. It should however be emphasized that the estimate of h is shighly uncertain owing to the relatively high standard deviations in the coefficients of $\Delta^2 u_{(t-1)}$ and $\Delta^2 u_{(t-2)}$.

8.3. Summary

In this chapter we have presented the results of estimates o different models intended to describe steel inventory invest ments in the engineering industry. Two approaches were tried the direct method and the indirect method. In the former w studied inventory increases as a function of transaction precautionary and speculative determinants. In the latter w studied how the last-mentioned variables affected total pur chases of steel and arrived at conclusions regarding thei effect on inventory investments. In the latter respect we devote some attention to the so-called QJ models, in the formulatior of which explicit allowance was made for involuntary inventor fluctuations.

At this point the following questions arise. Which of the various model approaches has been the "best"? Which factors have determined the variations in the steel inventory invest- ments of the engineering industry and its total purchases?

By way of introduction we shall endeavour to answer the first question. This brings us onto the subsidiary problem of the realism of the model in which the occurrence of an adjustment factor plays a vital part. After this we shall discuss the effect of different factors on the various model approaches. In this connection we shall also review the result of the application of other proxy variables besides those shown in tables 8: 1— 8: 6. Finally we shall attempt to give an analytical outline of the historical development of the demand for steel in the light of the results of the regression analysis.

8.3.1. **A general comparison of the explanatory value and usefulness of different models.** Seen in terms of statistical explanatory value, expressed in R terms, the approach generally described by equation 4.5. can be said to give the consistently best results. Apart from high R values the different versions of this approach have also resulted in theoretically acceptable coefficient estimates. The reliability of the results appears to be greater when the estimates are based on the first difference of equation 4.5. than when they are based on its original form. This is because the problem of multicollinearity is evidently smaller in the former than in the latter case. The assumption that $E(A) = 1$, i.e. that $\Delta L_t = \Delta L^*_t + \epsilon_t$ (equation 4.4.) results in reasonable coefficient estimates but gives R values that are 10—15 per cent units lower than in the cases where A can be chosen freely. The inventory models implicated in the estimates according to the direct method have according to

$$\Delta L_t = A\,(L^*_{t-1} - L_{t-1}) + \epsilon_t$$

approximate estimates R values on a level with those given for equation 4.4. which may be said to confirm our expectations. There is however one striking exception. As was shown in table 8: 7 b, we obtained R values above 0.85 when we used $(J - BQ)_t$ as an indicator of inventory investment. This was regarded as a result of the increase in steel in goods in process, here indicated by $(C - BQ)_t$, being to a high degree explained by the same variables as ΔL_t plus a trend factor.

Since equation 4.5. gives better R values and has apparantly as sound a theoretical basis as any of the others, it should be preferable to them.[1]) Let us also accept this conclusion as regards our analysis of historical developments. But this analysis is not the principal object of the present study, which is ultimately concerned with the contribution of the models to forecasting. At this point other aspects come into the picture. The choise of model is no longer as self-evident as before. Is the fact that equation 6.12. gives an R value for the implied inventory increase model of 0.71 as against the 0.79—0.85 of equation 4.5. counterbalanced by the fact that the number of variables describing inventory increase is less and easier to forecast in the former case than in the latter? This question cannot be answered without first presenting an estimate of the value of the information obtainable from a particular model and the costs which this involves. Consequently it is beyond the scope of the present study.

As regards the comparison of the partial approaches of the direct method, the estimate of $\hat{A}$ is clearly of the utmost interest. A has proved to be sensitive to changes of specification. This seems quite natural: Given different values of L^*_{t-1} the equation $\Delta L_t = (L^*_{t-1} - L_{t-1}) A_t$ is bound to be satisfied by different values of a quantity A_t. The same applies, as has already been remarked, to a regression constant A calculated for different time series (L^*_t) with different development patterns.

Apart from varying according to model specifications, A also changes value when one proceeds from an estimate of equation 4.5. to an estimate of its first difference. This latter change was found to be due to the fact that the relation between $\Delta^2 L_t$ and ΔL_{t-1} and the relation between ΔL^*_{t-1} and ΔL_{t-1} differed from the corresponding relations in the original version. Since multicollinearity appears to be less in the $\Delta^2 L_t$ version than in ΔL_t version the estimate of A given in the

[1]) This conclusion is borne out by the fact that estimated consumption, ${}^cC_t = J_t - {}^c\Delta L_t$ can well be described by an acceptable model.

former should be preferable to that obtained in the latter.

Although it is difficult to specify any one value of $\hat{A}$ as "the right one" we can at least say that all the estimates given are in the interval (0.28, 0.78) and that most of them come within the interval (0.40, 0.70). We can also say that the greatest risk of accepting a false hypothesis in drawing the conclusion that $A < 1$ which is created by any of the specifications quoted is 0.07. This should entitle us to conclude that there is some kind of inertia in adjustment to an equilibrium inventory determined in a given way and that this inertia is adequately described by a constant factor.

However, in order to be able to identify $\hat{A}$ as an estimate of the reaction coefficient λ we must accept a determination of the equilibrium inventory L^* (or of ΔL^*) as "the right one" and assume that the use of supply variables eliminates or considerably reduces the risk of $\hat{A}$ being influenced by circumstances due to the state of the market. In the terms used in chapter 2, this would mean that $E(\pi) = 1$.

As regards the two approaches of the indirect method, the explanatory value of equations 4.8. and 4.9. is in terms of R values in general higher than that of the so called QJ models. This superiority in explanatory value of the first set of models has however been achieved by using a great number of variables, some of which are difficult to employ for forecasting purposes. Thus, since the QJ models are of simple construction and based solely on order data and/or production data, they are also attractive from the point of view of forecasting. This is particularly true of equation 6.12., which is the only one of the different versions of the indirect method to give a wholly acceptable value for the von Neumann ratio, apart from which it is based entirely on order data. Its determination of the equilibrium inventory can be approximated to the following simple rule of memory:

$L^*_t = C^*_{t+1} - 10 \cdot t + 500$; $t = 1$ is 1 quarter 1957

It should be pointed out in this connection that the results of both the direct and the indirect method leave no doubt as to the considerable influence of order inflow on consumption, inventory investments and ipso facto on total purchases, which accordingly can well be regarded for forecasting purposes as a function of order inflow.

8.3.2. The determinant factors of the equilibrium inventory. Tables 8: 1—8: 6 show that the equilibrium inventory is deter-

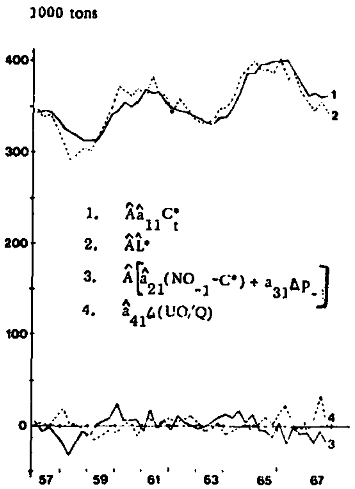


Fig. 19

mined to a very great extent by expectations regarding consumption, irrespective of whether these are indicated by anticipated consumption according to barometer data, by anticipated consumption according to a "linear decision rule", the coefficients of which have been estimated from time series data, or by order inflow. This is obvious from figure 19. There is nothing very surprising about this result, but it may seem rather surprising to anybody who has observed the debate on cyclical trends in the steel market, in which every conceivable factor except the one mentioned here has been ascribed considerable importance in connection with inventory fluctuations. It should also be made clear, however, that the result is governed by the model specifications. Thus there is no discernible relation between inventory level and observed consumption, while on the other hand the simple correlations between inventory level on the one hand and different market situations determinants on the other is generally in the region of 0.45.

If however we consider changes in equilibrium inventories, other variables assume a more prominent influence, as can be seen e.g. from the β coefficients shown in table 8: 4. This applies above all to the variables indicative of precautionary purchases. Of these we have shown $\Delta(NO_{t-1} - C^*_t)$ and $\Delta_w UO_{t-1}$, which are taken to reflect purchasers' assessments of their future steel requirements and of the current market situation respectively. In certain estimates the variable $\Delta_w L_{t-1}$ has also been added as independent variable. Of these the first variable makes the consistently largest contribution to the variations in ΔL^*. We can also note that according to the regression calculations it takes half a year longer for a change in steelworks' inventories than for changes in their volume of order to produce the change in equilibrium inventories. The variable $\Delta_w L_{t-1}$ seems to be of more consequence to long-term changes in the steel inventories of the engineering industry than to cyclic variations in the same. As an alternative to the volume of orders we have also tested the price of steel. which reflects the supply of steel on the international market. This variable was found to have a coefficient with a level of significance of 0.05, but the use of the variable in question created greater problems of multicollinearity than the volume of orders.

The relevance of the price speculation variables varied considerably as between the different estimates. They are important in tables 8: 1, 8: 2 and 8: 3, while their role in 8: 4 is small and non-existent in estimates by the indirect method. The reason for this instability is probably to be found in the fact that Δp and $\Delta^2 p$ prove to be well correlated with one of the other variables or with the linear combinations between them given by the least square method. This in turn is connected with the fact that the price of steel is sensitive to variations in delivery times on the continent, which in turn is due to the cyclic synchronization of the Swedish and continental steel markets resulting from the considerable influence of enginering exports on the demand for steel in Sweden.

It is also worth mentioning that we have experimented with the measurement of the effects of price speculation using dummy variables certain periods of speculation have been tagged in the light of comments in branch periodicals and interviews. The dummy variables D_1 (for speculative purchases) and D_2 (for speculative abstention from purchase) with a value of 1 during periods of speculation and O during other periods were inserted instead of $\Delta^2 P_t$ in equation 4 in table 8: 4. We found that the scope of speculation during these periods varied between + 15 thousand tons and—8 thousand tons. However this approach is to be viewed solely as an experiment in historical quantitative analysis. It must be admitted that our aspirations to source criticism and analysis in this respect are not calculated to survive a critical appraisal.

8.4. Upswings and downturns in steel purchases during the sixties as explained by the models.

So far we have considered the explanatory value of different inventory and consumption models together with the importance of individual variables over the entire period 1956: 1—1967: 2. At this stage it may be worth our while to concentrate on a few particularly eventful periods, more specifically periods distinguished by drastic fluctuations in steel purchases. In the accompanying figure for actual and estimated purchases, the level rises steeply on three occasions and falls drastically on a fourth. Between the first quarter of 1959 and the first quarter of 1960, purchases rose by approximately 50 per cent, after which they remained more or less constant for a prolonged period. During 1963 and the first half of 1964 the level of purchases rose again, this time by 45 per cent. Two years later, in 1966, the level of purchases fell by 17 per cent in half a year. As can be seen from the figure, these changes are quite adequately explained by a combined consumption and inventory increase model. This would seem to justify an attempt to describe developments during the periods under consideration in terms of this model. In this connection we shall also see what explanation the model has to offer for the 1969—70 upswing. This latter period was not included in the sample period, which makes it a suitable test period for the model in question.

The estimated purchase series has been obtained from estimates of actual consumption and actual inventory increase:

$$\hat{J}_t = \hat{C}_t + \hat{\Delta L}_t$$
$$\hat{C}_t = 0.5338Q + 0.4898\,NO_t + 1.2165 \cdot t - 12.64$$
$$\hat{\Delta L}_t = 0.48\ BARC^*_t + 0.31\,(NO_{t-1} - BARC^*_t) +$$
$$+ 1.59\,\Delta_{\text{imp}} P_t - 43.49\,\Delta_w\,(UO/Q)_t - 0.40\,L_{t-1} + 33.08$$

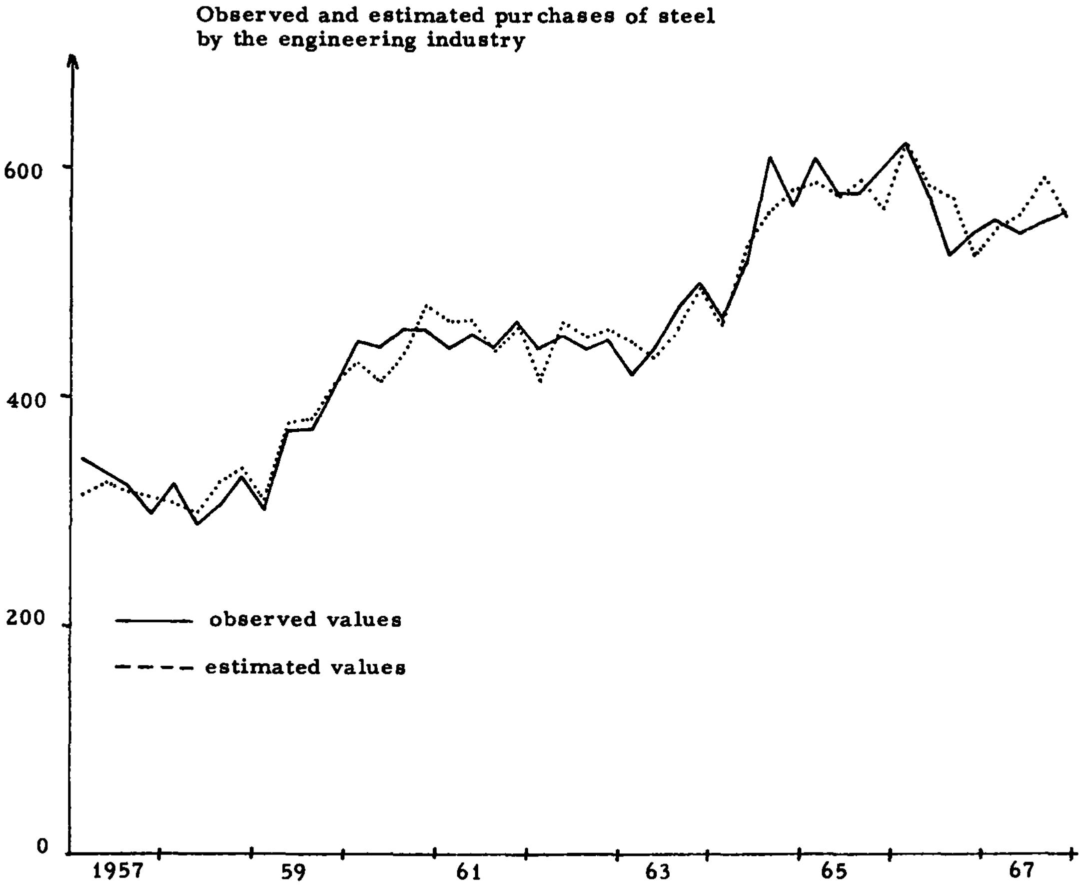


Fig. 20

In our discussion we shall also bear in mind what was observed previously, namely that planned consumption for one quarter is apparently determined by orders received during the three of four quarters preceding it.

8.4.1. The 1959—60 **upswing.** A widespread downturn in western Europe during 1958 was followed by a quantitatively steep upswing. Initially this upswing was dominated by increased housing production together with increases in inventories and consumption. From mid—1959, industrial investments tended more and more to be the prime mover in the western European business trend. This had far-reaching effects on the Swedish demand for steel. Thus orders received by the engineering industry rose by no less than 40 per cent in one year (Sept.—Nov. 1958—Sept.—Nov. 1959).[1] The greater part of this increase to begin with concerned exports, but this sector was eventually matched by orders for the home market. This prompted the engineering industry to step up its plans for production and steel consumption. According to the measurements based on Business Tendency Survey data (*BARC**) planned consumption increased by 23 per cent between the first quarter of 1959 and the first quarter of 1960. Output during this period rose by no more than 13 per cent, while steel consumption (${}^{c}C_t$) rose by upwards of 20 per cent owing to a steep rise in the amount of steel in process in the engineering industry. In the consumption model this quantity is expressed as a linear function of orders received. The effect of this development can also be illustrated by means of inventory statistics, according to which the rise in goods in process can be estimated to have contributed to just over a third of the total increase in consumption of 310 thousand tons.

The steep rise in planned consumption caused equilibrium inventories to rise between the first quarter of 1959 and the first quarter of 1960 by approximately 180 thousand tons or 25 per cent. The effect of price speculation on equilibrium inventories during this period was negligible ($<$ 10 thousand tons). Owing to the effect of the "reaction coefficient" (here = 0.40) and the late deliveries resulting from this unexpectedly

[1]) Since we are here dealing with orders received by the engineering industry, it should be noted that this series differs from the official series in two respects. Firstly, orders to the various sub-branches have been weighed together in terms of the share of those sub-branches in total steel consumption. Secondly, the series has been converted from work hours to units of output volume.

steep rise in demand with Swedish and foreign steel-works, the inventory increase (${}^{c}\Delta L_t$) during the period in question barely exceeded 100 thousand tons.

8.4.2. The 1963—64 upswing. During the first years of the 1960s there were certain forbodings of a severe recession, which however never materialized. The rise in production did tail off somewhat, but even during the "worst" years, 1962 and 1963, industrial production was still rising by 5—6 per cent annually. Yet even in the autumn of 1963 there was still fairly widespread pessimism concerning business prospects, as can seen, with a few exceptions, from the economic reports published during the autumn months.[1]) Although the misgivings of these years did not have any notable effects on the growth of output, they did lead to a fall in investments in raw material inventories and goods in process. This was the case in the engineering industry, with the result that purchases of steel stagnated during this period. As can be seen from fig. 30, the purchasing curve declines from the fourth quarter of 1961 to the first quarter of 1963. Purchases between these periods fell by something in the region of 10 per cent.

During the early part of 1963, however, there were clear signs of an approaching upswing, not least within steel-intensive branches of industry. Thus orders to the West German machine tool industry rose at an increasing rate during 1963 and the first half of 1964 after a steep fall during 1961 and 1962. This upward trend soon spread to the Swedish engineering industry, where orders received rose fairly steadily by 16 per cent from the first quarter of 1963 to the last quarter of that year and thereafter by upwards of 20 per cent by the last quarter of 1964. Towards the end of 1963 this order trend began to exert a definite influence on the production and consumption planning of the engineering industry, where consumption planned for the fourth quarter of 1964 amounted to 565 thousand tons, which was 23 per cent more than the figure for the third quarter of 1963. Realized consumption proceeded almost exactly according to the plans as estimated here.

One way of elucidating the influences behind the rise in steel consumption is to compare the "use of steel consumption"

[1]) One remarkable feature in this connection was that the economic report published by the Swedish Federation of Employers, The Economic Situation, was far more optimistic than the report Business Prospects, Autumn 1963, published by LO (the Swedish Confederation of Trade Unions), despite the imminent negotiations for a new wage agreement.

in 1964 with that of 1963. Consumption in the engineering industry in 1964 was apprioximately 270 thousand tons higher than in 1963. Exports accounted for just over 60 per cent of this increase, while domestic demand for consumption and investment and the rise in inventories in process and finished products in the engineering industry each accounted for a further 20 per cent. Here too, then, the rise in inventory investments had a great deal to do with the rise in steel consumption.

The rise in planned steel consumption stimulated inventory increases. As the model suggests, since orders received increased more rapidly than planned steel consumption, firms were also prompted to increase their precautionary inventories. Price speculation, by contrast, was a completely negligible influence, here as in other cases. Altogether equilibrium inventories (L^*) rose by approximately 110 thousand tons (19 %) between mid—1963 and early 1965.

Delivery times were very short at the commencement of the upswing, so that the desired inventory increases could soon be effected. But the rise in orders to the steel industry had soon attained such a pitch that order stocks and delivery times both soared. According to the inventory model used here, the loss of purchases resulting from this "constriction" of the steel market was no more than 10 000 tons for the whole of 1964. According to certain estimates by the indirect method, the effect of this loss was three times greater. As we saw earlier, the difference between these estimates may be due to the fact that the quantity we here regard as a reaction coefficient, i.e. the coefficient for L_{t-1} with inverted sign (0.40), is in fact a combined coefficient of supply and demand. This quantity, which has too low a value to be purely a coefficient of reaction, could thus account for part of the supply effect. Moreover the coefficient of the explicit supply term will be found to increase if we make the regression with a predetermined value for A of e.g. 0.6.

8.4.3. The 1966—67 **downturn.** The upswing tailed off during 1966 in the majority of western European countries. Recession tendencies became more widespread, so that the downturn came during 1967 to affect most of western Europe together with the U.S.A. This reversal of the previous trend applied above all to the demand for capital goods, which in turn had a considerable effect on the demand for steel. Demand in the Swedish engineering industry was naturally influenced by the change in the international economic situation, not least as regards the most steel-intensive sectors of that industry. The trend was further accentuated by the stagnation of investments in plant and a fall in the consumption of durables in 1966 and 1967 below the level for 1965.

The fall in demand was reflected in order figures. Orders received declined successively throughout 1966 and 1967, so that orders received were about 8 per cent lower in the second half of 1967 than they had been during the second half of 1965. This decline in orders received prompted the engineering industry to plan a reduction of its steel consumption. According to our gauge, *BARC**, planned consumption fell by 8 per cent between the first quarter of 1966 and the first quarter of 1967.

Although actual consumption fell considerably during 1966, consumption over the whole year was only 1.3 per cent lower than in 1965. Consumption in 1967 was 2 per cent lower than in 1965.

As will be seen from the accompanying table, changes in the domestic deliveries by the engineering industry led to a total fall in steel consumption of approximately 390 thousand tons in 1966 and 1967, while the rise in exports by this industry during the same years represented an increase in consumption of *c.* 410 thousand tons. It should be added that the change in investments in goods in process the same year corresponded to changes in consumption of−110 and−60 thousand tons respectively. This factor, then, played a considerable part in variations in the demand for steel, just was as found to have been the case with the periods studied earlier.

The change in orders received and planned consumption caused equilibrium inventories to fall by *c.* 100 thousand tons from the beginning of the first quarter of 1966 to the beginning

Table 8: 7

	Changes			
	1966		1967	
	in tons	in % of C_{1965}	in tons	in % of C_{1966}
1. Exports of engineering products	+270	+11.5	+143	+6.1
2. Fixed Investments + consumption	− 91	− 3.9	− 75	−3.2
3. Inventory increase	−118	− 5.0	−110	−4.7
4. ΔC (estimated, 1)+2)+3))	+ 61	+ 2.6	− 42	−1.8
5. ΔC (observed)	− 30	− 1.3	− 16	−0.7
6. Residual, 5)−4)	− 91	− 3.9	− 26	−1.1

of the fourth quarter of 1967. Here again, the effect of price speculation of the equilibrium inventory was negligible. The actual fall in inventories during these seven quarters was almost the same (—90 thousand tons).

In view of the size of the coefficient of reaction (0.40), the actual fall of 90 thousand tons is too great for the model to be completely accurate. The supply term accounts for only a small portion of the difference between ΔL_t and $\lambda(\hat{L}^* - L_{t-1})$. The residual can however be seen as a result of consumption falling less than was planned, thus leading to an involuntary inventory reduction.

8.4.4. 1969—70 **upswing.** After a period of slow production growth an upswing began to make itself felt in Sweden during the second half of 1968. The trend mounted rapidly, so that by the end of 1969 both physical capacity and available labour were engaged practically to the full in most sectors of industry. The upswing continued throughout the greater part of 1970. During this year, however, the growth rate of total production slowed down due to the shortage of factors of production.

The upswing was above all attributable to investment and export demand. The most remarkable change occurred in inventory investments, whose growth during 1969 constituted no less than 26 per cent of the GNP increase, i.e. GNP (1969)—GNP (1968). According to preliminary estimates, the corresponding proportion for 1970 was still higher.

Among steel-consuming firms in the engineering industry, the upswing was above all apparent in a rapid rise in export orders. Orders received from the home market also rose, though less rapidly. Total orders received by the engineering industry during the second half of 1969 were *c.* 16 per cent higher than during the second half of 1968. Orders received during 1970 remained more or less at the level attained during the latter part of 1969. The rise in demand led to a steep rise in planned consumption. Our measure, $BARC^*$, shows an increase which is actually somewhat greater than the rise in orders received.

During the first half of 1970 the engineering industry continued to step up its consumption plans. The plans were almost completely realized. Thus actual consumption during the second half of 1969 was over 16 per cent greater than during the second half of 1968.

The steep rise in demand and the increased consumption of which it was the principal cause are shown by our inventory model to have brought about a steep rise in equilibrium inventories. The latter were also increased during this period for speculative reasons. As we have already seen, the period between the end of 1968 and the spring of 1970 witnessed a price rise the equal of which had not been seen since the days of the Korean war. Despite the exceptional vigour of the price rise, price speculation during the first three quarters of 1969, the period when its effect was positive ($\Delta^2 P_t > O$) raised equilibrium inventories by barely 20 thousand tons.

Actual inventory increase however was inhibited by increased delivery times. Neither in Sweden nor elsewhere in western Europe were steel producers able to keep their deliveries abreast of the rapid rise in demand. The result was a widespread and extreme increase in orders on hand and delivery times. According to the inventory model applied in this case, the delivery time factor entailed a loss of some 20 thousand tons of inventory increase during the period 1968: 4—1969: 4. Other model specifications in tables 8: 1—8: 7 indicate that this loss was of the order of 40—60 thousand tons.

		ΔL	$\Delta\hat{L}$
1969	I	7.5	18.0
	II	71.8	72.0
1970	I	36.9	29.7

As regards this period we are in a position to compare the model values with direct observations of inventory fluctuations in the engineering industry. As can be seen from the accompanying table, the model agrees surprisingly well with reality, bearing in mind the uncertainty normally attaching to calculations of this kind. At the same time, however, we should remember that during the sample period too the model was found to be most reliable when the inventory fluctuations involved were large ones and less reliable when they were small.

During this upswing the increase in the quantity of steel in process in the engineering industry came to play a still more important part than during previous related upswings. The steel consumption of the engineering industry was over 15 per cent more in 1969 than in 1968. Almost 2/3 of this increase went to increase the amount of goods in process. Exports accounted for almost the whole of the remainder. Thus consumption and fixed investments were of little significance in the steep rise in steel consumption during 1969.

List of symbols

1. Variables

AC	Apparent steel consumption
C	Steel consumtion
${}_0C$	Steel consumption corrected for changes in steel i goods in process
D_t	Dummy variable
E	Steel exports
E	Mathematical expectation
e	Observed residual
H	Finished goods inventories with the steel consumer
J	Purchases of steel, deliveries received by consumer
L	Steel inventories held by steelworks, merchants an consumers[1])
${}_cL$	Steel inventories held by consumers
${}_mL$	» » » » merchants
${}_wL$	» » » » steelworks
${}_uL$	Involontary or unplanned inventories
M	Steel imports
N	Quantity indicating revision of consumption plans defined on page 222
N	Net tendency, balance; defined on page 202
NO	New orders, inflow of orders, incoming orders
P	Price of steel
${}_mP$	Index of merchant's quotations
${}_{\mathrm{imp}}P$	Import price index
Q	Production[2])

[1] In chapt. 2—8 L denotes steel inventories held by consumers.

[2] In most cases the subindex c in ${}_cQ$ is dropped, Q thus indicatin production by the steel consumers.

${}_{c}Q$	Production in steel consuming industries
${}_{w}Q$	Steel output
q	a specified function of expected production
r	interest rate
S	Steel consumers' deliveries of finished products
t	time
UO	Unfilled orders
${}_{c}UO$	Unfilled orders, order backlog in steel consuming industries
${}_{w}UO$	Unfilled orders, order backlog in steelworks
u	a specified function of incoming orders in the past, defined on page 222
V	Cost
v_i	Weights
w_i	Weights
${}_{T}X$	A vector of variables indicating the transaction motive for inventory holding
${}_{P}X$	A vector of variables indicating the precautionary motive for inventory holding
${}_{S}X$	A vector of variables indicating the speculative motive for inventory holding
Z	variable indicating the supply situation for steel

2. Coefficients, parameters, statistics

a, b, c, d, h	Structural coefficients
e	Base of natural logoarithm (chapt. 2)
$\alpha, \beta, \gamma, \delta, \lambda, \pi$	Parameters describing the dynamic properties of the models
$\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}$	Structural and other coefficients
ϵ, ω, η	Stochastical non auto-correlated variables with zero mean and constant variance
DW	Durbin Watson statistic
$\sigma^2{}_x$	Variance of x
*	The asterisk * is used for indicating ex ante (expectation, plan) quantities. Thus $C^*{}_t$ denotes planned consumption for period t. *BAR* indicates a measure obtained from the Business Tendency Survey (Barometern) and *MOD* a measure obtained from a model. Thus $BARC^*{}_t$ and $MODC^*{}_t$ denotes planned consumption according to barometerdata and a specified model respectively.

Circumflex (^) above a constant or a variable signifies estimates obtained from a sample

$\bar{x}, \bar{y}$ etc. detones arithmetic average (mean) of variables

R Multiple correlation coefficient corrected for loss of degrees of freedom.

Appendices to Part III

1. The calculation of quarterly series for steel consumption and steel inventory investments in the engineering industry

The calculation of quarterly series for steel consumption and steel inventory investments in the engineering industry has been generally described in the text. The basic point of departure is the following accounting identity:

$$^{c}\Delta L = J - {}^{c}C$$

According to this formula a calculation of one of $^{c}\Delta L$ or ^{c}C will by necessity imply a calculation of the other. The quarterly series for inventory investments used in the regression analyses has been obtained via the calculation of a quarterly series for steel consumption. The initial position as regards data has been the following:

- Yearly data for J, ΔL and C have been accounted for since 1954.
- Quarterly data have been available for J only.

In constructing quarterly data for steel consumption we have assumed that it has the same course of development in the short run as hours worked. Because of productivity increases the former has however a much more faster rising long term trend than the latter. This gives us the problem of allocating the yearly increase in the ratio *steel consumption/hours worked* to quarters. In order to avoid artifical jumps between the fourth quarter of one year and the first quarter of the following year, which generally arise when one divides the increases evenly between the quarters, we have used a method developed by Aspén and Bergström in a context similar to this one[1]). Transferred into our problem their formula can be written

$$^{c}C_{it} = B \cdot HW_{it} \cdot \gamma_{it}; \quad t = 0, 1, 2 \ldots \text{ denote years}$$
$$i = 1, 2, 3, 4 \text{ denote quarters}$$

legend:

$^{c}C_{it}$	calculated steel consumption in the i:th quarter of year t
B	constant
HW_{it}	hours worked in the i:th quarter of year t
γ_{it}	trend factor

The trend factor γ_{it} is defined as

$$\gamma_{it} = (1 + g_t \cdot i)\gamma_{4.,t-1}; \qquad \gamma_{4.\,-1} = 1$$

Here the allocation of the yearly "productivity" increase is dependent on the development in this respect in the preceding year. Observed

[1]) See Aspén and Bergström, Den månatliga industriproduktionsindexen omlagd, Statistisk Tidskrift, 1967:4, who have developed the method in order to distribute the yearly production of some industrial sectors on months.

steel consumption equals calculated steel consumption in each year. Hence g_t can be solved from the equation

$$C_t = \sum{}^c C_{it} = B\sum{}^4{}_{i=1} HW_{it}(1 + g_t i)\gamma_{4,t-1}$$

As could be understood from the formula, the ${}^cC_{it}$-series will behave fairly well, i.e. it will have no big "artificial jumps" as long as the changes in HW consistently under- or overestimates the changes in C. As has already been mentioned it is in this case a question of consistent underestimation.

2. An alternative approach

It is possible that our method of calculation will result in a consumption curve which is more even than the real one. If this should be true, the calculated inventory investments will have a more irregular pattern than real inventory investments. In other words the calculation method used will give too much of the "stochastic part" in realized purchases to inventory investments and too little to consumption.

In order to get an idea how this part has influenced the results, we have tried an opposite approach, meaning that we have first calculated a quarterly series for inventory investments and by subtracting this quantity from observed realized purchases we have obtained a consumption series. Here we have assumed that the relative changes in steel inventories held by the engineering industry can be described by business tendency survey data over investments in raw materials inventories of this industry. By regression analyses for the period 1955—69 the following "transformation rule" was obtained:

$$\Delta^e \log \hat{L}_t = 0.00811 + 0.0187 \sum N_{it}; \quad R = 0.90$$

L_t is the observed steel inventory level at the end of year t and N_{it}, the net tendency, is the percentage of engineering firms reporting that they have increased their raw material stocks during the i:th quarter minus the percentage reporting inventory decreases.

The subsectors have been weighted together, the weights being their shares of the total steel inventories held by the engineering industry.

The error of year t

$$\epsilon_t = \Delta \log L_t - \Delta \log \hat{L}_t$$

has been equally distributed over the quarters so that calculated and observed inventories are equal at the end of the year.

The inventory level at the end of the first quarter in year t is consequently

$$L_{1,t} = L_{4,t-1} \cdot \exp\,(0.00203 + 0.00187 \cdot N_{1t} + 0.25 \cdot \epsilon_t)$$

In order to separate the two calculations of inventory investments, denote the series used in the text by ${}^{c1}\Delta L_t$ and the series obtained from net tendencies by ${}^{c2}\Delta L_t$. Now ${}^{c2}\Delta L_t$ appears like a smoothed version of ${}^{c1}\Delta L_t$. To give an impression of the difference between the two indicators in what concerns their irregularity it can be mentioned that the standard deviation of ${}^{c1}\Delta^2 L_t$ is 30.2 thousands of ton, while that of ${}^{c2}\Delta^2 L_t$ is 14.3. A natural question is: what will be the result if we use ${}^{c2}\Delta L$ as dependent variable instead of ${}^{c1}\Delta L$ in the regression equations presented in chapter 8. Of course we get changed numerical values of the different coefficent estimates but the essential results according to tables 8: 1 to 8: 3 will remain after the exchange of dependent variable. This is shown by the following equation:

$$
\begin{aligned}
{}^{c2}\Delta \hat{L}_t = \underset{(0.065)}{0.381}\, BARC^*_t + \underset{(0.064)}{0.172}(NO_{t-1} - BARC^*_t) + \\
+ \underset{(0.889)}{1.069}\Delta P_t - \underset{(0.096)}{0.461} L_{t-1} + 94.0
\end{aligned}
$$

$R = 0.808; \quad DW = 2.01$

This equation gives no doubt the same general impression as those presented in table 8: 2, but there is one obvious dissimilarity. In that table the variable $\Delta(UO/Q)$ functions as an indicator of involuntary inventory changes. The introduction of this variable here gives no indication what so ever of the prevalance of such changes. A natural interpretation of this result is that the involuntary inventory increases has been filtered off by our calculation method. Instead the variable $\Delta(UO/Q)$ "explains" some of the variance in ${}^{c2}C$, which in the light of our earlier discussion seems to be a logical consequence.

As a *third* alternative we have combined the two calculation methods by taking the unweighted average of ${}^{c1}\Delta L$ and ${}^{c2}\Delta L$. Broadly speaking this means that we have spread the stochastic changes of J (or its irregularities) equally on consumption and inventory increases. The indroduction of this measure will not alter the regression equation very much. The following relation has been obtained:

$$
\begin{aligned}
{}^{c3}\Delta \hat{L}_t = 0.5\,({}^{c1}\Delta L + {}^{c2}\Delta L)_t = \underset{(0.050)}{0.408}\, BARC^*_t + \underset{(0.064)}{0.231}(NO_{t-1} - \\
- BARC^*_t) + \underset{(0.453)}{0.967}\Delta P_t - \underset{(0.084)}{0.417}\, L_{t-1} - \underset{(19.63)}{18.70}\Delta(UO/Q) + 48.8
\end{aligned}
$$

$R = 0.857; \quad DW = 1.55$

$\Delta(UO/Q)$ has not even in this case any relevant influence on estimated inventory investments.

What calculation method is the best one? By our treatment of the problem we have revealed a relative preference for the first one. Our basic reasons to stick to this method as the main method are the following.

a) ${}^{c1}\Delta L$ as well as ${}^{c1}C$ are well explained by models which make sense from a priori points of view. The correlation between observed and estimated J is somewhat bigger in this case than in the other two.

b) Part of the apparently stochastic changes in J seem to be positive or negative *involuntary* purchases. It seems more natural to attribute those changes to inventory investments than to consumption.

3. Planned consumption

In the regression analysis of the determination of inventory investment by the direct method two measures of planned consumption is used, $BARC^*$ and $MODC^*$ respectively. The first one is based on business tendency survey data while the second one is derived from a linear decision rule and containing new orders, orderbacklogs and consumption in $(t—1)$ as arguments.

The general procedure in the specification of $BARC^*$ has been the following: A linear relation between the relative change in steel consumption and the net tendency for actual production was estimated. The coefficient estimates were applied to the net tendency for anticipated production whereby we obtained an estimate of expected relative increase in consumption.

Thus we got

$$\Delta^c \log \hat{C} = \underset{}{0.000738} + \underset{(0.0002191)}{0.0007500} \Sigma a_j \cdot NA_j; \quad R = 0.54$$

which was transformed to

$$BARC^* = \exp\,[0.000321 + 0.000326\, \Sigma a_j N_j] \cdot C_{-1}$$

where a_j is engineering sector j:s average share of total steel consumption. NA_j and N_j are net tendencies for actual production and for expected production respectively.

When calculating $MODC^*$ we followed a corresponding procedure. Firstly we estimated the equation

$$\Delta C = \underset{(0.141)}{0.362}\, C_{-1} + \underset{(0.324)}{0.512}\, \Delta UO_{-1} + 0.414\, \Delta NO + 4.05; \quad R = 0.60$$

There we defined $MODC^*$ as the sum of the right hand side of this expression and C_{-1}. The constant term is a trend term indicating that C grows at a faster rate than the stock of orders and new orders.

4. Trend adjustment of some variables

Because of orders being measured in terms of hours worked, productivity increases create a growing gap between an index of output and an index of new orders. This has been taken into acccount in two different ways.

When calculating the difference $NO_{-1} — C^*$ in applying the direct method we have given C^* the same long term trend as NO. So is for instance $BARC^*$ (NO-trend) equal to

$BARC^* + 6.096 - 6.6192 \cdot t$; 1956: 1 = 1

This trend adjustment has no importance in $\Delta^2 L$ equations (table 8:3).

When defining expected production, applying the indirect method, from new orders, the latter variable has been multiplied by a trend factor. This has been determined by the difference in growth rate between production and new orders. Hence

$Q/NO = \text{constant} \cdot \exp [0.0131 \cdot t]$ and

$NO\,(Q \text{ trend}) = \text{constant} \cdot NO \cdot \exp [0.0131 \cdot t]$

It has of course been simpler to use these methods than having tried to explicitly take into account the productivity increases. The method used has also been justified by the fact that productivity increases seem to have been very stable during the estimation period.

It should be added that Q and NO are weighted averages of production and new orders in different sectors of the engineering industry, the weights being their percentage shares of total steel consumption.

Part IV
Steel Imports and the Marketing Policy of Home Market Firms

0. Purpose and delineation of the essay

In the two preceding sections steel consumption, steel inventory investments and realized purchases of steel were studied from the point of view of demand, while the supply of steel was only incidentally considered. We turn now to consider certain of the cyclical qualities of steel supply.

0.1. Fluctuations in the share of imports

Our introductory essay showed that the steel market is unstable in several respects, in other words that variables to which we normally attach importance when describing the development of a market are subject to considerable cyclical fluctuations.[1]) This was found to be the case e.g. with consumption and inventories, variations in which were analysed in the two preceding essays. Imports are indubitably to be classed among the more unstable quantities, as can also be seen from the accompanying figures of the development of total steel imports and import share.[2]) It will be seen that imports underwent a marked cyclical growth during the fifties and sixties, which is not surprising in view of the development of demand. More remarkable is the instability of import share, which, seen in

[1]) The terms stability and instability are here used in their empirical sense which can differ from their theoretical connotation. We will therefore say that a variable is unstable if it shows big fluctuations, regardless of whether those fluctuations are cyclical with a constant or even decreasing amplitude.

[2]) The term import share is here taken to mean imports divided by total realized purchases.

Imports of finished steels

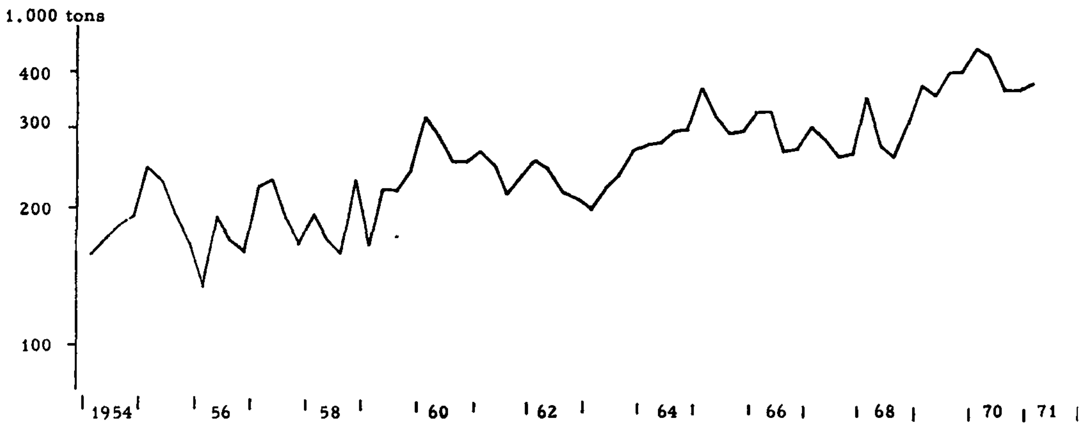


Fig. 1a

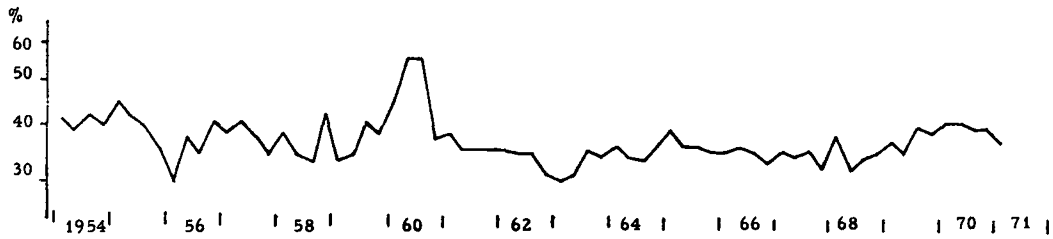


Fig. 1b

terms of quarterly figures, varied between 28 and 60 per cent during the period 1956—71. There is a natural connection between these fluctuations and the cyclical marketing policy of Swedish steelworks, i.e. their short-term decisions regarding production, deliveries to the home market and exports as well as pricing. We shall return in due course to a statistical account of the development of production, deliveries and prices.

0.2. Design and limitations

This essay will be mainly concerned with variations in imports and import share, but the analysis of these quantities also involves questions which are related to the activities of steel-works and wholesalers. The essay has therefore been arranged as follows. Following a rough but for present purposes sufficiently specific "static" picture of the steel market together with a definition of the main concepts we shall be employing, a presentation will be made of the general assumptions on which the study of our main problem is to be based. A description will then be given of a number of macro import models. These models entail certain assumptions concerning the behaviour of steelworks. To obtain a clearer view of this aspect a somewhat closer study will be made of the marketing policy of steelworks. A distinction is drawn here between ordinary and special steel producers. This distinction is justified by the different competitive situations of the two groups of enterprises. Finally a section somewhat in the nature of an excursus will be devoted to purchases and sales by stockholding merchants. Here as in the preceding essays, the principal emphasis will be on the empirical content of the analysis, although this is by no means to be taken as a gurantee against theoretical speculations. As in the two preceding essays our basic view is that a fruitful empirical analysis have good theories as prerequisites.

The argument is confined to short-term marketing policy, so that no further account will be made to investment policy over and above that undertaken in Part I. Our grouping of products will be confined to the categories of ordinary steels and special steels. Since this grouping completely corresponds to that of firms, the sections on marketing policy will consequently not deal with short-term changes in the product mix.

1. Outline of the market and definitions of terms

The term market in economic theory refers to a place where goods and services are exchanged. Often the market is described in pictures in which the participants are divided into groups which are graphically symbolized by squares, circles or other geometrical figures. These figures are usually linked by lines or arrows denoting flows of goods or information. In the present context the commodity is finished steel, the place is Sweden and the groups of participants in which we are interested are producers, stockholding merchants and consumers of steel. The connection between these groups to be studied here is the flow of goods. The Swedish market is not closed, for there are considerable amounts of steel entering and leaving the country.[1])

A simple sketch of this market is given in the following figure.

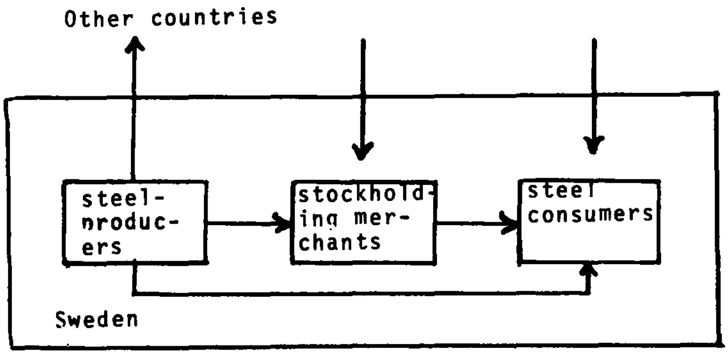


Fig. 2a

[1]) Here as in the preceding parts we will alternate between the terms stockholding merchants, merchants and wholesalers.

The Swedish market is represented by the large rectangle, within which we find the various participants in the market. The area outside the rectangle, the universe, here stands for the rest of the world. The arrows denote flows of goods, so that arrows crossing the national frontier represent exports and imports of finished steels.

Total deliveries of steel to consumers can be divided into three categories: direct imports, direct deliveries from Swedish steelworks and deliveries from merchants. In mathematical symbols this can be expressed as follows:

$$S = {}_dM + {}_mS + {}_cH \qquad 1.$$

Denotations:

S total deliveries to consumers
${}_dM$ direct imports
${}_mS$ deliveries from merchants to consumers
${}_cH$ deliveries from Swedish steelworks to consumers

In the following we shall somewhat modify the concept of deliveries (or purchases) to include inventory increases by merchants, since although this is only a small sector of total steel demand there is reason to suppose that it can perceptibly influence relative imports. This modified concept of deliveries can be written:

$$S' = S + \Delta_m L \qquad 2.$$

Now $\Delta_m L = {}_mM + {}_mH - {}_mS$

so that $S' = {}_dM + {}_mM + {}_cH + {}_mH$

Denotations:

$\Delta_m L$ steel inventory investment by stockholding merchants
${}_mM$ imports by merchants
${}_mH$ deliveries by steelworks to merchants

Total deliveries will here be taken to mean the quantity S'. In discussing the distribution of total deliveries between imports and deliveries from Swedish steelworks, we shall start from equation 2. Thus the import share is defined as

$$({}_dM + {}_mM)/S' = M/S' = 1 - H/S' \qquad 3.$$

where M is total steel imports and H total deliveries from steelworks to the Swedish market.

These definitions are illustrated in the figure below. The figures beside the different arrows denote the corresponding flows of goods as percentages of total realized supply, i.e. production plus imports. The relations refer to the two-year period 1968—69.

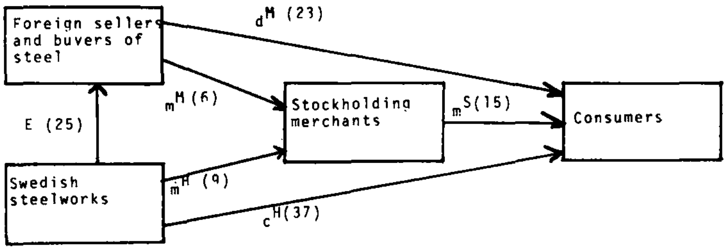


Fig. 2b

A new quantity has been added here, namely *E* (exports of steel). In the figure steel is regarded as *one* product and all steelworks are considered as *one* group of producers. As was observed in Part II and will be further demonstrated in due course, there are many reasons for dividing steel into ordinary and special steels and for making a similar distinction between producers of ordinary steels and producers of special steels. We shall therefore conclude our introductory description of the market with a description in tabular form of the flows of special steel and ordinary steel. Here as previously figures denote deliveries as percentages of total supply.

Table 1. Deliveries of finished steel (excluding semi's and tubes) as percentages of total supply, i. e. output+imports of ordinary and special steels.

	$_cH$		$_mH$		E		$_dM$		$_mM$	
	tons	Kr.	t	k	t	k	t	k	t	k
Ordinary steels	31.0	21.6	8.6	6.2	16.6	10.3	21.7	14.6	6.2	4.2
Special steels	6.0	12.7	0	0	9.0	28.1	1.1	2.2	0	0

It can be seen here that the share of special steel in home market demand, which is small in terms of tonnage, is strikingly great in kronor. Since, however, special steel accounts for a large proportion of export deliveries, it also comprises a large proportion of output, namely 20—25 per cent in terms of tonnage and 50—60 per cent in value. The share of output of special steel in total steel output in Sweden is exceptionally high by international standards, while imports on the other hand are predominantly made up of ordinary steel.

According to the table merchants only deal in ordinary steel. The statistics do not permit a division of their trade into ordinary and special steels, though with regard to the historical period under consideration we can say on the strength of interviews and other sources that ordinary steel has predominated in merchants' sales from stock. Recently however there has been an increasing tendency for certain special steels to be sold through merchants, presumably because the items in question have begun to lose the character of special products. If this trend continues the present system of product classification will be deprived of many of its advantages from the point of view of market analysis.

2. A theoretical framework for analysing the composition of supply of home produced and imported steel

2.1. Perfect markets and real markets

In markets characterized by perfect competition, changes in demand have the same impact on all sellers, since the price is given for each of them and their cost and behaviour functions in the broadest sense are identical. If we change our assumptions merely to the extent of allowing firms to have different cost functions, a rise in demand, to take one example, will still produce the same rise in prices for all firms. On the other hand the change in the quantity supplied will vary from firm to firm. The magnitude of this change in a firm will depend on the slope in its supply curve, i.e. its marginal cost curve. The flatter this is, the greater the rise in sales resulting from a rise in demand. Thus in order to calculate the effect of a rise in demand on the share of the market held by an individual firm or group of firms, we have to know the marginal cost curves of the various firms. If we dispense with still more of the assumptions defining the concept of perfect competition, allowing products to be heterogeneous, firms to produce more than one commodity each etc., the problem of analyzing market shares of different firms will become exceedingly complex even in theory.

Thus our possibilities of studying this problem would appear to diminish as our market models become more realistic, so that the prospects of constructing a testable market share model for the steel market, which as we have seen in earlier chapters is far from perfect from the theoretical point of view, do not appear to be very bright.

In fact we have no intention of studying changes in supply in detail. Rather we are concerned to explain the distribution of deliveries between Swedish and foreign steel. This should be quite feasible. Our assumption is a normal one in analyses of a more macro nature, namely that the development of the quantities in which we are interested is determined by a small number of distinguishable factors. This means that many of the variables included in the decision functions of individual firms will be eliminated when studying the results of their decisions e.g. at branch level as evidenced, say, in order and delivery series.

2.2. The basic approach

2.2.1. A causal scheme. Some of the steel products sold on the Swedish market can be classed as typical import commodities, while others are to be regarded as typical Swedish products, in the sense that the former are supplied by foreign sellers only while the latter are only sold in this market by Swedish steelworks (either direct to consumers or via Swedish merchants) Other products are marketed by both Swedish and foreign sellers.

When the demand for typical import commodities rises, all other things being equal, this results in a rise in imports, which are not affected by a rise in demand for typically Swedish steel: the latter can only lead to a change in deliveries from Swedish steelworks.[1]) In these cases there is no problem of allocation in the above sense. Clearly this problem is confined to the third group of steel products. In order to be able to say how a change in the demand for these products will affect imports and deliveries by steelworks to the home market, we need to know more about the factors which influence the distribution of demand between these supplier categories and the way in which they do so. These general premises are described in the figure in the marginal.

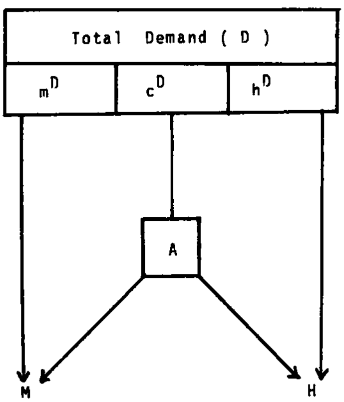


Fig. 3

Here $_mD$, $_hD$ and $_cD$ denote the demand for typical import products, the demand for typical domestic products and the demand for products which can be delivered from abroad or by Swedish steelworks. In the last mentioned case we can speak in terms of competing products. A can be regarded as an allocation operator dividing demand for competing products between Swedish and foreign steelworks. Let us assume that this allocation is determined by the variables x_j ($j = 1, 2 \ldots n$) and that demand is always realized. We can then formulate the following general import model:

[1]) In both cases, of course, a rise in demand can be met by a reduction of wholesalers' stocks. On this cf. the following section.

$$M = {}_{m}D + f(x_1, x_2 \ldots x_n) \cdot {}_{c}D \qquad 4.$$

The mirror image of this equation is the equation for deliveries by steelworks to the home market:

$$H = {}_{h}D + (1 - f(x_1, x_2 \ldots x_n))\, {}_{c}D \qquad 5.$$

Thus the share of imports is determined by the proportion of typical import goods and the proportion of competing materials in total steel demand, and also by the x variables, which in turn determine how much of the demand for the last-mentioned group of products will be met by imports.

2.2.2. Competing and non-competing imports. A test of equation 4 presupposes that imports competing with Swedish steel can be statistically distinguished from non-competing imports. There may be technological or economic reasons for the occurrence of non-competing imports. The first of these reasons applies to products for which Swedish firms do not know the special production technique required or (to take a more short-term view) which cannot be manufactured domestically with the production apparatus available at a particular moment. The second reason applies to products which Swedish firms do not find it remunerative to include in their production programmes, even if this would be feasible using existing plant. The first category includes e.g. sheets for car bodies while the latter is mainly composed of products with relatively low quality requirements.[1])

Typically Swedish steel products cover the greater part of the special steel group. At the beginning of the period we are studying, the market in this product sector was almost completely dominated by Swedish steelworks. The service and close contact with consumers associated with the sale of these products have made it hard for foreign firms to challenge this predominance. Even as regards ordinary steel, an appreciable proportion of demand goes, for natural reasons, to Swedish manufacturers. This is the case with steel consumption by engineering works integrated with steelworks. The survey on the structure of the Swedish steel industry published by Jernkontoret puts this proportion at 20 per cent of total steel consumption.[2])

[1]) During the last few years, however, the production of sheets for car bodies has begun to assume noticeable proportions.

[2]) The Swedish steel industry on the Eve of the 1970s, Stockholm 1969. (App. 7).

For all their apparently very high level of specification, the available statistics afford little opportunity of a complete analysis of the development of imports along the lines we have laid down, but even if the three groups of steel products are not completely verifiable statistically, this division will nonetheless provide the basic approach of our continuing analysis.

To begin with, however, let us assume that the three groups of products — we can call them *m*-steel, *c*-steel and *h*-steel — are in demand in constant proportions, i.e.

$$
\begin{aligned}
{}_mD/D &= m \\
{}_cD/D &= c \\
{}_hD/D &= h
\end{aligned}
$$

where m, c and h are constants whose sum is 1. Equation 4 can now be written:

$$M = (m + f(x_1, x_2 \ldots x_n))\, D \qquad 4.a.$$

so that the share of imports will be

$$M/D = m + f(x_1, x_2 \ldots x_n) \qquad 4.b.$$

We shall in due course take these equations as our point of departure when specifying different import models. First however we shall refer briefly to an interesting study by Lennart Fridén in this connection before going on to consider some of the dynamic properties of the market and their implications for the construction of models.

2.3. Constant ratio between home and world market prices: Fridén's approach.

As we saw in Part I, Swedish ordinary steel prices have faithfully followed world market prices in both the short and the long run, so that the ratio of the price index for ordinary steel in Sweden and the price index for steel prices on the world market has been fairly stable. What effects does this stability have on the allocation of deliveries between domestic and foreign steel? This is the problem at issue in one of the import models described by Fridén.[1]) He begins with the figure shown in the margin.

An exogenously determined price, in this case a world market price, applies on the market. At this price demand exceeds domestic supply. This should lead to a demand for

[1]) Fridén op.cit., cap. 2.

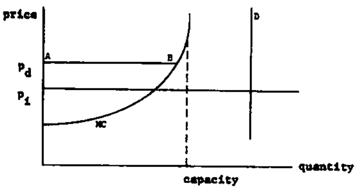


Fig. 4

imports of steel. In order to be able to calculate the size of imports, one must, as Fridén observes, "know the buyers' preferences as between domestic and foreign steel when there are no differences of price". To begin with he bases his argument on the assumption that imports are marginal, i.e. that buyers tend first and foremost to satisfy their demand through domestic manufacturers. Thus at given supply and demand curves imports are entirely determined by the level of prices and the slope of the curves.[2]) If we allow the curves to shift, imports will also depend on the variables determining the position of the curves, the shift parameters. Fridén illustrates this with an example which he later employs in an empirical analysis. The curves in this analysis are linear. If demand is $a_0 + a_1 p + a_2 x$ and supply $b_0 + b_1 p + b_2 y$ imports will be

$$M = D - S = (a_0 - b_0) + (a_1 - b_1)\,p + a_2 x - b_2 y$$

x and y are shift parameters.

Since $a_1 < 0$ the coefficient of p is also < 0. If imports are marginal then, according to the assumptions made above, they will vary inversely with the level of prices. We shall return later on to this simple but sometimes practical model.

2.4. Two important dynamic characteristics

The phenomenon in which we have been interested in this work is concerned with growth and, to an even greater extent, with cyclical variations in various quantities. As a result the time dimension has played an important part in our observations. This does not necessarily imply that time has to be taken into account in an analysis of the relations between these quantities. Cyclical problems and problems of growth can very well be — and frequently are subjected to statical analyses. The import model described above is a case in point.

Sometimes however circumstances oblige one to give the analysis a dynamic character, in the sense that time is used as a scale to which production, consumption and other econo-

[2]) Supply and demand are both dependent on price, $D(p)$ and $S(p)$, and imports are $M = D(p) — S(p)$. Deriving this expression with respect to p we obtain

$$dM/dp = dD/dp — dS/dp;\ dD/dp < 0 < dS/dp.$$

Thus the price sensitivity of imports is in the linear case determined by the sum of the slope coefficients in the supply and demand curves respectively.

mic quantities are referred.[1]) This is often the case with econometric studies of cyclical fluctuations. Even when these cyclical analyses are firmly based on a statical theory of equilinrium one is still forced to take into account the fact that once equilibrium is disrupted a new equilibrium is not rapidly attained. According to this view the statistical picture of economic development is characterized by shocks and incomplete movements towards equilibrium. This attitude has dominated our analysis of variations in demand and especially inventory investments, and there is no reason for us to abandon it now. This means that we shall adhere to *the idea of levels of equilibrium for economic quantities and to the hypothesis that a gap between equilibrium level and actual level results in a process of adjustment.*[2])

In studying variations in imports we have reason to concentrate on what from the point of view of dynamic analysis are two particularly important properties of the steel market. These properties are important above all by virtue of their potential influence on the development of the share of imports.

The first property concerns *the time elapsing between a change in demand and its realization in the form of corresponding changes in deliveries to buyers.* We can say that, if this time exceeds certain limits, we are not entitled to treat the determination of deliveries in a simultaneous model. This need not affect variations in the share of imports if we define the latter quantity as M/S. If on the other hand there is a difference between the delivery or waiting times for Swedish and imported steel, this will affect the variations in question. Since, according to available data, delivery times within the ECSC, from which the bulk of Swedish imports originate, are on average far shorter than those observable for Swedish steelworks, there is reason to suspect that imports react faster than deliveries from Swedish steelworks to changes in demand. This will involve fluctuations in the share of imports in deliveries (M/S) even in cases where the share of imports in demand is constant over time.

The second property of the steel market which should be borne in mind when analysing the cyclical pattern of develop-

[1]) See Ragnar Fisch's seminal essay Statikk og dynamikk i den økonomiske teori, Nationaløkonomisk Tidskrift, LXVII (1929) pp. 321—379.

[2]) If—as we have reasons to believe—this kind of inertia or inability of economic agents to rapidly adjust themselves to new situations is predominant, the transient behavior of economic variables is of much more interest than their equilibrium values.

ment concerns the *differences in pricing* which have existed between Swedish and continental steelworks. Whereas the former have generally charged prices as per delivery date, the latter sell at the prices current on the ordering date. This difference in pricing systems probably has a considerable influence on the direction of price speculation. If at a given juncture, prior to which prices have been stable for some time, buyers expect prices to rise, they will buy more than they need for planned consumption and for purposes of normal inventory adjustment. For natural reasons this extra demand will to a greater extent than is usually the case be directed towards foreign sellers, since the placing of orders with Swedish steelworks could mean their having to pay a higher price: prices may rise before the delivery date.

This effect of expectations concerning future price development is comparable to the effect of a change in the price relation between imported and Swedish steel. As a result of the difference in pricing routines, anticipations of a change in prices entail a change in the price relation in question.

Let us illustrate this property of the Swedish steel market by means of a simplified example: steel consumers planning their purchases anticipate a rise in prices. If they immediately place an order with representatives of foreign steelworks they will obtain their deliveries for the planning period at current prices, while if they order from Swedish steelworks they can except to pay a higher price. For the sake of simplicity we shall disregard differences in special costs connected with purchases from the two sources. Anticipations with regard to prices now result in a change of corresponding magnitude in the price relation. If the price relation was originally 1 the anticipation of a 20 per cent price rise will lead to a reduction of the relative price of imports by almost 17 per cent. $(1-1/1.20 = 0.166)$. This will result in a rise in import demand at the expense of deliveries to the home market.[1]) The extent to which purchases are re-allocated will depend on the utility which consumers associate with different levels of the share of imports.

These preferences can be described in a "demand curve" showing how the share of imports in total demand (M/D) varies with the relative price of imports, i.e. P_m/P_h where P_m is the price of imports and P_h the Swedish steelworks' prices.

[1]) It is conceivable that total steel demand will be unaffected by anticipations regarding prices. If it rises (as a result of speculative inventory investment) we shall base our allocation between M and H on a demand which is corrected accordingly.

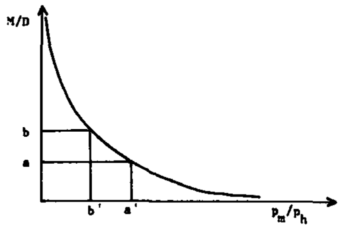


Fig. 5

The anticipated price rise mentioned earlier leads to a fall in the relative price of imports from *a*' to *b*' and a rise in the share of imports from *a* to *b*. If no further price rise is anticipated during the next planning period, the price ratio and share of imports will revert to their original levels.[1])

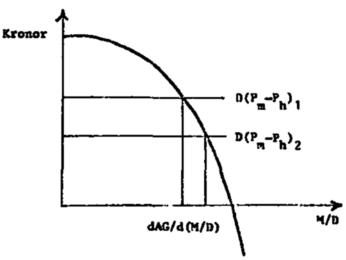


Fig. 6

[1]) The demand curve can equally well or perhaps even better be expressed as a function of the difference between P_m and P_h. We can regard it as the result of a "profit maximization". It seems reasonable to assume that a firm associates different levels of the share of imports with different "levels of utility" as expressed in money. As a profit-maximizer it will try to maximize the difference between this "allocation gain" (AG) and direct purchasing costs (PC). Assuming a fixed level of demand ($\bar{D}$) the two quantities can be expressed in the following way:

$AG = AG(M/\bar{D})$ and

$PC = P_m \cdot M + P_h \cdot (\bar{D} - M)$

Maximization of ($AG - PC$) gives

$dAG/d\,(M/\bar{D}) = \bar{D}(P_m - P_h)$ or $dAG/dM = P_m - P_h$

as a necessary condition.
The left side can be taken as the marginal utility expressed in money and the right side as the marginal cost of the share of imports. If the former declines monotonously we obtain equilibrium points for M/D. See figure 6.

3. Import models

3.1. Some simple forecasting models

It is a common experience that imports fluctuate more than total realized demand. This applies equally to total imports and to imports of many important commodities. Fridén has shown that imports of steel are no exception in this respect. The widely fluctuating shares of imports are a conspicuous feature of the international steel market. If steel import cycles are parallel to total demand cycles and the ratio between the amplitudes of these cycles shows a high degree of stability, this is obviously a useful starting point when making short and medium term forecasts.

We know from Part II that a relation of the kind described above can be expressed by the equation

$$\Delta \log M = a_0 + a_1 \, \Delta \log S \qquad 6.$$

Now total deliveries have proved to be related to industrial production (I). This relation can be expressed

$$\Delta \log S = b_0 + b_1 \, \Delta \log I$$

so that imports will also be a corresponding function of industrial output, i.e.

$$\Delta \log M = c_0 + c_1 \, \Delta \log I; \; c_0 = a_0 + a_1 b_0; \; c_1 = a_1 b_1 \qquad 6.a$$

If we test these relations on annual data for the period 1956—69, imports and total deliveries of steel being measured in tons of finished steel, we obtain the following relations[1])

[1]) The regression equations presented in this part give three statistics in addition to the estimates of the coefficients, namely their standard deviations, which are given in parentheses under the coefficient values,

$$\Delta \log M = -0.0179 + \underset{(0.347)}{1.732}\, \Delta \log S; \; R = 0.857; \; DW = 2.16$$

and

$$\Delta \log M_{-1/2} = -0.1069 + \underset{(1.168)}{4.770}\, \Delta \log I; \; R = 0.806;$$

$$DW = 1.38$$

According to these results imports are very sensitive to variations in total deliveries and even more sensitive to variations in industrial output. The results agree well with those given in Part II for corresponding relations between total deliveries and industrial production. With a certain approximation, the relation between imports of steel and industrial production can be exemplified as follows. An annual growth rate of at least 5.2 per cent is required in industrial output in order for imports to rise. Changes of x per cent units in the growth rate of industrial production will lead to a change of $4.8 \cdot x$ per cent units in imports of steel. Thus a 10 per cent rise in industrial production will cause imports to rise by upwards of 23 per cent. As we saw in Part II, the value of the constant ($-$ 0.1069) is not to be regarded as a pure trend. Using the same calculation method as was described in that connection, we obtain a long term trend whereby imports decline by two per cent per year in relation to industrial output.

The best fit has been obtained by giving $\Delta \log M$ a lag of half a year over $\Delta \log I$. In Part II we found that the maximum correlation lead of S with regard to I was a quarter of a year. Thus imports of steel are an even earlier indicator of business cycles than are total deliveries of steel to the Swedish market, and would therefore seem to be a variable worthy of observation for purposes of short-term forecasting of the general economy.

Since imports are apparently more flexible than deliveries from Swedish steelworks, it seems reasonable to suppose that the share of imports in total deliveries of steel rises with increases in steel inventories. Let us assume that the relation is described by a constant elasticity function

$$M/S = a_0 \, (L/L_{-1})^{a_1}$$

---

the correlation coefficient (R) and the Durbin-Watson statistic (DW). These concepts are defined in the brief outline of linear regression given in chapter 7 Part III. Finally, as regards logarithms, we shall be using common (Briggsian) logarithms.

Let us also take as our starting point one of the relations for steel deliveries expressed in Part II, namely

$$S = b_0 I \cdot (I/I_{-1})^{b_1}$$

In this expression $(I/I_{-1})^{b_1}$ constitutes a description of (L/L_{-1}). Imports thus become

$$M = c_0 I \cdot (I/I_{-1})^{c_1} \qquad 8.$$

where $c_0 = b_0 a_0$ and $c_1 = b_1 + a_1$

It will be recalled that equations 6, 7 and 8 are not formed from any explicitly formulated theory. They merely represent three alternative ways of expressing the relation between variations in imports and those of total demand for steel (or total deliveries of steel). Of course, as we have already seen, it is an advantage from the point of view of forecasting if we can find stable, easily manageable relations between these quantities.

If we estimate the structure of equation 8 by using yearly data covering the period 1956—69 we obtain a value of 3.520 (1.251) for the coefficient c_1. Since the coefficient b_1 in Part II was estimated to 1.582, the implicit estimate fo a_1 is equal to 1.938. According to these calculations a change of x per cent in steel inventories will coincide with a 2 x per cent change in the share of imports. The results of these calculations confirm the impression of a buffer character in imports conveyed by even a superficial glance at the import curves.

3.2. The allocation function

If the allocation of steel demand between typical imported steel and typical domestic steel is constant over time, variations in the share of imports are entirely attributable to the factors determining imports of the steel products sold on the Swedish market by both domestic and foreign manufacturers. We spoke earlier in general terms of an allocation operator or an allocation function, $f(x_1, x_2 \ldots x_n)$. It is now time to specify this function more closely. We shall begin by considering which variables can be included in such a function, after which we shall define various import equations more exactly.

3.2.1. Effects of price speculation. We have already seen that the ratio between the Swedish steelwork's prices and those of foreign steelworks is fairly constant. Changes of anticipation regarding price developments could however conceivably influence imports, in view of differences in pricing principles. The question of measuring such anticipations is dealt with at some length in Part III and there is no cause to reiterate the argument here.

Here as in Part III, the analysis is affected by the fact that our observations mostly refer to realized purchases and not orders. Above all, we have no statistics regarding orders placed by Swedish purchasers with foreign steelworks. If, as is probably the case, speculation is predominantly concerned with the distribution over time of new orders, then in order to be able to identify it we have to know the relation between increases in orders received and increases in deliveries. We can exemplify the problem as follows. Assume that in a stationary equilibrium purchaser's demand for steel rises (owing to a sudden change of expectations regarding prices), resulting in an increase of the rate of new orders placed. The rise in orders leads to a rise in deliveries. The time elapsing between the rise in orders and the rise in deliveries will depend on current delivery times, but these in turn will probably be influenced by the rise in orders. This will be the case if steelworks meet variations in demand by letting their unfilled orders act as a buffer between orders and deliveries. Thus later incoming speculative orders will have to wait longer than the earlier ones with the result that the rise in deliveries will be spread out over a longer period of time than the rise in orders.[1]) This situation is illustrated in figure 7.[2])

The rise in deliveries following a speculative rise in demand is affected in two ways by the order/capacity situation at the steelworks, namely the juncture when the rise in deliveries commences and, secondly, the duration of the rise in deliveries. The higher the utilization of capacity, the more protracted the rise in deliveries following a steep rise in demand is liable to be.

[1]) Forrester, using the technique of simulation, has described the way in which various properties of the information and decision system give rise to delayed, smoothed and amplified reactions of deliveries to changes in orders. See Forrester J. W., Industrial Dynamics, New York 1961.

[2]) One can quite well imagine that short-term speculative rises in orders received which are rapidly followed by corresponding reductions need hardly be reflected at all by the development of deliveries or by the allocation of deliveries on different kinds of sources, e.g. between imported and domestic steel. However, we are solely concerned here with the latter kind of development, so that speculative movements which are only evident from order data do not come within the scope of our inquiry.

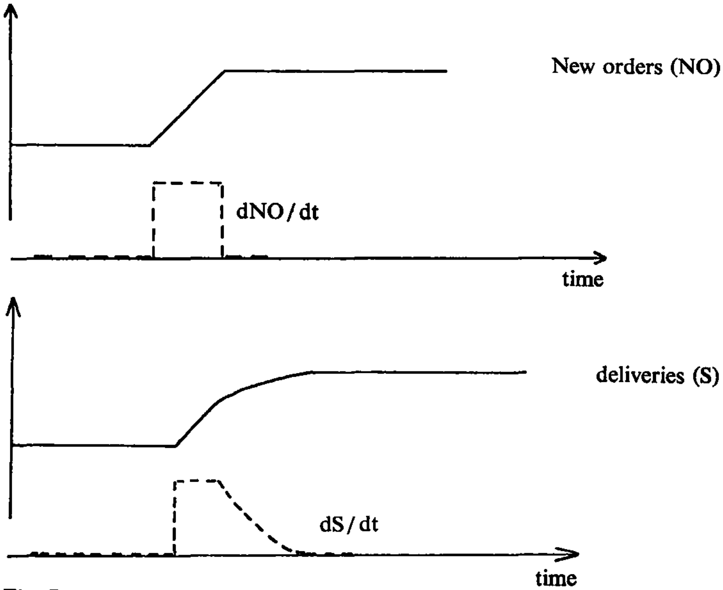


Fig. 7

The extent to which this relation affects our analysis will depend on our aggregation level with respect to time. If our observations refer to brief periods we shall find that there is no single lag between orders and deliveries and perhaps also that there is no unique distributed lag between the two quantities. The same applies of course to the time lag between the change giving rise to the speculative rise in orders and the rise in deliveries. If we consider longer periods, the time lag problem will be simpler because we need only take into account a smaller number of periods, but on the other hand valuable information will be lost as a result of the aggregation and the relation between orders and deliveries may be drastically obscured.[1])

3.2.2. Delivery times and buyers' preferences. Interviews of consumers and merchants show that reliable deliveries and waiting periods are two main considerations when deciding on from where to purchase. The reliability of deliveries refers

[1]) Cf. Part III, section 4.5., where it is pointed out that the important consideration is often not the duration of the observed phenomenon but the duration of its consequences. Thus the "gain" in aggregating away certain problems like the identification of lag structures can be misleading. It can for instance happen that an occurrence of a sudden but swiftly receding protraction of delivery times by home market firms can have effects of imports over a relatively long period of time. In the aggregated data we will not be able to see these changes in delivery times, but we will observe a change in imports, which we will not be able to analyze unless we disaggregate the data over time.

to the ability of the seller to meet the agreed delivery date. The more certain buyers can be of obtaining deliveries on schedule, the easier their planning becomes. Planning is also simplified by short delivery periods.

Deliveries from domestic steelworks are generally considered more reliable than imports, even though the latter may involve shorter delivery periods. The reliability of deliveries is probably a cyclical phenomenon. As we saw earlier, steel cycles are quite closely attuned to business cycles generally. Thus during boom periods delivery plans can be disrupted by breakdowns, which result in more serious delays during high capacity utilization than otherwise, and by bottlenecks in the freight market. There is less risk of such delays during recession periods. Since Swedish and foreign suppliers can be affected in different ways and at different times by changes of this kind, it is reasonable to suppose that variations in the relative reliability of deliveries by Swedish steelworks can occur. Any change in the comparative reliability of Swedish and foreign deliveries will of course affect buyers' preferences as between the two categories.

Delivery times are governed by the trade cycle. If cycles in Sweden are differently phased from those in the countries exporting to Sweden, this will result in variations in the ratio between the average delivery times of Swedish and foreign steelworks and, consequently in buyers' preferences between the two categories.

According to our premises, a rise in the ratio of delivery times of Swedish works to those of foreign producers, all other things being equal, will raise import demand and with it the share of imports.

3.2.3. Supply from foreign sellers. The willingness of foreign steelworks to sell in the Swedish market probably varies according to the price levels of other markets, above all their own. A rise in world market prices (and, consequently, in prices on the Swedish market) coupled with constant prices on the domestic market will of course improve the profitability of exports and with it export supply. If domestic demand rises at given relative prices, firms will probably stand to profit by a reduction of their exports, since the opportunity cost of exports will probably rise as a result of increased demand in the home market. Not only is an apparently temporary accumulation of imports thought to entail serious risks of losing shares of the market in the long run, the special costs associated with exports are generally (though not invariably) higher than the special costs of domestic deliveries. A rise in domestic demand means that sales in the home market can be increased without any special sales promotion. The additional revenue thus earned is generally greater than the net loss of revenue incurred through a corresponding reduction of exports.

Between 55 and 60 per cent of Swedish imports come from the countries of the ECSC and almost 15 per cent from the United Kingdom. Domestic prices are more rigid than export prices in both these areas. In practice this means that export prices are subject to heavy cyclical fluctuations whereas domestic prices in the ECSC are slower to adjust to the state of the market. Steel prices in the U.K. are entirely administrative and exhibit no cyclical variations. Domestic prices are higher than export prices, except during periods of peak prices on the world market, which have hitherto been of brief duration. Judging by relative prices, one would expect foreign supply on the Swedish market to be high during an international boom on the steel market and low during periods of recession. For obvious reasons, the international steel cycle co-varies with domestic steel cycles in the countries here under consideration. When world market prices rise, steel demand in the ECSC and the U.K. generally rises with them. The very fact that export prices in the ECSC rise above domestic prices during boom periods suggests that supply is more sensitive to domestic demand than to the price ratio, and this will be our initial hypothesis regarding import supply.

3.2.4. Conclusion. Summing up we can say that the allocation function, which descripes how purchases of the steel offered by Swedish and foreign sellers is divided between these two groups of firms, contains variables describing price anticipations, delivery times and domestic demand. In general terms this function can be formulated

$$_cM/_cS = f(P^*/P,\ _aTD,\ _hTD,\ _aDK) \qquad 9.$$

where P^*, $_aTD$, $_hTD$ and $_a(D/K)$ denote anticipated price, delivery times abroad, delivery times at home and demand for steel in relation to the production capacity of the countries exporting steel to Sweden. If we adhere to our previous assumptions regarding the proportionality of the development of typically Swedish and typical imported steel, we automatically obtain an expression of the total share of imports

$$M/S = m + f(\ldots) \qquad 10.$$

3.3. The import model confronted with half-yearly data for the period 1959-70

In the previous section an import model was presented which was unspecified with respect to functional form. Nor was it fully defined as regards variable content. The functional form will be chosen here more in terms of practical considrations than according to sound theoretical principles. Here we shall only take into account logarithmically linear equations. These are at all events relatively simple to interpret and apply when the variables differ in terms of the unit of measurement. Also they do not generally give different results from the corresponding arithmetically linear equations as far as the practical significance of different variables is concerned. The definition of the variables, i.e. the combination of theoretical quantities with the available mass of data, will be discussed in connection with the presentation of two regression equations, which follows here. These equations are estimated on half-yearly data which have *not* been adjusted for seasonal variations. The two equations are

$$\log M = -0.6799 + \underset{(0.1588)}{1.4293} \log \hat{D} - \underset{(0.1415)}{0.3540} \log K_{-1} +$$
$$+ \underset{(0.1477)}{0.3481} \Delta^2 \log P_{-1/2} + \underset{(0.01789)}{0.03402} SED + \underset{(0.1008)}{0.0974} \Delta \log (UO/K_{-1})$$
$$R = 0.985;\ DW = 2.34$$

$$\log M/S = -0.6321 + \underset{(0.1282)}{0.3275} \log (\hat{D}/K_{-1}) +$$
$$+ \underset{(0.1156)}{0.1166} \Delta^2 \log P_{-1/2} + \underset{(0.0856)}{0.2071} \Delta \log (UO/K_{-1})$$
$$R = 0.827;\ DW = 1.89$$

D denotes an estimated value for realized demand, K the production capacity of steelworks, UO their unfilled orders in tons and P merchants' price quotations for steel, while SED is a dummy having the value of 1 in the first half and 0 in the second half of every year. Thus seasonal adjustment is made implicitly. One important reason for this procedure is that imports do not exhibit clear seasonal variations.

The variable $\hat{D}$ requires a more detailed description. Here we have started with the observation that deliveries of Swedish and imported steel to the engineering industry exhibit the same cyclical and roughly the same long term pattern as deliveries to all consumers (vid. Part III, cap. 1.). We have also made use of the estimates of consumption and investments respectively which were made in that part to obtain an estimate of total deliveries. In doing so we have started from the following estimate

$$\hat{D} = 37.9 + 1.062C^* + 1.713\Delta^*C + 1.555\Delta_w UO_{-1}$$

where

$$C^* = \text{antilog}\,(\log C_{-1} + 0.000630\,\mathscr{N} + 0.00042)$$
$$\Delta^*C = C^* - C_{-1}$$

$\mathscr{N}$ = net tendency, forecast for next quarter or during later years forecast for next half year.

Returning now to the import equation we can thus establish that the first has imports and the second the share of imports as dependent variable. The similarities and dissimilarities of the two formulations can be hard to distinguish. In the first place the ratio

$$\frac{P_{-1/2}}{P_{-1\,1/2}}\bigg/\frac{P_{-1\,1/2}}{P_{-2\,1/2}} = P_{-1/2}\cdot P_{-2\,1/2}/2P_{-1\,1/2}$$

has in both cases been used as a measure of the price expectation variable, P denoting merchants' quotations for ordinary bars. Secondly the ratio $\hat{D}/K_{-1}$ has been used as the primary measure of delivery times in Sweden. Here variations in the size of capacity in relation to demand denote variations in the time a purchaser expects to have to wait after placing extra orders with a Swedish steelworks in relation to delivery periods at foreign steelworks. As regards the estimate of the equation for the import ratio, however, the change in the delivery period actually observed has been added as independent variable. This variable is intended to reflect the rise in the actual import ratio occurring as a result of delays in deliveries by Swedish steelworks. Whereas the ratios D/K_{-1} is assumed to influence order placement including direct purchases from stock, the relative change in delivery times as measured by the ratio $(UO/K_{-1})/(UO_{-1}/K_{-2})$ is assumed only to affect the difference in the speed at which orders to Swedish steelworks are effectuated as compared with the rate at which import demand is realized.

Turning to the coefficient estimates and their standard deviations we find that our basic hypotheses concerning the appearance of the distribution function have received a certain amount of empirical support from the variables discussed. In view of the great variation in the quantities involved we can also say that they played a considerable part in the fluctuations of imports during the 1960s.

Although the speculation variable in the second equation has a large standard deviation, price movements seem to have had some importance on the choice of purchasing source.—It will be remembered that the price quotations in question have fluctuated violently.

We might mention for the sake of information that attempts to add log D/K_{-1} and log OU/K_{-1} for the ECSC, which is the source of the greater part of steel imports, give the "right" signs to the elasticities in question, but these are so small and their standard deviation so large that they can be dismissed forthwith. The surprising thing is, however, that these variables, which are intended to express restrictions on import supply, do not even become significant if the analysis is confined to the steel imports from this area. Looking back to recent boom periods we find that Sweden's share of ECSC steel exports rose on these occasions. This can be taken to imply that Sweden is one of the export markets that are given priority during shortages. The main reason for this priority status is probably the strength of the bands existing between Swedish purchasers and steelworks in the ECSC. Transportation costs are probably a major consideration here, though tradition too may be an equally potent force.

4. The cyclical marketing policy of steelworks

In this chapter we shall study the cyclical marketing policy of steelworks. The term cyclical marketing policy is used here in a general sense to denote the way in which firms react to cyclical fluctuations of demand. Our main concern will be with short-term production policy, but we shall also make use of other variables to characterize the steel industry in this respect.

In the static version of the classical theory of prices, a change in demand at given prices—a shift in the demand curve—leads to the adjustment of prices or of the quantity supplied of the product in question: normally the adjustment applies to both variables. In reality changes in demand do not produce any immediate adjustment of prices or production. Firms producing for stock will either reduce or increase their stocks of finished products to begin with, while those producing to order will react by a change in their volume of unfilled orders. Often firms produce both for stock and to order, which means that they can react in both ways simultaneously.

Thus during an incipient rise in demand the volume of unfilled orders will increase and stocks of finished products will diminish. This may lead firms to raise production or prices or both. We shall disregard price adjustment for the moment, turning instead to consider the adjustment of output.

The alacrity and vigour with which firms adapt their output to changes in demand may depend on the existence of "mechanical lags", i.e. properties of the information and decision mechanisms of the firms in question. But the speed and vigour of their reactions may also be governed by considerations of profitability. It is usually expensive to adjust production rapidly to demand. At the same time a large-scale smoothing out of production can lead to losses due to the heavy fluctuations of orders on stock and inventories resulting from such a production policy. It follows that production adjustment of optimum profitability is presumably characterized neither by complete flexibility in relation to demand nor by a total smoothing out of production.[1])

The Swedish steel industry produces mainly to order, though production for stock does occur on a considerable scale. In order to study the short-term market policy of this industry one must therefore observe variations in both unfilled orders and inventories. But we shall also take note of a third means of evening out production apart from price changes, namely *variations in sales to secondary markets.* A fall in demand on the firm's ordinary or primary markets can lead to a redoubling of efforts to sell in markets where the firm only occasionally figures as a seller, i.e. secondary markets.

Short-term marketing policy, not least as regards pricing, is probably influenced by the current marketing situation of the firms in question. We shall enlarge on this in due course, but first we must undertake a division of steel enterprises into two groups which are quite differently placed in this respect.

4.1. The two types of steelworks

Earlier we drew a distinction between ordinary and special steels. These two products are defined in terms of their content of alloys and carbon. Special steels comprise alloy steels (excluding low alloy steels) and high carbon steels, while ordinary steels comprise low carbon and low alloy steels.

These differences are of no intrinsic relevance to studies of supply and demand, but in the present case they coincide with other, highly important differences. In terms of both tonnage and kronor, ordinary steel accounts for the overwhelming proportion of total supply not only in Sweden but in the entire world. Ordinary steels are a far more homogeneous group of products than special steels. As the name inplies, the latter are used to satisfy special requirements with regard to corrosion resistance, hardness, tensility etc. and various combinations of these properties. Consequently the special steel sector has developed a wide range of different products.

For these reasons it is natural for plates, sheets, bars etc. of ordinary steel to be produced in far longer series than the

[1]) See Part III: 5.2.3. for a more exhaustive discussion of these problems.

corresponding special steel products. It is equally natural for special steel to be more expensive and to have a far wider price range than ordinary steel. Another important fact to bear in mind is that the two groups of products are marketed in different ways. Whereas ordinary steel is sold as a staple product, often through merchants (the German term Massenstahl is singularly apt), sales of special steel require a great deal of customer contact and service activity.

Although technically speaking it is possible for special and ordinary steels to be produced in one and the same plant, most manufacturers specialize in one or the other sector. Most of the total output of ordinary steel comes from steelworks more than 90 per cent of whose production consists of ordinary steel. The same applies to production of special steel. In recent years there has been a striking trend towards greater product concentration by steelworks.

Thus the Swedish steel industry may be said to consist of two distinct components, namely a special steel industry and an ordinary steel industry. We shall refer to the firms in these two sub-branches as *s-works* and *o-works* respectively.[1]) There are still steelworks, however, whose output is very much a mixture of special and ordinary steels but they count for a very small part of total steel output.

As we indicated in table 1, there are distinct outward differences of market orientation between the two groups. Thus 65—70 per cent of the output of the s-works is exported, the share of imports on the domestic market being less than 15 per cent. The corresponding figures for the o-works are 27 and 40 per cent respectively. Thus the o-works produce mainly for the domestic market, where they encounter stiff competition from foreign firms. They are small by international standards and their export sales are only a minute fraction of total demand on the markets in question.

The s-works by contrast are typical export enterprises with practically worldwide coverage. For obvious reasons they also dominate their home market. Unlike the o-works they usually also bulk large in their export markets.

Our next concern will be to investigate whether these differences have produced distinct patterns of behaviour with regard to short-term marketing policy. We shall begin with a brief theoretical analysis in which the different situations of the two

[1]) Firms here is taken to mean the plant in which short-term decisions are taken regarding prices and production. Accordingly two plants within the same group will be treated here as two firms.

groups of firms will be defined in terms of marketing policy. We shall then analyse data from the period 1959—70 in an attempt to identify characteristic features of the cyclical marketing policy of the two groups. We have already had occasion to observe the effect of changes in the delivery times on the share of imports. A study of short-term marketing policy automatically brings us onto the question of this kind of variations. In this way we may hope to learn more about the causes of import fluctuations.

4.2. Price taking and price discrimination: the o-works

Although Swedish manufacturers of ordinary steel cater first and foremost for the home market, they are also active in several export markets, so that their revenues derive from several different markets. We shall try with the aid of a simplified static model to describe their total sales and the distribution of those sales between different markets. In so doing we shall proceed on the following assumptions:

- firms manufacture one product — allbeit a composite product
- the revenue from each market is a single valued function of the quantity of steel sold to the market in question (q_i)
- sales to each market are associated with a traceable cost dependent on the quantity of steel sold
- the common cost of production is a unique function of the total volume of production (q) but is independent of the market allocation of the latter.

If we denote profit by V, revenue and traceable cost from sales to market j as R_j and T_j respectively, and the cost of production as C, we can formulate the following static profit equation:

$$\begin{aligned} V &= \textstyle\sum_j (R_j - T_j) - C; \qquad\qquad j = 1, 2 \ldots m \\ R_j &= f_j(q_j) \\ T_j &= g_j(q_j) \\ C &= h\,(\textstyle\sum q_j) = h\,(q) \end{aligned}$$

For maximum profit the following m conditions must be satisfied:

$$\frac{dR_j}{dq_j} - \frac{dT_j}{dq_j} = \frac{dC}{dq} \quad j = 1, 2 \ldots m$$

The left side consists of the marginal revenue minus the marginal traceable cost of sales to market j. We shall refer to this quantity as the *net marginal revenue* (nmr_j). The right hand side shows the marginal cost of production (mc). Thus the necessary conditions for maximum profit are

$$nmr_1 = nmr_2 = \ldots\ldots = nmr_m = mc$$

Thus net marginal revenues must be equal to each other and to the marginal cost.[1] The use of traceable costs in this estimate makes it easy for us to see that firms can sell in two or more markets where prices are different and at the same time beyond their control. A situation of this kind would be unthinkable if we had not made allowances for traceable costs: firms would sell the whole of their production in the market offering the highest price.

The situation of the o-works is such that both domestic and foreign prices are given. We have already seen that the price of ordinary steel on the Swedish market is dependent on world market prices. Swedish steelworks might conceivably bring down prices on the home market, but this is an unrealistic proposition in view of the very small rise in sales that would result from it. If a price were charged in excess of the current world market price (including customs and freight), this would lead to a considerable fall in production, so that this course of action is equally inconceivable from the point of view of profitability. The Swedish o-works have still less chance of influencing prices in export markets. As a result they figure as price takers both at home and abroad.

The market situation of the o-works is illustrated in a simplified form by figure 8.

Net marginal revenue on the home market (nmr_1) is assumed here up to a certain point to comprise the difference between a price given by the world market and a constant marginal traceable cost. This point represents the quantity which the Swedish firms can sell if they keep to this price. A reduction in prices can lead to a slight increase in sales, but in order to achieve this effect one would have to reduce prices to such an extent as to bring nmr_1 below zero. Instead it is profitable to apply practically the whole of the remaining capacity

[1]) The fulfilment of the necessary conditions is not as self-evident here as in cases where traceable costs are disregarded, as is customary in expositions of the theory of price discrimination. Thus if dT_j/dq_j are quadratic functions of q_j, nmr_j will also be quadratic functions of the same variable in the case where the demand curves are linear.

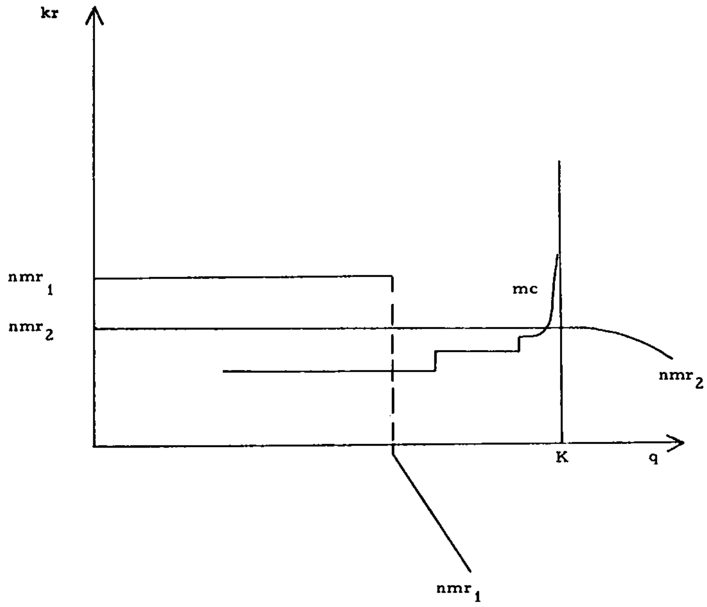


Fig 8

(K) to production for the world market. The marginal cost curve is assumed to be stepwise horisontal. (At certain levels of production, it is necessary to increase the number of shifts which leads to discontinuous rises in production costs). Once full utilization of capacity has been attained, however, the *mc* curve can be expected to rise steeply.

On the basis of these assumptions, capacity utilization by the o-works will invariably be high. A rise in domestic demand here represented by a shift to the right of the nmr_1 curve, will lead to a rise in domestic sales at the expense of exports and vice versa. A rise in capacity will shift the rising phase of the mc curve to the right and with constant domestic demand result in a rise in exports.

As we turn from the static to a dynamic analysis, we shall return to the problem posed in our study of imports. We saw that imports were dependent on the delivery periods for Swedish steelworks. The question now arises, how long does it take firms to react to changes in domestic demand. For example, does their involvement in export transactions during recession periods result with the onset of a boom period in a "vacuum" leading to an influx of imports? Clearly an empirical investigation of relations of this kind is called for.

4.3. Short-term behaviour in oligopolistic markets: the s-works

The initial market situation of the s-works is in many respects completely different from that of the o-works outlined above as regards the determination of output and prices. In the first place s-works in Sweden and on the major foreign markets are generally so large that they have to take into account each other's reactions and those of foreign works if they make alternations to their marketing policy. This means that they are in an oligopolistic market situation. Secondly their sales are often associated with heavy service inputs, which means that they cannot rapidly invade new markets to make up for falls in demand in their traditional territories.

Both these circumstances should be important when analysing short-term price and output decisions in the special steel sector. But the mere fact of the markets in question being oligopolistic does not of itself provide us with a theory of price and production behaviour, for the simple reason that there is no general theory of oligopoly. Instead both theory and reality have furnished us with a host of different market solutions. However, price adjustment in these markets would appear to be slower than in competitive markets.[1]) Slow price adjustment is accompanied by rigidity in shares of the market. Variations in demand can therefore be expected to influence the output levels of all firms.

4.4. Looking at the data

The general theoretical aspects of the marketing policy of the o- and s-works did not lead to any exact market models. On the other hand certain hypotheses were advanced concerning production and pricing policy and concerning the distribution of deliveries between the domestic and export markets. According to these hypotheses, the output of the s-works is more susceptible to fluctuations on demand than the output of the o-works while the reverse applies to prices. The output of the o-works is evened out by means of contracyclical variations in their shares of the domestic and export markets for ordinary steels.

Hypotheses of this kind can at least be preliminarily tested by direct observations of data in diagrams and simple tables. This will be the approach adopted to begin with. Next however

[1]) See e.g. K. J. Cohen and R. M. Cyert: Theory of the Firm: Resource allocation in a market economy, New Jersey 1965.

we shall try in two very simple econometric models to give a quantitative picture of the determination of the flows of goods on the markets for ordinary and special steels respectively.

However, there are no data immediately available for a time series analysis of the two markets. Apart from the period from 1968 onwards, we do not even have access to annual data regarding the variables we need to observe.

The statistical situation is as follows: the production statistics distinguish between special and ordinary steel at the crude steel stage but no corresponding division is made regarding output of finished steel. The two product groups are identifiable however in the foreign trade statistics.

In order to be able to calculate supply, deliveries to the home market etc., we have converted exports and imports to crude steel weight. A general description of this procedure is given in Part II. It must be stressed, however, that in calculating delivery data for the two quality groups we have used different weights from those we used to calculate total steel supply for the OECD countries (including Sweden). In the latter case we used the ECE's weights. Here we shall use the ECSC's conversion factors for ordinary steels, while the conversion factors for special steels are taken from Swedish steelworks. The conversion factors have been kept constant throughout the period studied, 1959—70, with one exception, namely stainless steel, where a clear trend towards rising yield has led us to make the conversion factors for stainless products a linear function of time.

The series thus obtained differ in two important respects from the data used in table 1. In the first place they comprise tubes and semis. Secondly the estimated deliveries to the home market will automatically include deliveries for further processing into engineering products within one and the same plant. The main consequence of this is that the shares of the domestic market will be larger in crude steel weight than in the form in which they were presented in table 1. On the other hand this account retains the fundamental differences between the markets for special and ordinary steels as shown in table 1.

Finally it should be emphasized that the theoretical part referred to groups of firms while the statistical account refers to types of product. Since ordinary steel and special steel are predominantly produced by typical o-works and typical s-works respectively, an analysis of their behaviour on the basis of product data appears justified. In some cases where product mixing has occurred it has been possible to divide the firm in question into two parts, of which one produces only ordinary steel and the other only special steel.

4.4.1. Pricing and production A preliminary analysis of the development of prices and output substantiates the hypotheses put forward previously. It will be recalled that demand for special steel resembles demand for ordinary steel as regards the trend and particularly as regards fluctuations around it, though the amplitude of the cycles is on average greater in the case of special steel.[1]) In principle therefore we can compare e.g. the output curves of the two types of product in order to see where the stabilization of output is greatest.

As will be seen from the accompanying figure, special steel output exhibits far greater fluctuations than ordinary steel output. The average trend deviation calculated on seasonally adjusted half-yearly data for the period 1959—70 is 7.5 per cent for the former and 4.0 per cent for the latter group of products. For obvious reasons, the differences in this respect have produced corresponding differences in capacity utilization.

[1]) The average deviation of realized demand $(H + M)$ from its trend during the period 1959—70 was 6.5 per cent for ordinary steel and 10.5 per cent for special steel. Calculations based on half-yearly data.

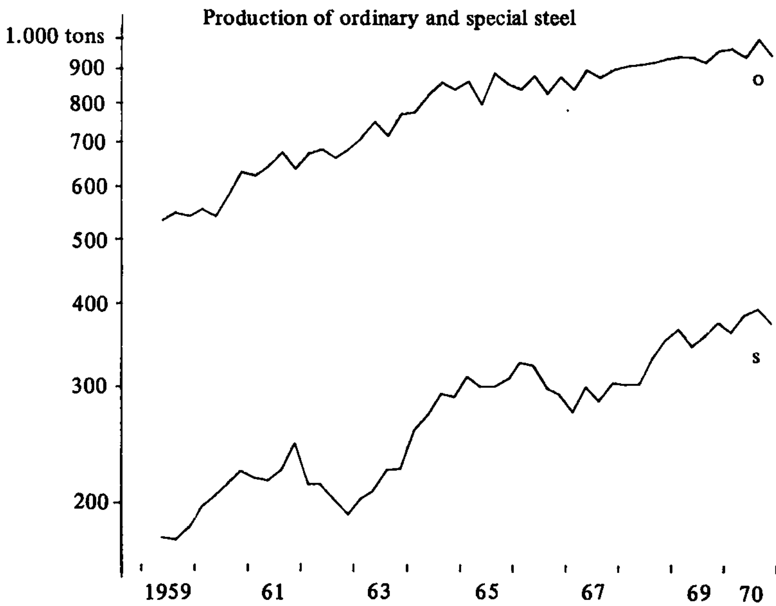


Fig 9

Excess capacity of the s-works and the o-works

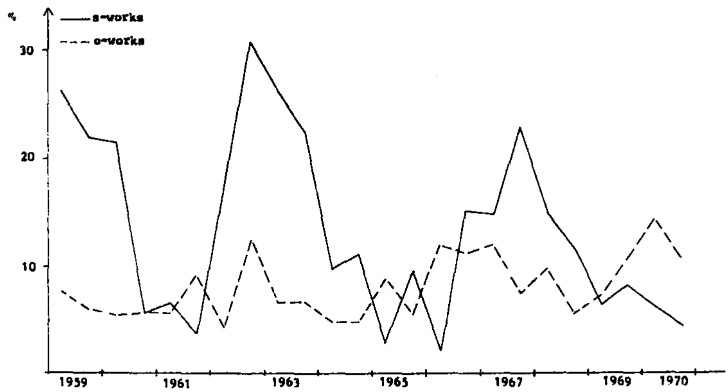


Fig. 10

As can be seen from figure 10, fluctuations in excess capacity, i.e. $1-Q/K_{-1}$, have been far more pronounced in s-works than in o-works. Capacity here refers to furnace capacity, which is normally the bottleneck of steel production.[2])

The pattern of behaviour appears to change towards the end of the observed period. During the boom year 1969 capacity utilization declined in the o-works and the same thing happened to the s-works during the second half of the year. This decline is probably attributable in its entirety to a shortage of other production factors than furnaces. Thus production at some works was restricted by the electricity shortage resulting from an unusually long period of dry weather. Shortage of labour also seems to have had a more inhibitory effect on output than during previous boom periods.

According to preliminary figures the recession of 1971 induced a reversion to normal conditions. Capacity utilization appears to have fallen during this year by 5 per cent in the o-works and approximately 10 per cent in the s-works.

The reverse applies to the development of prices. Special steel prices exhibit a far more rigid pattern than the prices of ordinary steel, as can be seen from figures 11 and 12. Extreme caution should however be exercised when interpreting curves of this kind and a somewhat more detailed commentary is therefore called for.

Of the three special steel prices accounted, the price of tool steel and the price of high speed steel give the impression one

[2]) This holds true even if we include the hot and cold rolling stages of production in our sector concept.

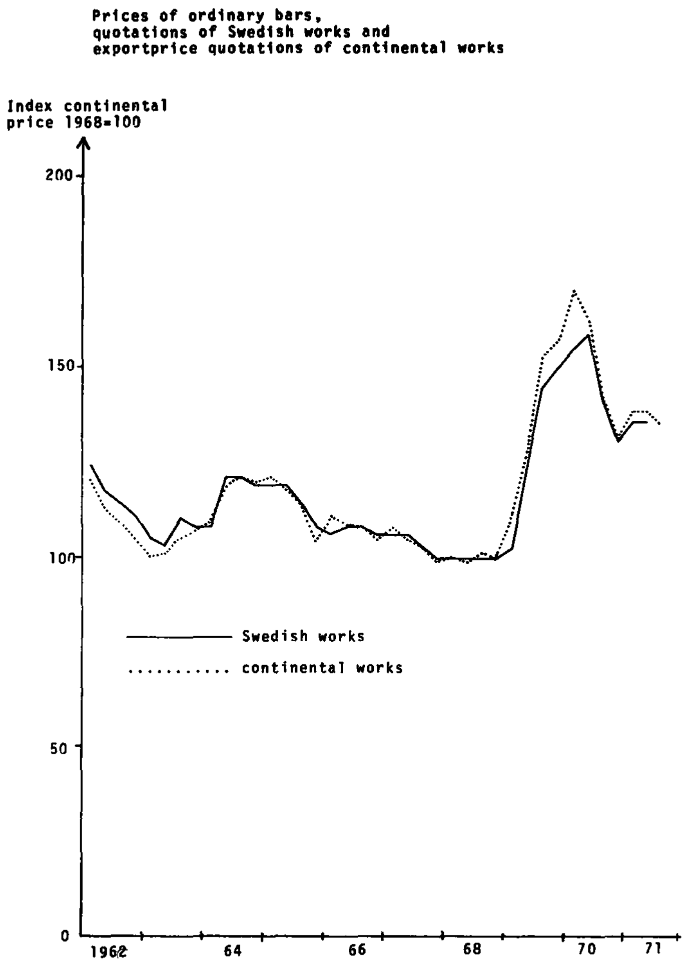


Fig. 11

expects when studying oligopolistic markets: prices change seldom and such changes as do occur are small in relation to the fluctuations of demand.[1]) On the other hand the development of stainless steel prices after 1960 exhibit fluctuations of an amplitude little short of ordinary steel prices, though even during this period price changes are less frequent than in the case of ordinary steel. One major reason for the increased

[1]) Due to existing information the demand for the two commodity groups has showed big fluctuations during the period covered by the price curves.

Prices in Sweden for high speed and tool steels

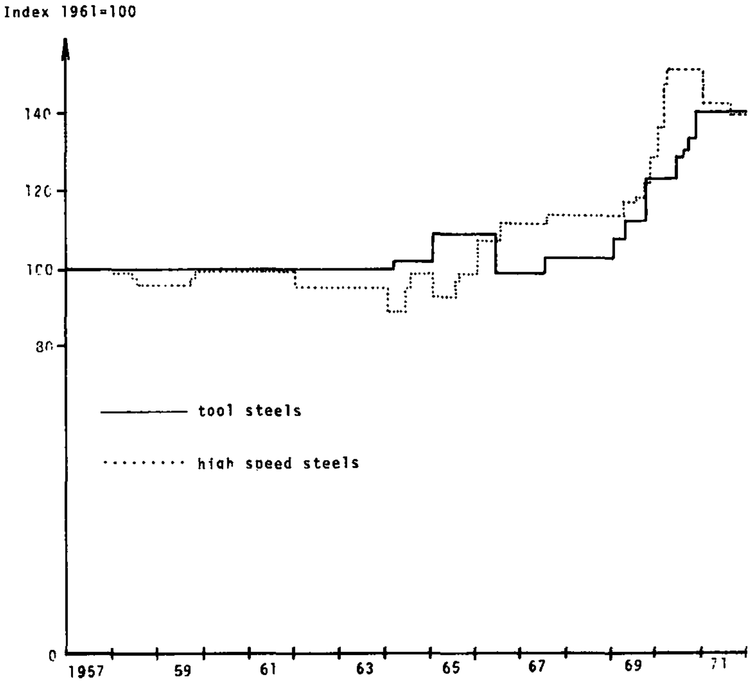


Fig. 12a

Prices in Sweden for stainless steels, warmrolled sheets, 3 mm of a common quality.

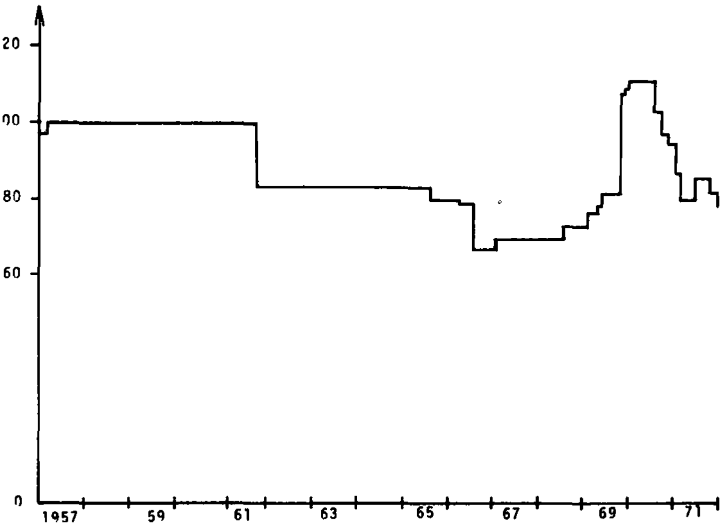


Fig. 12b

mobility of stainless steel prices seems to be that commonly occurring qualities of stainless steel have lost their character of special product and have developed into a commercial commodity.

It should be borne in mind that the prices in question refer to quotations for basic qualities. The price actually paid by purchasers, the effective price, includes increments for quality deviations, extras as they are termed, and possibly for freight, as well as discounts of various kinds. When demand falls off, the fall in effective prices is first evident in the form of hidden or open discount increases.[1]) When this price fall has been in progress for a certain period of time, the official quotation is reduced by way of confirmation of current tendencies. A similar process occurs during upturn periods. When following a period of stagnation demand again begins to rise, sellers become less generous in the matter of discounts and other special terms, and price quotations are subsequently raised accordingly.

Thus quotations lag behind the effective price and the frequency with which quotations are changed is predominantly an administrative question. It follows that, contrary to the practice sometimes adopted, one cannot compare the price mobility of two products by counting the number of changes undergone by their price quotations during a given period.[2]) There can be little doubt that the price mobility of tool steels and high speed steels is less than that of stainless and ordinary steels, but the last two groups of products can hardly be distinguished in this respect merely on the basis of price quotation statistics.

The price curves for ordinary steel refer to bars but are also indicative of every other important product. We have already observed how the o-works figure as pricetakers and how their price consists of the world market price plus customs and freight. The term world market price as used here refers to ECSC export prices. These in turn have proved to be highly correlated with capacity utilization by steelworks within ECSC. One exception to this rule is provided by the 1969—70 boom, when prices soared even though there seemed to be a great deal of surplus capacity. Professor Ruist has shown however

[1]) Firms can for instance refrain from charging "extras" for special dimensions or qualities, when demand falls.

[2]) See e.g. Carling, Alf: Industrins konkurrensförhållanden, SOU, 1968: 5, page 255.

that this surplus was mainly a statistical chimera.[2]) Briefly the price mechanism can be said to operate as follows.[3])

A rise in steel demand and the increased capacity utilization which it produces will cause output to proceed at rising marginal costs. The statical marginal cost curve is assumed to be of the kind shown in figure 8. The rise in steel production will also increase the demand for raw materials such as coke, scrap and pig iron, with the result that the prices of these products will rise. These price rises lead to an upward shift in the marginal cost curve and, consequently, in rising steel prices.

One is naturally led to wonder whether there is any connection between the difference in price movements between ordinary and special steel and the difference in their output development. Has the apparently superior stability of special steel prices caused an unstable output? Before endeavouring to answer this question there are two important facts which we must take into account.

- The short-term price sensitivity of special steel demand is negligible. See Part II.
- In the short run special and ordinary steel are complementary rather than rival products.

This means that differences in price development cannot give rise to differences in the development of total demand. We have also been able to establish similarities in trend and cyclical patterns as regards realized demand for the two products.

But the fact that the price elasticity of total demand for steel is close to zero does not mean that the demand on individual firms and groups of firms cannot be affected by pricing. Thus it is conceivable that Swedish steelworks raise their shares of the market during recessions and reduce them during boom periods by means of faster and/or more drastic price changes than their foreign competitiors are capable of.

If the analysis is confined to the Swedish market, no support is to be gained for any such pricing policy on the part of the o-works. In the case of the s-works it is more pertinent to ask whether their pricing has not in fact been less flexible than that of their foreign competitors. It is also difficult to find anything

[2]) Erik Ruist, The Case of the Vanishing Excess Capacity—Experiences of Trends in the Steel Market 1968—1970, Jernkontorets Forskning, Stockholm, 1971. (in English) Also in Jernkontorets Annaler, Nr. 10, 1971 (in Swedish).

[3]) Vid. Fridén op.cit.

to support this thesis when considering the whole of the period studied, namely 1959—70. There are however clear indications that the s-works did not reduce their prices as much as their foreign competitors in 1970 and 1971: if this is true it does a great deal to account for the steep rise in the share of imports that took place during those years.

4.4.2. Home market deliveries and foreign trade. Figures 13—16 show the division of realized demand for special and ordinary steel between deliveries from the home market and imports together with the division of total deliveries by steelworks between home market and exports. With the help of these diagrams we can undertake a preliminary analysis of the influence of foreign trade on the stability of the output of the steel industry.

Imports have been of little consequence in special steel sectors. Although in relative terms imports of special steels have fluctuated widely, they have had little effect on deliveries to the home market by the s-works, which are entirely reflective of the development of total realized demand. Nor do exports appear to have had any significant stabilizing effect. The rapid trend of export growth has been inhibited during periods of stagnation of decline in the steel demand of the OECD countries. Moreover, as we have already seen, an anticyclical export policy is difficult to practise, for reasons of sales technique.

A different picture emerges when we turn to consider ordinary steel. Here the share of imports in total realized demand has on some occasions been in the region of 45 per cent, while the share of exports in total deliveries by o-works did not pass the 30 per cent mark until the end of our period. Consequently there has been a considerable import surplus in the ordinary steel market during the period under consideratoin.

Earlier we discussed variations in total imports of steel. Since steel imports are predominantly made up of ordinary steel, an analysis of imports of this type of product would merely entail a reiteration of our previous argument. We can note, however, that imports reacted promptly and violently during the three boom periods investigated, these boom periods being followed by periods of stagnation and recession during which the o-works successively recovered the shares of the market of which they had thus been deprived. During the recent recession, however, this readjustment has been slower than on previous occasions.

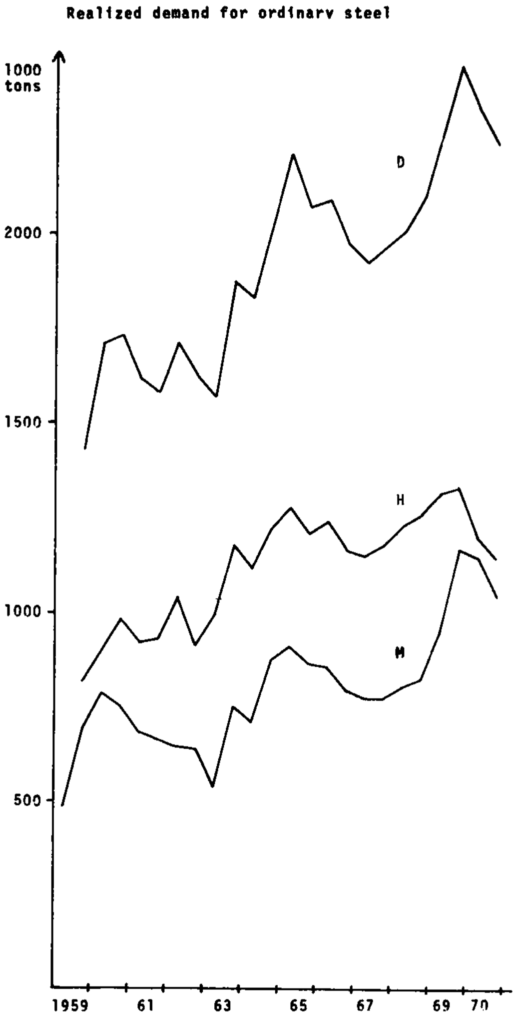


Fig. 13

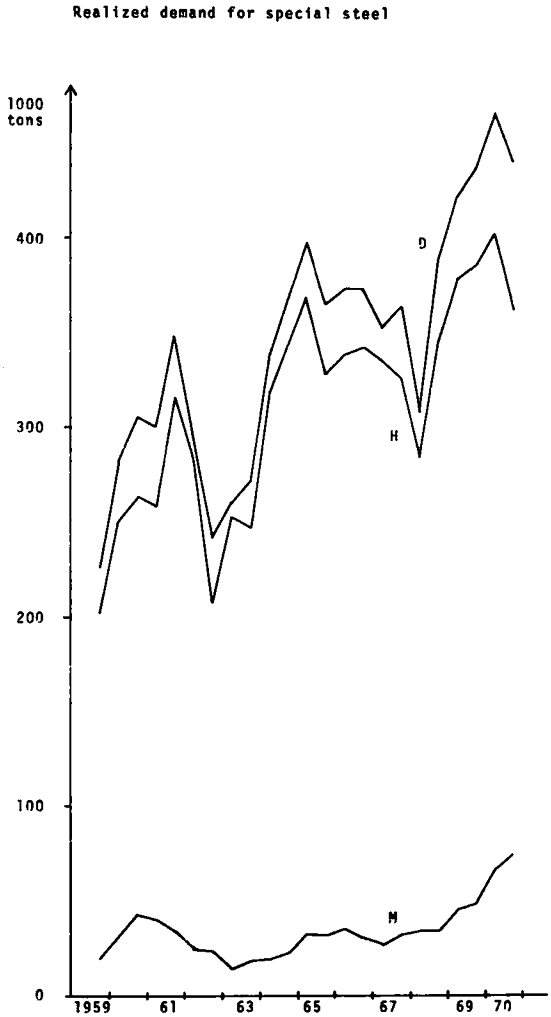


Fig. 14

As will be seen from figure 14, the share of imports continued to rise in 1970 despite a very heavy fall in realized demand. This is all the more remarkable bearing in mind the considerable rise in stocks of finished steels at the o-works during the same year.

This observation should be related to two other observations regarding 1970, namely steep rises in consumers' inventories of steel and a palpable decline in the delivery times of the

Output and deliveries by the o-works

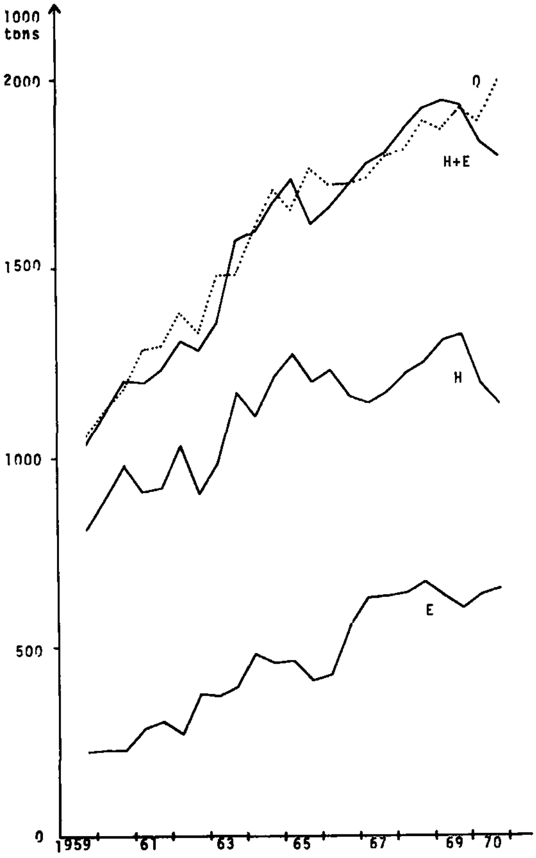


Fig. 15

Output and deliveries by the s-works

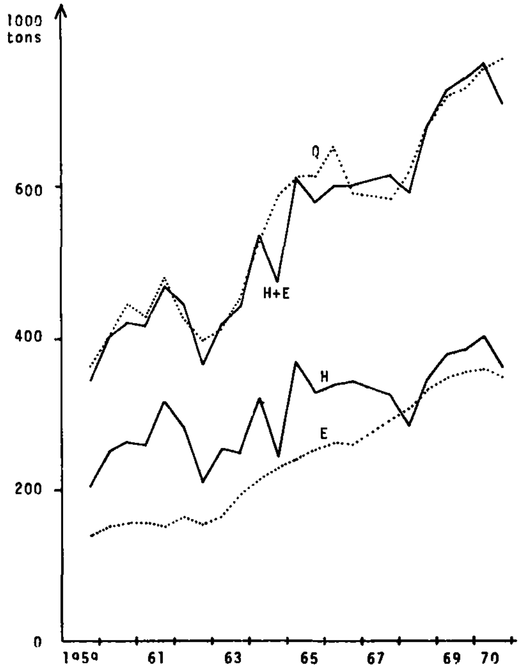


Fig. 16

steelworks of the ECSC.[1]) This suggests that the rise in the share of imports is matched by involuntary inventory increases by consumers. During 1969 and early 1970, Swedish consumers had placed very large orders abroad in relation to their immediate requirements owing not only to hedge buying and speculative considerations but also to a shortage of capacity in Sweden. In this way the current excess demand led to a rise

[1]) Although this variable proved of little consequence when estimating the import equations, the shortage in 1969 appears to have been more acute than delivery time data suggest. If the steel works stop receiving new orders when their delivery times have reached a certain length, the ratio *UO/K* will underestimate the real excess demand as expressed in the time the consumers have to wait for an order to be effectuated. This was no doubt the case during the boom 1969—70.

Year	NOE/NO %	NOET %	NOHT %
1964 1	23.0	12	5
2	21.3	-2	4
1965 1	21.5	-4	3
2	16.7	-32	2
1966 1	23.3	-8	-7
2	26.9	10	-6
1967 1	29.7	17	-11
2	27.7	11	-5
1968 1	28.7	15	-4
2	27.6	23	10
1969 1	24.4	4	13
2	23.0	-5	14
1970 1	25.7	-10	-5
2	25.7	-15	-8
1971 1	30.3	5	-9
2	25.9	-12	-1
1972 1	30.8	10	-3

NO new orders
NOE new orders from export markets
NOH new orders from the homemarket
NOET } deviations from
NOHT } a linear trend

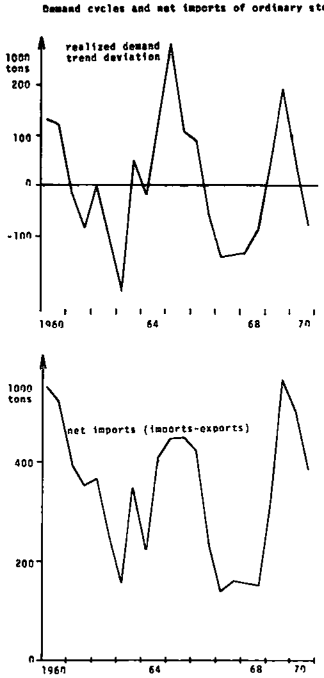


Fig. 17

in consumers' outstanding orders. The market situation soon changed. Delivery periods diminished, as did the consumers' outstanding orders. The Swedish steelworks now had difficulty in finding sales on the home market and they had very small prospects of rapidly supplanting imports.

Exports of ordinary steels show like home market deliveries a markedly cyclical growth. However, the two series are differently phased so that their sum, the total deliveries of the o-works, have a relatively high stability. As will be shown later on, the export fluctuations do not coincide with the demand fluctuations in the international steel market, a fact which supports the idea of the production smoothing being a result of conscious marketing policy by the o-works.

The inverse relationship between export and home market supply by the o-works is still more evident in the orderdata, its natural consequence being big fluctuations in the share of export orders in their total new orders. See table 2.

This kind of high capacity utilization export policy has obviously made the o-works less flexible in their ability to adjust their deliveries to a sudden increase in home market demand. This has, as we have seen, given imports a certain lead to home market deliveries.

The fact that imports of ordinary steel came to operate as a shock absorber during fluctuations in demand at the same time as o-works to a certain extent resorted to exports with a view to stabilizing their output resulted in heavy cyclical fluctuations in the balance of trade in the sector for ordinary steel. The accompanying figure reveals a very high correlation between demand situation, here defined as the trend deviation in deliveries to consumers $(M + H)$ and net imports. This relation implies that deliveries to the home market can be seen as a function of exports and time or, which is perhaps more in line with the causal chain, that exports are linearly dependent on home market deliveries and time. Thus deliveries by o-works would appear to be a linear function of time.[1])

[1]) The relation $D_t - a_0 - a_1 \cdot t = b_0 + b_1(M - E)_t + \epsilon_t$ implies the relation

$H_t = a_0 + b_0 + (b_1 - 1)\, M_t + b_1 \cdot E_t + a_1 \cdot t + \epsilon_t$, which if $b_1 = 1$ and $b_0 = 0$ are reduced to

$H_t = a_0 - E_t + a_1 \cdot t + \epsilon_t$ or

$H_t + E_t = a_0 + a_1 \cdot t + \epsilon_t$

a_0, a_1, b_0 and b_1 are constants. ϵ is a random variable with a mean value of 0.

4.4.3. The role of inventories and order backlogs in the long run and in the short. We estabilished earlier that exports were used by the o-works as an output stabilizing variable. One consequence of this policy, the aim of which is a high utilization of capacity, is of course a certain lag in adjusting to the demand situation on the home market. No such policy could be discerned in the case of the s-works. Since the two groups produce both to order and for stock, they can use variations in backlogs of orders as well as in inventories to stabilize their output.

Variations in order backlogs are shown in figure 18. As one might expect, these fluctuations are far greater at s-works than at o-works. The heavy competitions from imports encountered by the latter throughout the period in question gives them less chance of varying their order backlogs. The s-works, by contrast, have to a striking extent made their order backlogs serve as stabilizers of output in relation to demand. Clearly these works have run less risk than the o-works of losing customers as a result of such a policy.

Since the output of the o-works has fluctuated far more than that of the s-works, delivery periods have undergone much the same development in both groups in spite of difference in the short-term development of order backlogs. The declining trend observable for this quantity reflects the transformation of the steel market from a seller's to a buyer's market. This transformation has also influenced the inventory holding of different entrepreneurial categories. Whereas the duration of consumer's stocks of steel had fallen from 6 months to between 2 and 3 months by the end of the 1960s, the duration of stocks of finished products at steelworks had risen from 1 to 1 1/2 months. Thus the "responsibility" for maintaining stocks has been transferred from buyers to sellers.

As regards cyclical variations in inventory increases, greater tendencies towards an evening out of production have been particularly in evidence at the o-works. This is obviously the case with the 1967 recession and the subsequent period of expansion. During the latest recession too, the role of inventory investment in stabilizing output is unmistakeable. Here too we are probably faced with a conscious production policy. Inventory increases during recessions and inventory reductions during booms in the Swedish steel market are too persistent to be dismissed as involuntary inventory changes. We shall study these fluctuations in more exacts terms in the following section.

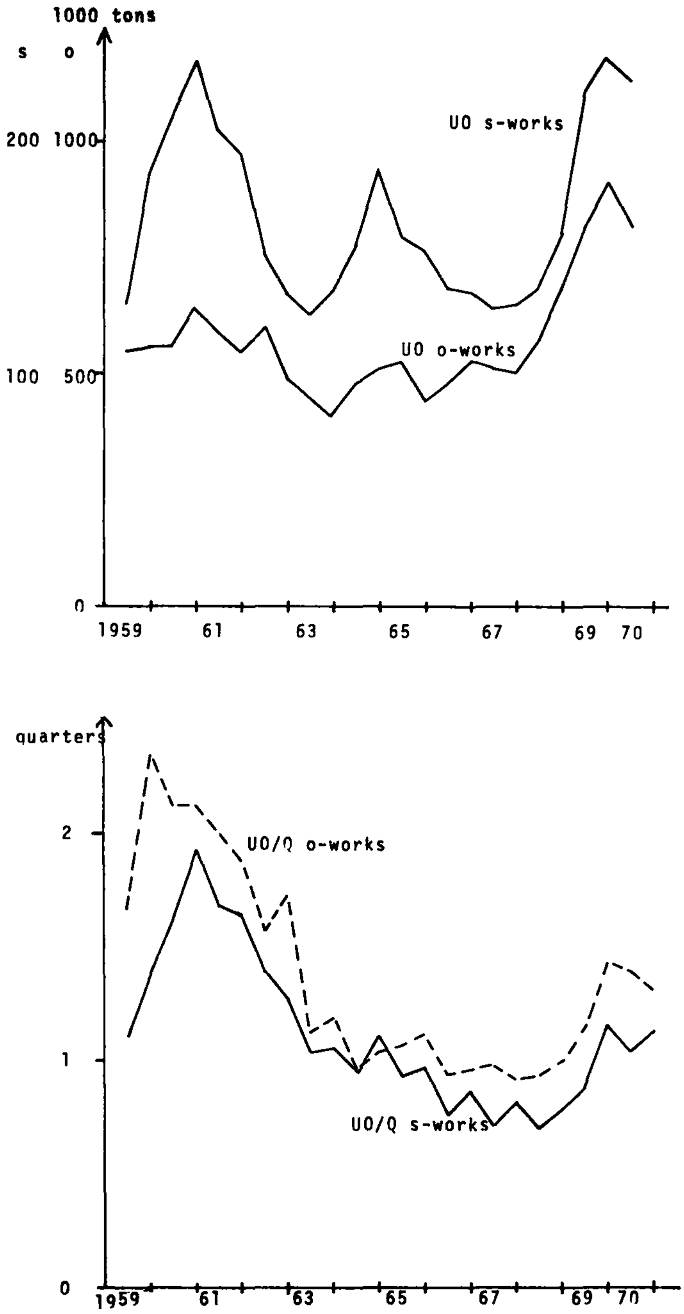

1000 tons
s o
200 1000
100 500
0
UO s-works
UO o-works
1959
61
63
65
67
69 70
quarters
2
1
0
UO/Q o-works
UO/Q s-works

Fig. 18

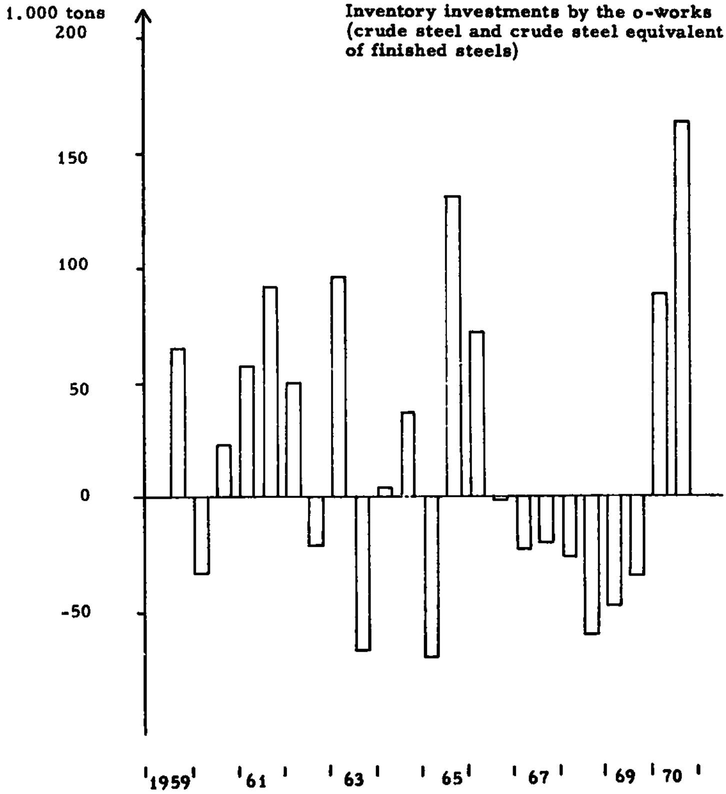


Fig. 19a

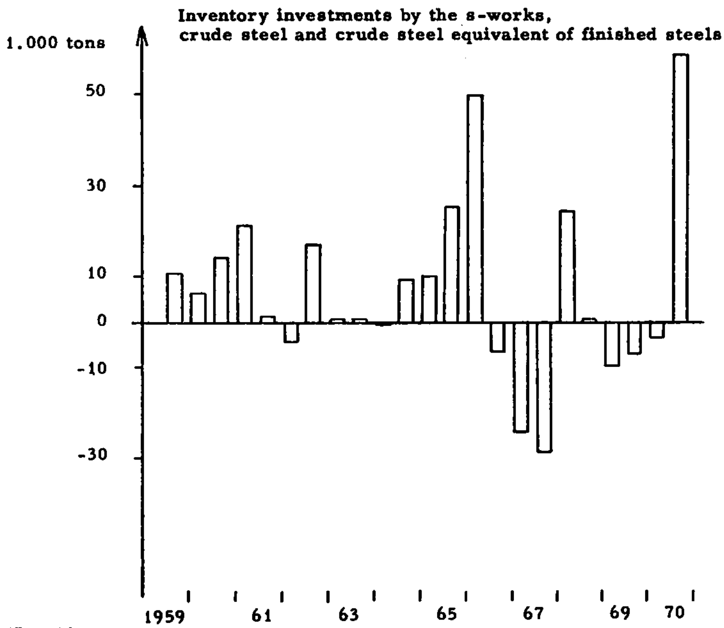


Fig. 19b

4.5. An econometric approach to the study of the short-term market behaviour of steelworks

4.5.1. **The general approach.** In section 4.4. we tried by means of empirical analysis of a speculative nature to find characteristic properties in the short-term markering policy of steelworks. We were particularly concerned with differences in the behaviour of o-works and s-works which according to our hypotheses were to be expected in view of the different market situations of these two kinds of steelworks. This section will be devoted to a short econometric analysis of the determination of output and deliveries. The principal aim of this analysis is to provide a more exact idea of the way in which deliveries by s-works and o-works, together with their inventory investments and output, are affected by the Swedish and international trade cycle at a given output capacity. The relations to be studied are illustrated in the following arrow diagram.

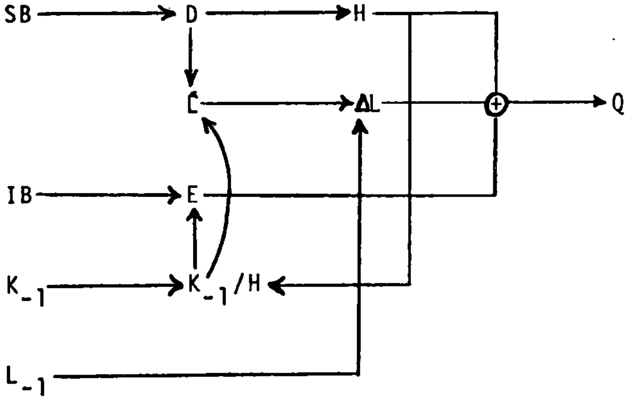


Fig. 20

The scheme may make a "mechanical" impression, but we shall give it a decision theoretic interpretation.

The firms, in planning their production, start with a judgement of trends in home market demand. Steel demand in other countries will affect the export demand with the Swedish steelworks, but in the case of exports the works are not only demand adjusters. They also try to place part of their estimated excess capacity on the international market. Hence, exports are negatively dependent on home market demand.

The stocks of finished steel held by the steelworks are regarded to be primarily intended for deliveries to Swedish consumers. Equilibrium stocks are consequently a function of expected home market demand. In addition to their sales function, the inventories may also be assumed to be used as output stabilizers. They are thus also thought of as being affected by the capacity situation, in the scheme expressed by the ratio K_{-1}/H.

By definition, planned output is equal to planned deliveries plus planned inventory increase. If we assume that output plans will always be realized, deviations between planned and actual deliveries will result in unplanned or involuntary changes in inventories. Big overestimates of demand will also very likely cause a decrease in order backlogs and in potential delivery times (UO/K). Hence, involuntary inventory increases and increases in delivery times will tend to be negatively correlated.

Expressed in equations this general system may have the following appearance. For reasons previously stated we shall only make use of a logarithmically linear version. We shall regard the case where the difference between planned and actual deliveries can be described by a stochastic variable with zero mean.

If we denote demand for steel in Sweden by DS and international steel demand by DI we can state the following equations for homemarket deliveries and exports respectively:

$$H = A_1 (DS)^{\alpha} e^{\epsilon_1} \qquad 11.$$

$$E = A_2 (DI)^{\beta_1} (K/H)^{\beta_2} e^{\epsilon_2} \qquad 12.$$

We shall for the inventory investment relation make use of the modified equilibrium stock adjustment model which was presented in Part III. Thus, we shall distinguish between the *equilibrium* level (L^*) of inventories at a certain point of time and the *desired* level (L^{**}) at a later point of time. The latter quantity is determined by the ratio L^*/L_{-1} and the adjustment speed, which here will be expressed in a similar way to that used in Part III[1]). By definition inventory investment during a period of time can be written

$$\Delta L = (L/L_{-1})L_{-1} - L_{-1} = (L/L_{-1} - 1)L_{-1}$$

We also have the following identity

$$L/L_{-1} = (L/L^{**})\,(L^{**}/L_{-1})$$

Due to our assumptions about involuntary inventory changes and about the adjustment to equilibrium, the first parenthesis is equal to one while the latter is

[1]) Cf. Part III page 160.

$$L^{**}/L_{-1} = (L^{*}/L_{-1})^{\lambda}; \quad 0 < \lambda \leqslant 1$$

If the equilibrium inventory can be expressed as

$$L^{*} = A_3 (DS)^{\gamma}$$

we will have the following equation for inventory investment

$$\Delta L = [(A_3 DS^{\gamma}/L_{-1})^{\lambda} - 1] L_{-1} e^{\epsilon_3} \qquad 13.$$

By using the identity

$$Q = H + E + \Delta L \qquad 14.$$

equations 11, 12 and 13 will provide us with a model for output. Given the level of demand, imports will automatically be determined in the system. This system shall be our point of departure when studying the short term market behaviour of the steel works. The equations will, however, be modified and we have every reason to believe that the two markets, the s-market and the o-market will differ in several respects.

4.5.2. Estimated structure and alternative formulations. Let us start with a preliminary estimate of equations 11, 12 and 13. As an indicator of demand for special steel we shall use the earlier defined variable $\hat{D}$ which is an estimate of planned purchases by the engineering industry. In this case the limitation to one group of consumers is of no significance since it covers practically all direct consumption of special steel. Ordinary steel is however consumed in other sectors as well, which will motivate our using total industrial production combined with a trend variable as a demand indicator in this sector. As a measure of international steel demand we shall try a weighted index of industrial production in different countries (IE), the weights being the percentage share of each country in total Swedish exports.

We shall change the inventory investment equation in one respect, namely as regards the assumption that $L = L^{**}$. Here we will try the hypothesis that the ratio of actual inventory to desired inventory level is a negative function of relative change in delivery times, the latter quantity being indicated by $((UO/K_{-1})/(UO_{-1}/K_{-2}))$, so

$$L/L^{**} = A_4 [(UO/K_{-1})/(UO_{-1}/K_{-2})]^{\gamma_2}.$$

We shall return to a discussion of the implications of this assumption.

By estimations made on *non*-seasonally adjusted half yearly data covering the period 1960: I—1970: I, we obtained the following structures:

Special steel

$$\log \hat{H} = -0.202 + \underset{(0.103)}{0.744} \log \hat{D} + \underset{(0.015)}{0.068}\, SED; \qquad 11.s$$

$$R = 0.920;\; DW = 2.02$$

$$\log \hat{E} = -4.899 + \underset{(0.078)}{1.786} \log IE + \underset{(0.011)}{0.026}\, SED; \qquad 12.s$$

$$R = 0.982;\; DW = 0.88$$

$$\begin{aligned} \Delta\log \hat{L} &= 0.017 + \underset{(0.111)}{0.306} \log \hat{D} - \underset{(0.105)}{0.367} \log L_{-1} \qquad 13.s \\ &- \underset{(0.109)}{0.314} \Delta\log UO/K_{-1} - \underset{(0.014)}{0.037}\, SED \end{aligned}$$

$$R = 0.717;\; DW = 1.59$$

Ordinary steel

$$\log \hat{H} = -0.692 + \underset{(0.649}{1.926} \log I - \underset{(0.009)}{0.018}\, t + \underset{(0.012)}{0.031}\, SED \qquad 11.o$$

$$R = 0.912;\; DW = 2.25$$

$$\begin{aligned} \log \hat{E} &= -3.464 + \underset{(0{,}264}{1.588}\, IE + \underset{(0.447)}{0.514} \log (K_{-1}/\hat{H}) - \qquad 12.o \\ &- \underset{(0.030)}{0.047}\, SED \end{aligned}$$

$$R = 0.917;\; DW = 1.71$$

$$\begin{aligned} \Delta\log \hat{L} &= 0.319 + \underset{(0.124)}{0.410} \log I - \underset{(0.135)}{0.556} \log L_{-1} \qquad 13.o \\ &- \underset{(0.160)}{0.746} \Delta\log UO/K_{-1} \end{aligned}$$

$$R = 0.837;\; DW = 2.70$$

We shall now proceed to discuss the estimates of home market deliveries etc. At this point we shall also briefly comment upon our choice of measurements, make some modifications of the general model and point out some differences between the market for special steel and that for ordinary steel.

4.5.2.1. *Home market deliveries.* Our main hypothesis in estimating the home market equation has been that these are determined completely by total demand on the home market. In the case of special steel this is a natural approach since imports are negligible. As regards ordinary steel imports they are, as we have seen earlier, not only relatively large but also more fluctuating than total realized demand. Our basic assumption is here that home market deliveries of ordinary steel has a "constant cyclical relation" to total realized demand. With this term we will mean that

$$H/H^T = (S/S^T)^{\delta_1} \qquad 0 < \delta < 1$$

Here H^T and S^T represent trend values of H and S respectively. Now we have not used S as dependent variable. Because of estimation reason we have instead used an index of industrial production (I) as an instrumental variable. From Part II we know that relative trend deviation in S could be well explained by relative trend deviation in I, i.e.

$$S/S^T = (I/I^T)^{\delta_2}$$

By insertion in the relation above we get

$$H/H^T = (I/I^T)^{\delta_1 \delta_2}$$

The estimated coefficient is thus an estimate of the product $\delta_1\delta_2$. Via an estimate of δ_2 the coefficient δ_1 has been calculated to be approximately 0.80. This result tells us that the average deviation in H around its mean has been 20 percent lower than the corresponding value for S.

Contrary to our expectations, the industrial production index and time perform equally well as $\hat{D}$ in the H-equation for special steel:

$$\log H = -\ 5.667 + \underset{(0.792)}{2.790} \log I - \underset{(0.011)}{0.030} \cdot t + \underset{(0.015)}{0.066}\, SED \qquad \text{12.sl}$$

$$R = 0.933; \; DW = 1.70$$

Here the elasticity of H with respect to I is much bigger than in the former case. This is partly due to the fact that total realized demand for special steel has bigger fluctuations than that for ordinary steel, partly on the above mentioned buffer properties of ordinary steel imports.

We found earlier that price speculation seemed to be of some importance for imports. It was also argued that the share of imports in total demand should be a positive function of expected price increases. It is therefore natural to believe that an expected price increase should ccteris paribus reduce the rate of home market deliveries by the o-works or leave it unchanged. If we insert $\Delta^2 \log p$, using the same price index as in the import equations, into the H-relation, we will get a coefficient estimate slightly different from zero. But if we increase the lag by one quarter we will get an estimate of 0.285 (0.122). This elasticity is only slightly less than that estimated for imports. Since the difference in lags is quite in accordance with the observed difference in delivery times between Swedish and continental works, we must conclude that speculation activity affects the purchases from Swedish works to roughly the same degree as it affects imports. It must be added that all statements made about price speculation in this book is completely tied to our measures. Many people would perhaps deny that there is any relevant link between the variable $\Delta^2 \log p$ and the phenomenon of reality generally known as price speculation.[1])

Equation 11.o can also be modified by variables expressing the short term market flexibility of the o-works i.e. their ability to rapidly change the level of output and/or the export share of deliveries. The residuals of the equation accounted for are positively correlated with the level of inventories at the beginning of the period and negatively correlated with delivery times. These variables add, however, very little to the explanation of the historical performance of home market deliveries.

4.5.2.2. *Exports.* According to the export equations, exports of special steel can be quite adequately explained by foreign demand for steel measured by a weighted index of industrial output for different countries. But the DW value reveals an unacceptable autocorrelation in the residuals. The variable $K/\hat{H}$ has no significance whatsoever and has been omitted from the equation. Exports of ordinary steels seems also to be reasonably well explained by the international steel demand. Here we have signs of a certain influence of capacity available for exports. If we dig a little bit deeper into the matter we will find that exports by the o-works at least in terms of the cyclical variations have far more "push" than "pull" properties. Even if E and IE are positively correlated because they are

[1]) Price speculation seems to have played an unimportant role for demand and home market delivieries of special steels. This statement refers to the group as a whole. Of course, there might have been speculative purchases of the same relative degree as those for ordinary steels for certain products especially in the stainless steel sector, but we shall not go into such details here.

both characterized by a strong trend, the correlation between the detrended values of the variables is clearly negative.[1])

Let us consider another estimate:

$$\log E = -1.503 + \underset{(0.300)}{1.803} \log K_{-1} - \underset{(0.417)}{0.238} \log H_{-1} - \underset{(0.282)}{0.680} \Delta \log H_{-1} - \underset{(0.028)}{0.067}\, SED \qquad 12.\text{ol}$$

$$R = 0.959;\ DW = 1.52$$

This regression equation represents the push version and indicates that exports of ordinary steel have been determined by capacity and home market delivery tendencies. A 10 percent rise in the latter during a given period, all other things being equal, will cause exports to fall by 6 percent during the next period. The rise in deliveries to the home market arouses expectations of continuing successes at home, with the result that efforts are made to provide scope for these deliveries by reducing the less remunerative exports.

4.5.2.3. *Inventory investments*. The primary hypothesis for the equilibrium inventory, L^*, was that it was determined by demand on the home market. The sales from stocks made by steelworks concern mainly the home market. However, rapid changes in the volume of unfilled orders and delivery times have been taken to give rise to involuntary inventory changes, so that changes in delivery times should be included in the inventory investment equations. Significant coefficient estimates are also obtained for these variables in both equations. The occurrence of involuntary inventory changes of systematic nature causes us some logical problems. According to our basic assumption the delivery plans of firms are realized, which in econometrics means that the difference between plans and outcomes can be explained by a stochastic variable. We shall assume this to be the case with exports. Hence, home market deliveries must systematically deviate from the plans of firms. An assumption which fits into the picture is that during boom periods they will constantly produce too little to satisfy demand whereby they cause increases in delivery times and involuntary reductions of inventories.

We have on several occasions found support for our hypothesis that the o-works' output is primarily capacity determined.

[1]) The simple correlation between t and E is bigger than the correlation between IE and E.

As a logical consequence of this they should be expected to adjust their inventories with respect to capacity level.

Starting with the "almost classical" flexible accelerator model (its logarithmic version) with the equilibrium stock being a function of planned deliveries, which in turn are a function of productive capacity available at the planning moment, we get

$$L^{**} - L_{-1} = ((f(S^*)/L_{-1})^{\lambda} - 1)L_{-1}$$

$$S^* = g(K_{-1})$$

Put together with our hypothesis about involuntary inventory changes and applied on the same data as the earlier given equation this approach gives the following statistical relation:

$$\begin{aligned} \Delta\log \hat{L} = & - 0.270 + \underset{(0.123)}{0.468} \log K_{-1} - \underset{(0.142)}{0.671} \log L_{-1} - \\ & - \underset{(0.147)}{0.705}\Delta\log UO/K_{-1} \qquad \text{13.o1} \\ & R = 0.857;\; DW = 2.69 \end{aligned}$$

The capacity $\rightarrow$ equilibrium stock model gives a somewhat better description of past development than the one presented earlier. Thus we have found some support for the hypothesis that the o-works also use inventory investments as an output stabilizer.

4.5.3. Conclusions. According to our theory of the market behaviour of the o-works and the s-works, the former, being price-takers, should try to keep their capacity-utilization as high as possible while the output of the latter was bound to be very dependent of the demand variations. We had already found sup port for these hypotheses in a fairly loose analysis. Then we tried to give them a firmer precision by studying the determination of home market deliveries, exports and inventory investments with the two mentioned groups of firms. In each case and thus in the market behaviour as a whole we found relevant differences between the o-works and the s-works.

Firstly, the sensitivity of home market deliveries to fluctuations in industrial production is stronger with the latter than with the former. *Secondly*, the exports of special steel can be explained by an index of industrial production abroad whereas the exports of ordinary steel is "cyclically" insensitive to that quantity. Export deliveries by the o-works are instead determined by their productive capacity and by their expectations

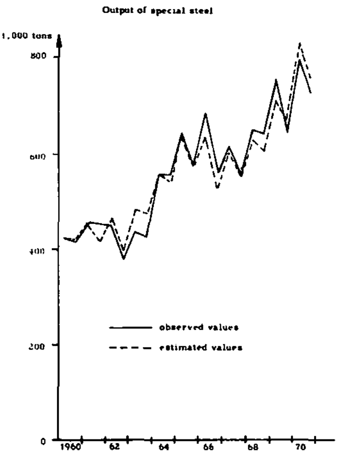


Fig. 21 a

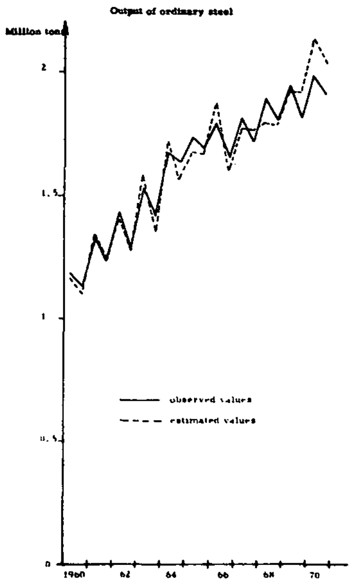


Fig. 21 b

about home market demand, the latter quantity being indicated by recent trends in their deliveries to Swedish customers. The high elasticity of exports with regard to capacity level reflects partly the rising export share of ordinary steel output, partly the fact that the o-works in order to fill a capacity gap of x percent need to increase their exports by roughly $3 \cdot x$ percent. *Thirdly*, the inventory increases are in the case of the s-works primarily dependent on the home market demand while they are used by the o-works to stabilize their production. This result should however be interpreted with some extra caution.

As showing the average behaviour during the sample period the regression equations do not take into account "structural" changes during that period. Those changes express themselves only in the goodness of fit tests. We spoke earlier about a learning process in inventory/production planning leading to a more contra-cyclical production stabilization policy. This seems in fact to have appeared in the special steel sector, as can be seen from the latest cycle, 1968—1972. Of course these tendencies towards "a new policy" could be dismissed as being incidental, but coupled together with policy statements from the executives of different firms they have to be taken seriously. It should also be pointed out that a few of the s-works have followed a markedly anticyclical policy during the whole sample period.

The estimates of home market deliveries, exports and inventory investments imply estimates of steel output. By using the identity

$$\hat{Q} = \hat{H} + \hat{E} + \Delta\hat{L}$$

we have got an indirect estimates of special and ordinary steel output.

For special steel the output estimate has been obtained by adding the estimates of its components given by equations 11.s1, 12.s and 13.s, while for ordinary steel we have taken the estimates from equations 11.o, 12.o1 and 13.o1. Acc. to these equations output of special steel is principally demand determined, whereas output of ordinary steel is essentially determined by production capacity. It should be stressed that this statement refers to cyclical variations. There are all reasons to believe that the growth of demand for ordinary steels in Sweden and other European countries has been a prerequisite of the capacity expansion at the o-works.

The "contra cyclical behaviour" of the o-works has appeared in three forms:

- Their home market shares have tended to increase in recessions and to decrease in boom periods.
- The trend deviation of their exports has especially during the last two cycles been negatively correlated with the trend deviation in the European steel demand.
- Inventory investments seem to be deliberately adjusted to the capacity-demand gap. "Involuntary" stock movements also appear to have a smoothing effect on output.

As may be seen from accompanying figures the residuals between observed and estimated values of output are surprisingly small. In view of the R-values of the relations estimated above, one might have expected greater deviations.

Of course the conditional standard error of $\hat{Q}$ must be less than the sum of those of its parts but so will also be the case with the standard deviation of Q in relation the sum of standard deviations of its components. We can therefore have no a priori idea about the value of $R(Q, \hat{Q})$. Now this coefficient is 0.970 for special steel and 0.955 for ordinary steel. The former indicator rises to 0.991 if we exclude the year 1963 in our calculation and the latter will be raised to 0.979 if we drop the last two observations. The R-values are in the case of special steel as well as in that of ordinary steel greater than the relevant weighted averages (see below) for the E, H and ΔL relations.

Let us examine this somewhat more carefully. Here we have estimated a variable by regression analysis of its components. In general terms we have one identity

$$y = \Sigma y_i \qquad i = 1, 2, \ldots, m;$$

and m regression equations

$$y_i = a + \Sigma b_{ij} x_j + \epsilon_i$$

Denote the variance of y_i and ϵ_i with $\sigma_i{}^2$ and $\mu_i{}^2$ respectively. Now the corresponding coefficients of determination can be written

$$R_i^2 = 1 - \frac{\mu_i^2}{\sigma_i^2}$$

which gives

$$\mu_i^2 = \sigma_i^2(1 - R_i^2)$$

If we add the different y_i estimates to get an estimate of y we will in the case of independence between the different y_i and between the different ϵ_i get a "total" R^2 of

$$1 - \frac{\mu^2}{\sigma^2} = \frac{\sum\sigma_i^2 - \sum\mu_i^2}{\sum\sigma_i^2} = \sum R_i^2 \frac{\sigma_i^2}{\sum\sigma_i^2}$$

Here the total coefficient of determination (and the correlation coefficient) is obviously equal to a weighted sum of corresponding coefficients of the regression equations. Since in our cases this equality does not hold true, there must be dependencies between the y_i and/or between the ϵ_i. We have now to expand the formula given above with the covariances of the variables and of the errors:

$$R^2 = 1 - \frac{\sum\sigma_i^2(1 - R_i^2) + \sum_r\sum_k \text{cov } \epsilon_r\epsilon_k}{\sum\sigma_i^2 + \sum\sum \text{cov } y_r y_k} \qquad r \neq k$$

As regards special steel output the R-value has been raised by a fairly strong positive covariation between exports and home market deliveries—caused by the "influence of time"—together with a slight negative sum of covariances in the residuals. Practically the same constellation implies for the output of ordinary steel. As may be seen from the figure there is a big negative error in the estimate of ordinary steel output for the upswing period 1969—70. This is due to the fact that the model does not contain other output restrictions than physical capacity. Hence it is not able to explain the sudden and unforeseen shortage of certain raw materials and electrical power.

Regarding special steel the model gives an overestimate of output in 1963. Here the main cause is the unableness of the equation for home market deliveries to explain the downturn in the demand for special steel during that year. Above all the indicators used, $\hat{D}$ and I, were too insensitive to the fall in fixed investment in the paper and pulp industry. Those outlays have a very strong effect on the demand for special steels, especially stainless steels.

The estimates of home market deliveries yield together with an estimate of realized demand an estimate of imports. Here we shall restrict ourselves to total yearly imports of the following reasons. Firstly special steel imports are too small during the sample period to be of any interest in this kind of analysis. Secondly, we have made no separate studies of total steel demand on half yearly data. We shall instead make use of those studies on yearly data with global models which were presented in Part II.

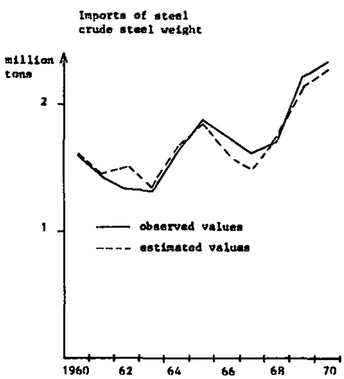


Fig. 22

Imports of steel will be estimated by using the following identity:

$$\hat{M} = \hat{S} - \hat{H}$$

$$\hat{S} = [\text{antilog}\,(1.4729 + \log I + 1.5823 \cdot \Delta\log I - 0.005103 \cdot t].$$
$$\cdot \overline{ACc}/\overline{AC}$$

$$\hat{H} = {}_s\hat{H} + {}_0\hat{H}$$

The estimate of realized demand is obtained from table 8d in Part II. Since this relation applied to purchases of finished steel and we are dealing with corresponding quantity in crude steel weight, the original estimate has been multiplied by the average ratio of apparent steel consumption in crude steel weight to apparent steel consumption in finished weight i.e. $\overline{ACc}/\overline{AC}$.[1]) The estimate of home market deliveries is the sum of the estimates given above for its two parts, i.e. deliveries of special and ordinary steel respectively. The estimate chosen for ${}_sH$ is that in which industrial production is the main independent variable. This means that imports are in this indirect estimate a function of the level of industrial production, the relative increase in that variable, and time, i.e. of the same arguments as in the import equations discussed in section 3.1. and there referred to as simple forecasting models. The only differences between this implied model and the direct ones in that section concern the estimation procedure and the functional form.[1])

As is evident from figure 22 the "general fit" is fairly good. The estimated imports show the same kind of variations as the observed imports. $R(M, \hat{M})$ is about 0.96 and $R(\Delta M, \Delta\hat{M})$ of the order 0.85. There is, however, a striking deviation both in direction of change and level for 1962—in relative terms about 15 per cent. This results mainly from an overestimate of H. On the other hand, a big overestimate of the same variable for the year 1970 is counterbalanced by an overestimate in S resulting in an almost exact estimate of M. In general the detrimental effect on R of S and H being strongly correlated has been outweighted by a positive and large covariance in the errors of corresponding regression equations. This is no coincidence, it follows from our model construction. Take for instance the case where we estimate the difference between two perfectly correlated variables by taking the difference between their estimates. Then if we use the same explanatory variables, we

[1]) We could, of course, have started with the estimates of apparent consumption of special and ordinary steel given in part II and from the sum of these variables subtract $\Delta\hat{L}$ (including merchants' inventory investments) and $\hat{H}$. This procedure is however more odd than it seems to be at first sight. The model formulations given in Part II were primarily aimed at explaining demand or realized purchases. As is seen from those studies and has been confirmed in this chapter, the arguments in those demand equations contributed little or nothing to explain the difference between apparent consumption and realized purchases, i.e. the steel inventory investment by steel works and merchants.

[1]) Here the import equation is of the general type:

$$M = \underbrace{A_1 I^{\alpha_1}(I/I_1)^{\beta_1} e^{\gamma_1 t}}_{\hat{S}} - \underbrace{A_2 I^{\alpha_2} e^{\gamma_2 t}}_{{}_0\hat{H}} - \underbrace{A_3 I^{\alpha_3} e^{\gamma_3 t}}_{{}_s\hat{H}}$$

will always get a perfect estimate of the difference, no matter what explanatory variables we use. In our case there is of course no perfect correlation between S and H—the systematic variations in $(S—H)$ has been observed and examined—and the S_t equation contains one additional variable to those in the H equations, but nevertheless we have to admit that the good fit for 1970 was obtained by mistake. In order to study imports more carefully we have to go back to the more detailed import models discussed in sections 3.2 and 3.3.

5. A short note on the activity of stockholding steel merchants

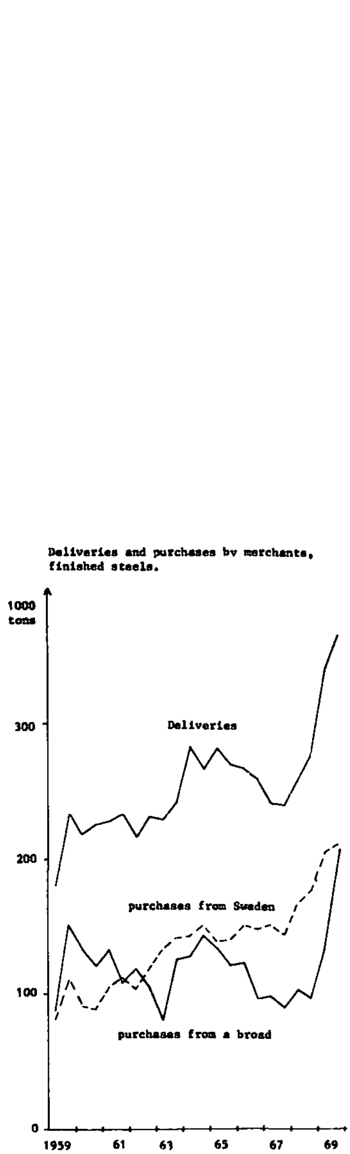


Fig. 23

So far we have avoided any closer consideration of merchants' activities. No such consideration was needed for our analysis of the main outlines of the development of supply and demand in the Swedish steel market. As middlemen, however, merchants play an important part in the market and of course may thus contribute to the special cyclical character which we have been able to observe in the allocation of demand between imported and Swedish products.

Merchants in the Swedish market occupy two distinct roles, namely those of the *middleman* and *stockist* respectively. In the present connection we shall concentrate on the latter of these roles, which means that the only form of activity considered here will be that of deliveries from merchants' stocks.

The basic features of this activity are outlined in figure 23, which indicates that merchants' activities are pre-eminently dominated by strong cyclical fluctuations. As regards purchases, one notes that merchants permit their imports to vary far more than their purchases from Swedish steelworks.

As will be seen from the accompanying table, the growth rate of merchant's activities has been lower than the growth rate of total demand for steel in Sweden. This means that total purchases by merchants from foreign and Swedish steelworks have grown slower than demand. This can probably be put down to the increasing concentration of the engineering and building industries, which has probably confined an increasing proportion of steel consumption to firms who by virtue of their size have considered themselves in a position to act as their own merchants. At the same time, however, particularly in recent years, Swedish steelworks have tended more and more to market their output via merchants, as witness among other things the great difference between the annual growth rate of merchants' purchases from Sweden and that of their imports.

	growth rate per cent per year	trend deviation
deliveries to consumers	3.6	9.2
purchases from Swedish works	7.0	8.8
purchases from abroad	— 0.0	21.0

note: The growth rates, obtained from least square estimates of exponential trend curves, refer to the period 1959—69. The trend deviations are the standard deviations, expressed as percentages, from those trend curves. All calculations are made from half-yearly data.

In order to arrive at a clearer understanding of merchants' activities, a broad econometric analysis will here be made of their sales, purchases and inventory investments, following roughly the same lines as in the preceding study of steelworks.

The subsystem of the steel market with which we are here concerned incorporates 4 endogenous variables, namely deliveries by merchants (${}_mS$), their purchases from abroad (${}_aJ$), their purchases from Sweden (${}_sJ$) and their inventory investments ($\Delta_m L$). As a consequence of the identity

$$ {}_mS = {}_sJ + {}_aJ - \Delta_m L $$

the number of structural equations will be limited to three; one equation is redundant. Since purchases from Sweden (${}_sJ$) appear somewhat less interesting than the other variables from the cyclical point of view, we have preferred to let them be analysed "indirectly", i.e. through the analysis of the other variables. We thus obtain the following estimate of purchases from Sweden

$$ {}_s\hat{J} = {}_m\hat{S} - {}_a\hat{J} + \Delta_m \hat{L} $$

As regards the specification of the predetermined variables (exogenous and lagged endogenous variables respectively) we shall regard deliveries as a function of total steel demand in Sweden. Deliveries can also be affected, however, by the size of stocks of finished goods at steelworks. The greater these are the more competition merchants will have to face from steelworks in the short run. The demand situation will also be assumed to play an important part in the determination of equilibrium and of purchases from abroad. In both these cases, however, price speculation is extremely likely to play an important part, for in our study of consumers' inventory investments and total imports, we found a certain element of speculation. The current supposition is that professional speculators are involved here. It is also probable that all kinds of hedge buying involve imported material. Seen from the merchants' point of view, world market supply is probably far more flexible than that of the Swedish steelworks. Merchants' imports can therefore be regarded as a function of their inventory investments.

The last hypothesis gives rise to some well-known problems of estimation. To solve these problems we can begin by estimating the equation for inventory investments. We can then insert the estimate for this quantity as an independent variable in the equation for purchases abroad. Like the market models for steelworks, the equations in the present system are estimated on the basis of non seasonally adjusted half-yearly data. The following results were obtained for the period 1959: I—1969: II

$$\log {}_m\hat{S} = \underset{}{0.1395} + \underset{(0.1219)}{0.3629} \log \hat{D}_{+1/2} + \underset{(0.2067)}{0.5097} \log \hat{D}_{-1/2} - \underset{(0.0755)}{0.1312} \log {}_oL_{-1}$$

$$R = 0.932;\ DW\ 1.77$$

$$\Delta\log {}_m\hat{L} = -0.5714 + \underset{(0.3204)}{0.6921} \log \hat{D} + \underset{(0.2053)}{0.6218}\, \Delta\log P_{-1/2} - \underset{(0.0032)}{0.0057} \cdot t - \underset{(0.1816)}{0.6699} \log L_{-1}$$

$$R = 0.876;\ DW\ 2.40$$

$$\log {}_a\hat{J} = -1.2225 + \underset{(0.3476)}{1.1359} \log \hat{D}_{+1/2} + \underset{(0.0412)}{1.2470}\, \Delta\log {}_m\hat{L} - \underset{(0.0040)}{0.0147} \cdot t + \underset{(0.0191)}{0.0412}\, SED$$

$$R = 0.921;\ DW\ 1.10$$

Firstly we can establish that the generally formulated hypotheses concerning merchants' behaviour in the relevant respects are borne out by the estimated relations, although the explanatory value in R terms may perhaps be thought to be low. It should however be borne in mind that we are not concerned here with series dominated by a linear trend but with quantities whose values exhibit heavy fluctuations. It should also be reported that in one single case have we obtained significant

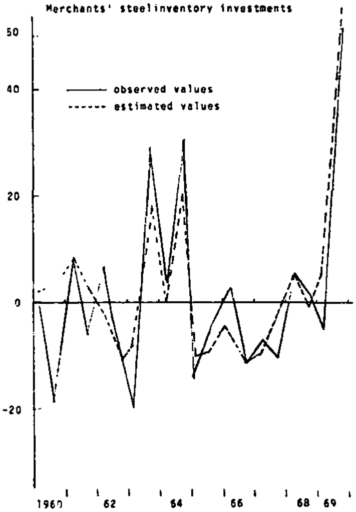


Fig. 24

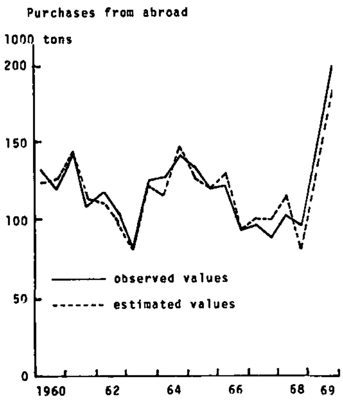


Fig. 25

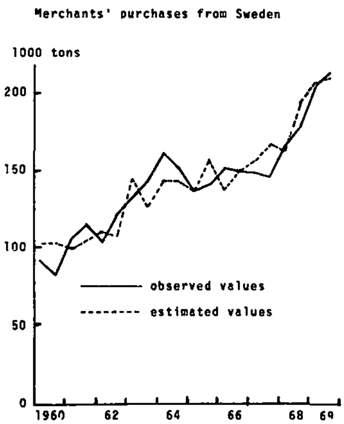


Fig. 26

coefficient estimates for a dummy variable explaining possible seasonal variations of residuals.

The equations for deliveries and purchases reveal a characteristic trait of merchants' activities, namely that they constitute a leading indicator of the general business cycle. We have already established that deliveries of steel are more than a quarter ahead of industrial output. Here we can establish that deliveries by merchants during period t are more correlated with demand at $t + 1/2$ than with demand at t, which is undeniably somewhat remarkable. In other words merchants appear to deliver steel before it is in demand. This can probably be explained by the rigidity of our indicator of demand, which, as we saw earlier, is based on forecasts made by firms themselves. These assessments, however, correlate well with recent tendencies of demand, with the result that the indicator used tends to reflect demand during the preceding period. If we use the variable $\hat{D}$ as an indicator of demand in the equation for ${}_mS$, we obtain a coefficient estimate of 0.859 (0.104), a R value of 0.91 and a DW value of 1.51. The coefficient estimate for log ${}_oL_{-1}$ remains practically unchanged. The lead character of merchants' deliveries is reflected by the fact that their timing coincides with orders from Swedish purchasers to o-works.

In our construction of inventory investment models we have employed the same equilibrium stock adjustment approach as in earlier sections. Here we have obtained clearer evidence of price speculation than in any of the preceding cases. The price elasticity of speculation is of the order of one.[1]) The disposition to speculation is apparently still more pronounced in the case of imports. This is at least suggested by the fact that its elasticity with respect to L/L_{-1} is larger than one. Since the cyclical variations in the latter variable are very much due to changes in the rate of increase in prices, we might conclude, keeping all qualifications in mind, that price expectations affect not only inventory fluctuations but also the allocation of deliveries between foreign and Swedish steel.

Both the inventory and purchasing equations include a trend term. Thus we have not tried to explain the long-term development in these variables. Inserting time as an independent variable in the equation for deliveries we obtain completely insignificant coefficient estimates, even if the variable ${}_0L_{-1}$, steel stocks held by the o-works, which serves partly as a trend variable, is eliminated. On the other hand we

[1]) This elasticity is the structural coefficient of $\Delta \log P_{-1/2}$. The estimate of this coefficient is 0.6218/0.6699 = 0.9282.

can very well let the last-mentioned quantity replace time in the inventory investments and purchasing equations. These results suggest that the transformation of the steel market from a seller's to a buyer's market has affected the whole range of merchant activities. Not only does it seem in relative terms to have reduced the level of activities and with it stockholding, it also appears to have contributed to the stagnation and somewhat declining trend of merchants' imports. At the same time as the growing excess capacity that existed in the steel industry during the greater part of the 1960s brought about shorter delivery periods and a relatively smaller need for stockholding merchants it also facilitated closer co-operation between merchants and Swedish manufacturers who at least during the initial stage of the transformation of the market situation were probably less commercially trained than the former.

The estimates of purchases from Sweden and from abroad are shown in two accompanying figures. According to the curves we have been more successful in explaining "essential" variations in the latter than in the former variable. The indirect estimate of purchases from Swedish producers is not especially good as regards cyclical variations, a result which is almost completely due to a corresponding inability of the equation for deliveries. It must be admitted that if we look deeper into the recent history of the Swedish steelmerchants we will find such structural changes which not only ought to have influenced the long-term trend of deliveries etc. but most likely also their cyclical appearance.

6. Summary

The principal aim of this essay was to study short term or cyclical variations in the composition of supply with regard to imports and home market deliveries, the last term being defined as realized supply on the Swedish market by the Swedish steelworks. The study was divided into two parts of which the first dealed with a direct analysis of imports and the second comprehended an examination of the short term market behaviour of the Swedish steel producers, which were split up into two groups, the o-works and the s-works respectively.

In the direct study of imports the analysis was concentrated to an allocation function, describing the allocation of demand for such steel which was supplied by both foreign and Swedish steel producers; both demand for typical Swedish steel and for typical imported steel were assumed to grow proportionally to total steel demand. Two main hypotheses were put forward to explain the variations in the import share of total steel demand:

- variations in the time the buyers have to wait for an order to be effecuated by Swedish works in relation to the time elapsing between orders and deliveries with relevant foreign suppliers, i.e. the relative delivery time, and
- variations in expected price increases.

The influence of price expectations on the import share has its origin in differences between Swedish and foreign suppliers as regards pricing. The former charged as a rule the price at the delivery date, while the latter applied the current price of the order day. If this observation on pricing rules was correct, it should be profitable for consumers and merchants to switch between the two groups of suppliers according to changes in price expectation.

We tried to test these hypotheses on non-seasonally adjusted half-yearly data for the period 1960: I—1970: I. Two regression equations were presented, the first one expressing imports as a function of total demand, delivery times etc and the second one having the ratio *imports/total deliveries* as dependent variable.

It was found that imports were sensitive to variations in the *capacity/demand* ratio. This variable was regarded as a proxy indicator of the delivery flexibility of the Swedish steel works. The introduction of corresponding indicator for the ECSC contributed practically nothing to the explanation of the variations in Swedish steel imports. The fact that the *capacity/demand* situation with the largest group of foreign suppliers to the Swedish steel market does not affect imports is of course surprising. It was suggested that this circumstance at least to some part had to do with the intimate business connections between Swedish buyers and continental suppliers prevailing since long ago. This relationship has made it relatively easy for Swedish buyers to rapidly get their demands satisfied even during boom periods. In this context it is worth remembering that Swedish imports is very small in comparison with the total steel production within the ECSC.

In the equation explaining the import share, M/S', the relative increase in actual delivery times (UO/Q) has a positive effect on the dependent variable. Even if the elasticity in question is only of the order 0.20, the changes in delivery times are often so big that they produce considerable changes in the import share. The intention behind our bringing the variable $\Delta \log (UO/Q)$ into the picture was to get an idea about the size of involuntary purchases, which if planned and actual consumption are always equal appear as involuntary inventory increases. All other things being equal a decrease in delivery times at the Swedish steelworks will raise the actual purchases above the planned purchases. This will raise the denominator in the ratio M/S since all additional deliveries can be attributed to home market deliveries.

As regards our hypothesis about price speculation we obtained an elasticity of imports with respect to the relative change in expected price increases as measured by $\Delta^2 \log P_{-1/2}$, P being the merchants' quotations for ordinary bars, of the order 0.35. Having used an estimate of total demand this elasticity should refer to the choice between Swedish and foreign suppliers and not to the total speculative stock increases.[1]) But when looking at the second estimate, $(M\hat{/}S)$, we can see that the elasticity has diminished to 0.12 whereby the standard deviation of the coefficient has become practically as big as its mean. This change could of course be dismissed as a consequence of our loosing control over *demand properties* of imports when dividing it by total deliveries. Later on we found however that also the homemarket deliveries of the ordinary steel producers, the o-works, had a corresponding price elasticity of 0.28. Now it seems after all as if the price speculation influence on imports concerns inventory increases and only to a fairly small degree the composition of purchases on Swedish and imported steel resepctively.

In the cited study by Lennart Fridén relative prices as such enter the import equations for different regions. The reason why this variable, relevant in most economic studies, has been omitted here is that the prices of ordinary steels very tightly follow the world market price. Hence the relative price of import is, with the mentioned exception, very stable.

The share of imports corresponds inversely to that of home market deliveries. This means that our statements on imports contain statements about home market deliveries. In the next sections we reversed the process. By studying the short term or cyclical marketing policy of the steelworks we also came to conclusions on imports. The implicit import model was however a comparatively simple one and contained only industrial production its relative change over time and time as independent variables.

Instead we put our main interest in this section to the characteristic behaviour in general of steel works in different phases of the business cycle. We tried especially to compare the o-works and the s-works in this respect. These two groups of firms are in essentially different market situations, the former acting as price takers and the latter being typical oligopolists. We found that pricing was rigid but output very flexible at the s-works, while the pricing and output of the o-works had the opposite properties. Since they were relatively big in their markets the output of the s-works had to follow the variations of demand, even if they used their order backlogs as buffers. The o-works used both exports and inventory changes as means in

[1]) The *D*-estimate does not contain a price speculation variable. In Part III we could not find any such effect by using the so-called indirect method. When we studied the inventory investment of consumers directly we found however evidence of price speculation even if it seemed to be small.

"fighting the business cycle". It seemed however that they had to pay the price of being inflexible during the early upswings as regards deliveries to the home market.

Since exports no doubt mean in general not higher prices but higher costs than home market deliveries, this behaviour may have been detrimental to profitability.

The market model was also given an econometrical approach which has already been summarized in section 4.5.3.

Finally we paid attention to the activity of merchants. Here we concentrated the study on their "sales over stock". Even if this forms a very small part of total deliveries, the fluctuations in their purchases from abroad are so large that they clearly influence the cyclical pattern of imports. Here we found very clear support for our price speculation hypothesis. The elasticity of equilibrium stock to expected price changes was almost one and estimated stock changes played a dominant role in the equation for merchants' imports. As regards total purchases of merchants there has been a trend towards an increasing share of the purchases from the home market, resulting in a long term stagnation of their imports.

Epilogue

In three separate parts we have studied different aspects of growth and cyclical behaviour of different quantities in the Swedish steel market. Our main general problem was to answer the question why the steel market in Sweden like those in other parts of the western world had shown such a markedly cyclical behaviour, though the economy as a whole had been characterized by an uninterrupted and, in the light of the inter-warperiod, relatively stable growth. Furthermore, we were particularly interested in how demand cycles spread through the steel sector and especially how they affected the short term marketing policy of steel producers. The last task seemed a priori to be of great interest for the analysis of foreign trade fluctuations.

The first two analytical parts were devoted to a demand analysis where interest focused on the dynamic properties of steel consumption and investments in steel inventories by consumers. The last part dealt with problems of supply, especially the dependence of imports on the marketing policy by firms—producers and merchants. The conclusions have been summarized at the end of each part and will not be repeated here. Instead we shall try to put the main pieces together in order to give a qualitative picture of the steel market in upswings and downturns. But let us just make some concluding remarks concerning methodology.

In the analytical parts the sequence of analysis has been the following:

General formulation of a theory → search for statistical measures of the quantities in that theory → specification of a model → estimation of parameter values of that model.

This means that our analysis resulted in numerically specified models, which in most cases are dynamic. If we now reverse the process of analysis we get an explanation of the past in terms of our original theory. Some people may accept the covariations between the variables in question and the estimated equations as facts but deny their supporting our basic theories. Others may claim that we have failed in our second step, i.e. in defining the relation between the theoretical concepts and the data. They can for instance argue that our rejection of the hypothesis of price speculation being very important in the Swedish steel market is a mere result of our failure to measuring the quantities creating speculation.

The argument against the *first* attitude is the following: The basic theoretical frames chosen here are such which have been successfully attempted in other studies and therefore have seemed to have fair chances of being powerful in steel market studies in future.

The *second* attitude may of course be very realistic. Lack of correspondence between variables of the theoretical model and variables of its statistical version is a source of over-generalized or completely erroneous conclusions. Here we have tried to be modest in our conclusions but sometimes we have made inferences from data to theoretical concepts without having specified the rules of inference. We have for instance "believed" in our measures of production plans and drawn conclusions accordingly.

In spite of all these possible objections concerning the different steps of analysis, the reader has nevertheless to accept the whole chain of analysis in order to find our explanation of the past and our inference from the past to the future adequate. Of course this does not mean that he must agree with all details in the analysis, but that he consents to our general approach of combining facts as they appear in data with a specified theoretical framework.

In the introductory part we asked ourselves how classic cycles, i.e. cycles with recurring absolute decreases in the variables in question, could occur in economies the total production of which appears to be growing at a fairly steady rate. It was found that fluctuations in steel consumption were created by variations in investments in goods in process and by changes in the product composition of sectors. Furthermore, these kinds of fluctuations could be explained in small models containing *GNP* and its changes, or alternatively industrial production and its changes. Through accelerator effects small variations in *GNP* or industrial production are transformed into heavy fluctuations in steel consumption. The strength of this accelerator effect is therefore a main cause of small growth cycles in the aggregates being followed by classic cycles in steel consumption. Because of those effects steel consumption has become a leading indicator in the business cycle.

A change in demand for consumer durables, fixed investments etc. appears in the engineering industry as a change in the rate of new orders. New orders affect the production plans of the firms. Now the transformation from new orders to production plans as they are measured in this study, involves a stabilization. Actual output is also stabilized in relation to planned output through variations in goods in process. Since steel input during a period equals steel in output plus steel in investments in goods in process, steel consumption will behave in roughly the same way as the planned output of the steel consumers.

Steel inventory investments by consumers are positive functions of the change in planned output (or of the change in new orders) and to some degree of the increase in the rate of change in prices. This means that total steel purchases by consumers, i.e. steel consumption plus their steel inventory investments, will oscillate around steel consumption. Consequently steel purchases, the purpose of which is to make output of cars, machines, ships etc. possible, have as regards cyclical behaviour very different properties from those of the output of these products.

Thus the chain

new orders → *planned output* → *realized output*

is affected by a stabilizing mechanism, while the chain

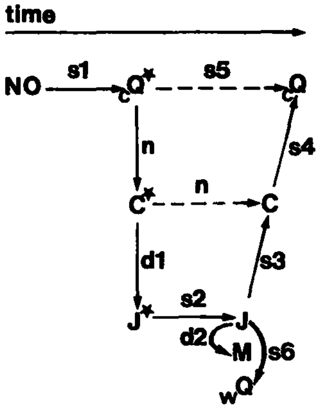
planned output → *steel purchases*

has the opposite property; the relation is destabilizing.

As regards the relation *steel demand* → *output of steel* the producers of ordinary steel, the o-works, act as to stabilize output.

By combining increases in exports, in inventory investments and in market shares in Sweden they compensate downswings in domestic demand, the obvious result being a high and a comparatively stable degree of capacity utilization. One further consequence of this kind of cyclical marketing policy is a fluctuating import share.

There is no similar mechanism in the market for special steel. Here producers, the s-works, do not even out fluctuations in domestic demand by increasing their exports etc. As in the case of o-works they use order backlogs as shock absorbers against violent fluctuations in order inflow. This stabilization mechanism however is not strong enough to prevent big cycles in output of special steels.



An attempt to illustrate some of the essential results in our study is given in the accompanying figure, which shows how variations in new orders to the steel consumers spread through the system. The transformation from variations in one variable to variations in another can be characterized by stabilization (*s*), destabilzation (d) or neutrality (n), the last term indicating that cycles in one variabel is transformed to cycles of corresponding amplitude. The picture also illustrates the general properties of the lag structure.

So far we have been looking backwards, although with the expressed purpose of becoming better judges of future developments. Of course the estimated structures may be of great help in short or medium term forecasting; as a matter of fact some of the models have been used with good results during the past 5 years. However we shall not turn to an appraisal of the forecasting abilities of different models but instead will end this study with a very brief discussion of a more basic matter: Will the Swedish steel market retain its cyclical properties in future?

To answer this question we shall start by assuming unchanged demand cycles in steel consuming sectors. By doing so we reduce our task to a judgement of general trends in the *inherent* dynamic characteristics of the Swedish steel market.

Let us divide this very general question into four subquestions which have been studied in parts II—IV:

- Will the steel intensities, i.e. steel consumption per unit of output in different industries, continue to fluctuate?
- Will the cyclical variations in steel purchases also in future be much bigger than those of steel consumption?
- Will the output of ordinary steels go on being more stable than realized purchases?
- Will the import share, i.e. imports/total realized purchases, fluctuate as before?

We may add a fifth question, which is analysed by Fridén:

- Will the future world market prices of finished steels show the same kind of instability as in the 1950s and 1960s?

Fluctuations in steel intensities are, as was made evident in Part II, due to fluctuations in investments in goods in process in the consuming industries. Since the variations in the latter variable can be explained by a slightly extended accelerator model, its importance should change with the size of the stock of goods in process in relation to the level of output. This ratio in turn is dependent on the length of the time between steel input and output of the steel-consuming goods. Average production times will most probably continue to shrink as a consequence of technical development and rationalization. So the stock/output ratio in question will decrease and the cycles in investments in goods in process will be of relatively less importance for steel consumption than before.

The difference in cyclical sensitivity between purchases and consumption of steel is by definition due to consumers investments in steel inventories. Their variations during the 1950s and 1960s seem to have been greatly determined by changes in (expected) steel consumption. The ratio

stocks of steel held by consumers/steel consumption

has however been decreasing and has thus reduced the relative importance of inventory investments to variations in purchases. Of course hedge buying and price speculation have at certain times interrupted this long term trend, but if the obvious tendencies towards higher speed of turnover of raw material stocks go on, these destabilizing factors will not be big enough to prevent a continued decrease in the relative importance of consumers' investments in steel stocks.

Now it should be added that total steel stocks, i.e. including those held by producers and merchants, will most likely fall less in relation to steel consumption than the consumers' stocks will do. Apparent consumption may therefore continue to behave for more cyclically than actual consumption.

The comparatively high degree of stability in the output of o-works is tahen to be a consequence of their particular market situation. Being by international standards rather small their pricing has not been independent. They have on the contrary acted as price-takers both at home and in export markets. Having the advantage of being small they have, however, been able to supply their "excess capacity" (available capacity—home market demand at existing prices) in the international market without causing decreases in world market prices. This has lead to a high and a surprisingly stable capacity utilization but also to a certain inflexibility. So on sudden increases in home market demand, especially at the beginning of an upswing, the additional requirements of consumers will to a great extent be satisfied by imports; the share of imports in total purchases increases and vice versa at the beginning of a downturn.

A prerequisite of this kind of transmitting cyclical swings in home market demand from production to foreign trade is that a large part of the demanded assortment is supplied by foreign as well as by Swedish suppliers. During the 1960s, especially during the latter half, there was however an evident process towards product concentration and towards more stable relations in different export markets. The result of these tendencies is on one hand that the difference between the product composition of imports and that of home market deliveries by the Swedish works has been larger than before and on the other hand that Swedish steel producers cannot jump into and out from different markets when convenient to themselves. If these tendencies will continue, the output of o-works will probably fluctuate more and more.—The possibility of completely evening out cyclical changes in demand by contracyclical inventory investments should after all be small.

As to the final question about steel prices we must find it very natural for them to fluctuate. We have seen the high sensitivity of steel demand to variations in *GNP* or industrial production and we know that steel production capacity is inflexible in the short run. The producing units have always (at least in modern times) been comparatively large and the optimum size of plant has been increasing. To raise capacity substantially is a very time consuming process. The time elapsing from investment decision to increase of output is a matter of years. The steel works have therefore no possibility of quickly adjusting their capacity to an upswing in demand. Thus, the result of an excess demand is a rise in prices. When demand levels off and turns downwards the initial result is a rising excess capacity. In competitive markets firms will try to supply a quantity equal to their available capacity in order to get some contribution to their big fixed costs. Thus excess capacity is activated into an excess supply resulting in a downturn in prices.

History has shown that in some markets this system has been brought out of order because of open or tacit agreements between firms. The "continental steel market" has however according to Fridén been mainly competitive even if home market prices seem to have been more rigid than export prices. It is, however, the latter prices which are (or at least have been) relevant to Sweden.

Fridén believes those prices to remain fluctuating and argues "... experience of previous co-operative ventures suggests that any attemps to regulate prices will be of temporary duration only, ...". This means that the downward price rigidity during the recession 1970—72, during which firms even raised their prices at a "visible" excess capacity of 25 %, should be an exception. Other people may think that the decrease in the number of sellers together with the observation that the Japanese steelworks have cut off some of their expansive plans as regards output and exports of steel are arguments for future price stability. It is however a common experience that even two can be too many for a lasting agreement, so Fridén's position may still be realistic.

Even if Fridén should be right, steel prices in Sweden may fluctuate less in future. This seems to be a result of the trade agreement between Sweden and the Common Market, according to which the Swedish producers of ordinary steel will come under the pricing system of the ECSC. Swedish buyers will then be charged domestic prices and not export prices by continental works.

As regards special steels there are reasons to believe that some qualities which are now special products will in future become "commercial" products, so that their prices will be determined in markets of a more competitive nature than is usually the case with special steels. On the other hand one might expect new products to enter which will probably have small fields of application and which for a while will be without substitutes. Hence the future price situation of the Swedish producers of special steels will depend on their mix of such products and "ordinary special steels".

The Statistical Material[1)]

This appendix contains a short account of sources to data presented in diagrams and tables or in the text. It also describes calculation of series from the primary data. Each "Part" will be treated separately. The following abbreviations will be used:

JF	Järnverksföreningens kvartalsstatistik, a quarterly statistical report with data on steel production and foreign trade in steel. Produced by Jernkontoret.
JK	Jernkontoret, the Swedish Iron Masters' Association.
KI	Konjunkturinstitutet, the National Institute of Economic Research.
SCB	Statistiska centralbyrån, the National Central Bureau of Statistics.
ECE:S	The Steel Market, formerly the European Steel Market. Published annually by ECE.
MEI	Main Economic Indicators. Historical tables. Published by OECD.

Part I

page 6 — GNP of the USA and Sweden for 1950-70 are taken from MEI, while corresponding data for the interwar period are from J.W. Kendrick, Productivity Trends in the USA, Princeton University Press, 1961 and Östen Johansson, The Gross Domestic Product of Sweden and Its Composition, Uppsala 1963.

pages 8-9 — GNP and industrial production indices from MEI, steel consumption from ECE:S.

page 11 — The table refers to tons of finished steels.

pages 12-13 — Tonnage figures of apparent consumption, production, exports and imports of finished steels are taken from JF, while corresponding data in kronor (constant prices) are calculated from SCB, Statistical reports on production and trade. Steel production in constant prices refer to finished steel only. The data differ therefore somewhat from the SCB quarterly production index. Its basic construction is described by Aspén and Bergström in Statistisk Tidskrift, 1967:4.

page 15 — The wholesale price index is published by SCB in Allmän Månadsstatistik (Monthly Digest of Swedish Statistics) where it is named "mellanprodukter av järn" (semifinished products of

1) I am very much obliged to Barbro Kristenson, Berta Nordén and Solveig Ribbing for friendly assistance and advice especially at the introductory stage of this work.

iron and steel). SCB also produces the import price index, which has been currently published in "The Swedish Economy" (KI). Merchants' price quotations have been obtained from Lascontakt, a company review published by Larsson, Seaton and Co, a shockholding merchant. The construction of the index of the continental export price quotations is described in Fridén's book.

page 17 — Fig. 5. Source: JK.

pages 18-19 — Information on costs and revenues have been obtained from Järnbruksförbundet, the Swedish Iron and Steel Works' Association. Their data represents a "cleaner" picture of the steel industry than corresponding data of SCB (Företagen).

page 20 — Fig. 8. Source: SCB.

Part II

This part deals to a large extent with three kinds of data:

- Apparent and actual steel consumption in Sweden
- Final demand and production in Sweden
- GNP, industrial production and apparent steel consumption in other countries

The Sources of the second and third data sets are SCB (National Accounts and Manufacturing), MEI and ECE:S.

As regards the first set of data, there is a problem of estimation which is slightly touched upon in the text and which concerns inventory changes in constant prices. Inventories are primarily measured in tons of finished steels only with a products division according to "forms" (bars, heavy plates, sheets, tubes etc.). No division into special and ordinary steel is made (until recently), which is disturbing regarding the fact that price differences in general are very big between those two groups of products.

In the calculations presented steel merchants' steel inventories are regarded as consisting of ordinary steels only. The consumers' steel stocks are supposed to be divided into special and ordinary steels according to the special steel content of their purchases. These special steel purchases / total purchases ratios have been calculated from an investigation made by Jernkontoret. As concerns producers, finally, each firm (=establishment) has its own special characteristics with respect to product mix. It has therefore been necessary to go down to the firm level to get a satisfactory result. The basic assumption here is that firms' inventories have the same product distribution as their production.

To summarize, a sum $\Sigma_k \; \Sigma_j \; p_{kj} \; L_{kj}$ is wanted, where subindices k and j refer to "quality" and "form" dimensions respectively. Because of lack of data this sum is approximated by

$$\Sigma p_{oj} L_{mj} + \Sigma_w \; \Sigma_j p_{wj} L_{wj} + \Sigma_j (\alpha_j p_{sj} + (1-\alpha_j) p_{oj}) L_{cj}$$

Legend:

p_{oj}	=	price of form j of ordinary steel in 1959
p_{sj}	=	price of form j of special steel in 1959
p_{wj}	=	price of form j made at work w in 1959
L_{mj}	=	merchants' stocks of form j
L_{wj}	=	stock of form j at work w
L_{cj}	=	consumers' stock of form j
α_j	=	average share of special steels in consumers' total purchases of form j.

Steel inventory data have been obtained from SCB and JK. Gruppcentralen (Group Association of Swedish Steelworks) has provided data on steel prices.[1)]

page 67 — Fig. 9 is reproduced from The Swedish Economy, 1971:3 (KI).

page 111 — Technique and structure components for Sweden are calculated from M 15. Corresponding calculations for the USA are made from a model containing 12 production sectors. A full account of sources is given in Ruist (ed.), The Future for Steel (forthcoming).

page 115 — GNP-figures for the period 1890-1930 are taken from J.W. Kendrick op.cit. Steel consumption 1890-46 is here put equal to crude steel production times the ratio (apparent steel consumption/steel production in 1946).

pages 123-24 — Figures 19a and 19b. Sources: OECD, The Chemical Industry 1969/70, Metallgesellschaft Aktiengesellschaft, Metallstatistik 1960-70, ECE, Aspects of Competition between Steel and Other Materials.

The figures for aluminium and plastics consumption are

1) Many thanks to Bengt Ingeland, Ulf Pehrsson and Göte Wästberg for their kind assistance and valuable comments on different price series.

multiplied by two factors. The first of these is an estimate of that share of consumption which replaces steel consumption and the second is an equivalence factor. The inverted value of the equivalence factor for aluminium tells how many tons of aluminium are needed on average to replace one ton of steel. These two factors are directly taken (the aluminium case) or calculated (the plastics case) from the ECE study. They have been assumed to be constant during the 1960s. It should be obvious that these estimates of replacements of steel are very crude. Even if the estimation of the level as well as of the growth rate of steel competing plastics consumption should be wrong in details, the general observation that plastics though it has had a period of "explosive" expansion still affect steel consumption marginally only, is valid. Readers who are interested in these conversion problems are also referred to U.J. Pasdach, Die Langfristige Stahlnachfrage in der Bundesrepublik, Köln 1966.

page 129

The building costs index is an unweighted average of the subindices published by Svenska Tarifföreningen, the Swedish Insurance Rating Association; for later years Svenska försäkringsbolagens riksförbund, the National Association of Swedish Insurance Companies (Index-meddelanden).

The price index for engineering products is a weighted average of the different subindices presented by SCB. For 1954-62 the index refer to wholesale prices, for 1963-69 to producer prices. The series are linked.

page 133

Steel consumption in the USA for the period 1950-1970 is from ECE:S. Corresponding data for 1946-49 are derived from production and foreign trade figures in the Annual Statistical Report published by the American Iron and Steel Institute.

Part III

The general properties of the main data, their sources and definitions have been explained in the text and in Appendices to Part III. Here some more concrete remarks on sources and calculations will be made.

The engineering industry's purchases of finished steels are of central interest in the analysis. It is defined as

total purchases - shipyards' purchases

of finished steel excluding semis, forgings[1] and steel for buildings.

1) This definition is similar to one used by JK for internal market surveys.

Total purchases is in turn defined as

production + imports - exports - inventory
increases at steelworks and merchants.

Production, imports and exports are obtained from JF, steel inventories at steelworks from JK (internal statistics) and steel inventories at merchants together with shipyards' purchases from SCB (restricted publication).

Steel consumption of the engineering industry is defined as

purchases - inventory increases.

Yearly data on inventories are provided by SCB. Some minor corrections have been undertaken for the purpose of getting a consistent stock series.

page 148 Fig. 5. The calculation of the B-series differs somewhat from that described above. Yearly steel stock increases including increases of steel in goods in process are estimated according to the formula (see page 57 for a similar estimate):

$0,38\, e^{-0,005\, t} \cdot$ increases in goods in process (in 1959 prices). The quarterly series, which are here seasonally adjusted and smoothed by a three-quarter-moving average (1/4, 1/2, 1/4) have been calculated in the way described in Appendix 1 (page 281).

page 179 Fig. 13. Source: Lascontakt (Larsson, Seaton and Co).

page 207 Table in the marginal. Source: SCB (Statistical Reports).

page 218 Fig. 14. Source: JK. Excess capacity is defined as

$$\frac{\text{total physical capacity} - \text{production}}{\text{total physical capacity}}$$

Capacity data presented in JF refer to the end of each year. The quarterly data are obtained by interpolation, which because of the stable increase in the original series has been an easy task.

page 238 Table 8:1. Data on new orders and order backlogs for the period 1955-62 have been published by IUI, the Industrial Institute for Economic and Social Research, in Orderläge och sysselsättning i verkstadsindustrin. Between 1963 and 1968 the same kind of order data were produced by SCB. In a report from IUI, Verkstadsindustrins orderstatistik, Ragnar Bentzel gives a description of the construction of those series and an appraisal of their value in different kinds of empirical economic analyses.

page 277 Table in the marginal. To fit into the L_t-equation on page 271 the new series of orders, which refer to value of orders received in current prices, has been deflated by the product of a price index of engineering goods and a productivity index of the engineering industry. Compare Appendices to Part III:4.

page 281 Mr. Åke Dahlbom, SCB (I-byrån) has supplied data on hours worked in the subsectors of the engineering industry. The series in question refer to hours actually worked during a month.

Part IV

This part deals to a high extent with deliveries of finished steels where quantities of different products have been weighted together into crude steel weight of finished steels. The conversion factors used in this context are as concerns ordinary steels those applied by the ECSC (see Eisen und Stahl), Statistisches Amt der Europäischen Gemeinschaften). This organization have also calculated conversion factors for special steels. Since in Sweden special steels make a very big share of total steel production it has been found worthwhile to use more detailed information than that provided by the ECSC secretariat. In the calculations made here account has been taken to an observed long-run increase of yield for some products. The basic information on yield or conversion factors has been occasionally supplied to JK by the different establishments.

page 288 Fig. 1a and 1b. Source JF. Import share is here calculated as

$$\frac{\text{Imports}}{\text{Apparent consumption-consumers' steel stock investments of finished steels.}}$$

page 292 Fig. 2b and table 1. Source: JK.

page 303 Industrial production index is taken from MEI.

page 320 Fig. 9. Source: JF.

pages 322-23 Fig. 11, 12a and 12b. The Group Association of Swedish Steelworks has supplied the Swedish price data. The prices of high speed steels, tool steels and stainless steels refer to a typical product within each commodity group. The index of export price quotations of continental works has been supplied by Fridén, who has used Metal Bulletin as a basic source.

pages 331-32 Figures 18 and 19. Order and inventory data are produced by JK. Inventory data are, however, primarily collected by SCB. In the calculation of the crude steel equivalent of steelworks' stocks of finished steels, each establishment has in principle been attributed a set of conversion factors. Thus the crude steel content of an existing level of inventories of finished steel is here calculated as

$$\Sigma_w \Sigma_j k_{wj} L_{wj} \qquad w = 1, 2 \ldots m; \qquad j = 1, 2 \ldots n$$

where k_{wj} is the conversion factor for product j applied on work w. To arrive at an estimate of inventories of special and crude steel respectively producers have been grouped into two classes the s-works and the o-works (see page 319). Some small establishments are however typically "mixed" as regards the composition of production. For those firms total steel stocks have been divided into ordinary and special steels with regard to the composition of their production. Thus total inventories of ordinary steel at producers are estimated as the sum of the inventories of the o-works and the calculated inventories of ordinary steel at the "mixed" works.

page 346 Data on deliveries, purchases and inventories of the stockholding steel merchants are taken from SCB.

Sectors of the input- output tables

Sectors in M 45 No.	Products	Corresponding No. in M 127[x]
1	iron ore and other ores	7,8
2	iron and steel	8,13
3	metals, metal manufactures, metal castings	9,...,12,19,22,23
4	implements and tools	14
5	bolts, nuts, screws, nails	15
6	fittings for gas, water, heating, steam	16
7	iron and steel furniture, safes, lighting fittings	17
8	other manufactures of steel	18
9	gas lamps, cooking apparatus for liquid fuel	21
10	galvanising, nichel-plating, tinning	24
11	motor cars	25
12	cycles	26
13	tractors, locomotives, rail-wagons, other vehicles	27,28
14	cast iron and articles of cast iron	29
15	internal combustion engines	30
16	water and steam turbines	31
17	machines for metal processing	32
18	machines for wood, pulp, paper	33
19	other machines for industry and handicrafts	34
20	agricultural machines	35
21	dairy machines	36
22	bearings, couplings, transmissions	37
23	heavy sheet metal work, iron and steel structures	38
24	office machines	39
25	refrigerating apparatus, washing machines and sewing machines	40,45
26	fans, ventilators, pneumatic apparatus, pumps	41,42

[x] M 127 refers to the input-output tables presented in Höglund and Werin, op.cit.

No.	Products	Corresponding No. in M 127
27	lifts and lifting apparatus	43
28	armaments, weapons, aircraft	44
29	central heating boilers, metal radiators	46
30	other mechanical engineering products	47
31	ships and boats	48
32	electric motors	51
33	other electrical products, instruments	49,50,52,···,58
34	plumbing and sanitary installation	59
35	repairs to motor cars and to other vehicles	60,61
36	repairs to machines and apparatus (not electrical)	62
37	repairs to electrical machines and apparatus	63
38	products of clay, store, glass etc.	64,···,70
39	sawn and planed timber, products thereof	71,···,75
40	pulp, paper and products thereof	76,···,83
41	agricultural products; food, beaverages and tobacco	1,···5;84,···,96
42	textile, leather, rubber and wearing apparel	97,···,108
43	chemical (incl.plastic)prodcts	109,···,116
44	buildings, painting etc.	117,118,119
45	services	120,···,127

Sectors in M 15

No.	Products	Corresponding No. in M 127
1	ores	6,7
2	iron and steel	8,13
3	metals	9,···,12
4	manufactures of steel and metals	14,···,24
5	products from manufacturing works	25,···,47,60,61,62
6	ships	48
7	electrical products	49,···,58,63
8	products of clay,stone,glass etc.	64,···,70

No.	Products	Corresponding No. in M 127
9	sawn and planed timber; products thereof	71,···,75
10	pulp, paper and products thereof	76,···,83
11	agricultural products; food etc.	1,···,5,84,···,96
12	textile etc.	97,···,108
13	chemical products	109,···,116
14	buildings, plumbing, painting etc.	59,117,118,119
15	services	120,···,127

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