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Keskusteluaiheita
Discussion papers

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ON DESCRIBING AND PROJECTING INDUSTRIAL DEVELOPMENT

A framework for studying the structural change and growth of the Finnish pulp and paper industries

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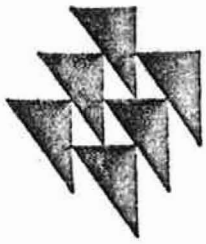

The present paper consists of the following seven chapters:

1. Summary of the problem to be presented
2. Purpose and problems of the study
3. Importance of the topic
4. Review of previous research on the topic
   - 4.1. Development projections for industrial policy planning and decision-making and for management
   - 4.2. Theoretically oriented studies
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1. SUMMARY OF THE PROBLEM TO BE PRESENTED

The purpose of this research project is to provide a better understanding of the medium and long term development of industries for the planning and decision-making in firms, economic organizations, financial institutions and the public sector. The present study, which is one of the kernel parts in the project, is confined to an examination of the structure and structural changes at the industry level. By structure we mean the distribution of the relative performance (efficiency) of the plants within an industry.

The problem of this study has been divided into major subproblems, e.g.: the economic formulation of the target of the study, the measurement of the distribution of the relative performance within an industry, the behaviour of the measure derived when a) the rate of capacity utilization fluctuates and b) the industry concerned is expanding/stagnating, possibilities to identify the factors causing structural changes etc. - The importance of the measurement of pressures on structural changes within an industry when preparing development projections is considered in Chapter 3.

This study can be classified as an industrial analysis, and from the methodological point of view it belongs into industrial econometrics. It concentrates on a very detailed level within an industry which is assumed to be rather homogeneous. The framework developed is dynamic and integrates micro and macro levels using Johansen´s (1972)

approach, which flexibly and realistically describes different industrial development processes and can be used analogously to Day´s (1963) recursive programming models. The adaptive nature will be emphasized but the behavioral and managerial theories of the firm will not be included in the theoretical framework at this stage. These will be discussed together with Leibenstein´s (1966) X-inefficiency at the end of the study when explaining reasons why the concept "structure", as defined in this study, does exist.

The measurement method used can be described as an extension of Salter´s industry model operating with the distribution of productivity of only one factor of production. Our attempt is to estimate the total efficiency of production by using production and cost functions. We use alternative functional forms and non-linear estimation instead of Cobb-Douglas functions and linear (after logarithmic transformations) methods used in previous studies. The behaviour of the distribution of the efficiency indicator is examined in different situations. The theoretical framework will be carried out at a general level applicable to all industries.

The nature of the preliminary empirical examination is experimental. We apply our framework to four rather homogeneous sub-branches of the Finnish pulp and paper industries. Dynamic aspects have been emphasized to the extent that cross-section data for only one year cannot be considered sufficient. We utilize primary data at plant level for the period 1960-1975.

Fields of potential contribution include the economic formulation of the problem, generalization of the efficiency estimation methods, arrangement of a test situation

of a new kind, emphasis of the dynamic approach and the theory of adaptive processes and analysis of the results obtained from an industry which is of great importance to the Finnish economy.

2. PURPOSE AND PROBLEMS OF THE STUDY

The p u r p o s e of this research project is to provide a better understanding of the many forces determing the development of industries through time, particularly changes in production, investment, technology and productivity. We try to improve methods used in medium and long term industrial projections which are relevant in formulating industrial policy by the public sector or economic organizations as well as in planning the future of the firm by management. In order to understand the medium and long term development we also have to deal with some short term implications, especially when evaluating the accuracy of the data and measures from the cross-section data[1]. This may provide some background information on forecasting the cyclical development of an industry. - An attempt to project the development of an individual industry will be the next step in the future.

The present study, which is one of the kernel parts in the project, is confined to an examination of the structure and structural changes at the industry level. By structure we mean the distribution of the relative performance of

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1) Almost all previous empirical studies have used cross-section data because it is rather difficult to get detailed time-series data needed by an industrial analysis of this kind. The importance of short term factors affecting the adjustment to longer term industrial change is emphasized e.g. in Hughes (1976), p. 3.

the plants or firms within an industry[1]. The p r o b l e m of this study can be divided into the following major subproblems:

1. Definition of the term "structure" most relevant to this study and sources of information on the structure of an industry and its changes to facilitate the analysis and projections of the development processes of industries.

2. One of the more specific problems is the measurement of the relative performance (efficiency) of establishments within an industry, in order to obtain a picture of the structure of the industry concerned. This problem can be divided into the economic part and the statistical one.

3. Behaviour of the indicator of structural change when:
   a) The industry concerned is expanding or stagnating.
   b) The rate of capacity utilization of the industry fluctuates e.g. caused by business cycles[2].

   To this same problem group, which we tackle by using Johansen's short-run macro production functions' framework[3], belongs two more points:

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1) For definitions and further discussion about "structure" and related concepts, see Hjalmarsson (1973).

2) The importance of this problem is due to the fact that in the empirical work of industrial analysis usually only cross-section data from very few years is available. We are therefore intrested in the sensitivity of our measurement to business cycles.

3) See Johansen (1972), pp. 13-19.

c) When demand declines, how does the industry reduce its capacity[1]?

d) How does the difference between best practice and average practice[2] vary as the rate of capacity utilization varies?

4. Is it possible to identify factors which have caused structural changes in the industry (technological change, changes in the relative prices of the main inputs, or both)?

5. Empirical comparisons of ex ante and ex post production functions and use of this information in forecasting the (technological) development of an industry.

6. What happens - and in which circumstances - to the establishments fallen into the group of the least efficient ones (do they close, invest and increase efficiency, merge with more efficient establishments etc.)?

It is necessary to illuminate these six problems and to explain them more thoroughly on the basis of a dynamic production and cost theory[3] in order to increase the predictability of development processes at the industry level. All these problems will be considered in the framework to be built up in this study.

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1) E.g. does the industry use at very low levels of output only its most efficient plants and take less efficient units in use when the output rises?

2) These concepts will be introduced in the study.

3) "... a study of the d y n a m i c s of production of a sector requires a study of how the short-run production functions changes through time", Johansen (1972), p. 26. The approach "dynamic production theory" adapted in this study is the same as in Johansen (1972), see pp. 137-184 and Hjalmarsson (1973) and (1974).

When seeking a solution to the above problems, there is the vital constraint that it will be necessary to compile the measure from statistical data collected regularly among industries, e.g. the Industrial Statistics. If we did not have this data constraint, we could solve our measurement problem by using management ratios[1]. There are, however, many practical difficulties. Usually management ratios are derived from the accounting information (balance sheets etc.) of firms which often consist of several plants belonging to different industries. Such data is therefore applicable only to the study of the behaviour of firms, and conclusions concerning the industry level would be limited to a few special cases[2]. Other restrictions are the poor comparability of data taken from firms in different countries, large resources needed in pre-handling the data and the need for extra information which usually cannot be obtained from all firms in the sample we are intrested in.

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1) See e.g. Summa (1975), Summa and Ylä-Anttila (forthcoming) and Teague and Eilon (1973).

2) In the main sample employed by Summa (1975) and Summa and Ylä-Anttila (forthcoming) it was possible to group relatively pure forest industry firms together and derive some conclusions at the industry level. However, changes of management ratios in the sub-branches could not be identified. The other sample, where forest industry firms had diversified to other industries, emphasized the sensitivity of results to different timing of business cycles of various industries.

3. IMPORTANCE OF THE TOPIC

The rapid growth of the need and use of medium and long term forecasts at the industry level was already mentioned in the introduction. In this chapter, the relevance of one limited problem - the relationship between structural changes and growth of one particular industry - will be examined in detail. After arguing for the topic, the importance of the problems presented in Chapter 2 will be dealt with, and finally, the importance of the empirical part of the project will be assessed.

When describing and projecting industrial development, prior research has been focussed almost entirely on the assessment of demand developments and availability of resources (mainly investment prospects and the labour force) based on earlier developments[1]. No explicit attention has been paid on the structure of the industry and the ensuing pressures for changes[2]. The n e e d to adjust the industry's internal structure to environmental changes (the structure and growth of demand, changes in the competitive position, technological development, changes in relative prices of inputs etc.) should, however, form the very basis for the projections: the c h a n c e s of adjustment (like availability of investment and labour recources), which generally tend to draw

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1) See e.g. the Industrial Commission 1975, NEDO (1973) and IUI (1971).

2) Efforts of this type by Wohlin (1970) and Ribrant (1970).

the main attention, will be included in the examination as major subfactors at the next stage. This study aims at filling an important but neglected gap in the set of concepts, theories and analytical tools needed to measure the pressures for structural changes within an industry when preparing development projections.

The increasing need for information on the structure and its changes is also due to a stronger pressure to be able to follow the performance levels of the same industries in competing countries. With the removal of economic barriers in international trade such countries have grown more numerous. Increased international competition has forced almost all industries into structural changes, but in some industries[1] the consequences (e.g. balanced regional and manpower development) have been so strong and rapid that the governments have been obliged to take economic and industrial policy measures. It is not possible to overemphasize this kind of research in the planning on which the public sector's conscious measures of restructuring are based.

Chapter 2 presents as its first problem the need to obtain information on the structure of an industrial branch and the changes therein, to facilitate the understanding and projection of the development processes. In a number of development projections, structural changes have been excluded, obviously because the necessary fundamental theory and set of tools are not adequately developed (e.g. as compared with investment and demand theories). The formulation of the theoretical background is also a necessary prerequisite to the following targets which pertain to applied research.

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1) E.g. in the United Kingdom textiles, steel and car industries and the shipbuilding, see Hughes (1976), pp. 11 and 59.

It is necessary to develop a measure to describe the structure of the industry at different stages if a dynamic development process is to be followed. The importance of creating an operational measure is not, however, confined to an examination of one particular industry: it may be useful when comparing different industrial branches and examining the impact of external factors on the structural development[1]. The suitability of the measure as an analytical tool presupposes that its behaviour in different situations is known as well as possible. Although the effects of variations in the rate of capacity utilization and the degree of expansion/stagnation of a branch are of great importance, they have not been sufficiently examined in previous studies.

The objects presented above are treated at a general level, so that the theoretical framework and the measures can be applied to any industrial branch. In the empirical part of the study, the suitability of the analytical tools is tested on four branches of the Finnish forest industries, on the basis of data by establishment for the period 1960-1975. These data provide a better opportunity to develop and test necessary analytical methods than those used in previous studies[2]. The stimuli obtained from the testing will be used for the further development of methods, before extending the research to other industrial branches. Bearing in mind the role played by the forest industries

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1) See e.g. Carlsson (1972).

2) Compare with Aigner and Chu (1968), Farrell (1975), Carlsson (1972) and Førsund and Jansen (1974) which have used only cross-section data of one year. An attempt to use both cross-section and timeseries data is in Førsund and Hjalmarsson (1976).

in the exports, investment and labour of the total Finnish industry[1], the information gathered on structural changes in the forest industries and their predictability can be regarded as a valuable result in itself. This is an acute real problem which economists and industrialists are faced with when calculating the need of the investments, structural changes in production capacity and increase of inputs usage arising from the output growth forecasts as presented e.g. the Industrial Commission 1975 in Finland and Walldén (1976) and from the forest industry firm's investment plans both in new capacity and conversions.

The field of the present study comprises a vital part of the preparation of medium and long term projections for an industry. So far little information of this kind is available and further research is thus needed.

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1) Walldén (1976), chapter 2 presents a detailed picture of the importance of the pulp and paper industries to the Finnish economy.

4. REVIEW OF PREVIOUS RESEARCH ON THE TOPIC

The major studies in the same field can be divided into development projections, designed for decision-making, and more theoretical studies, often including an empirical part. The objectives, the level of aggregation, the data and methods used and the contribution to industrial analysis are emphasized rather than the empirical results of the studies reviewed.

4.1. Development projections for industrial policy planning and decision-making and for management

In the Nordic countries, projections for the industrial development at the industry level have been prepared since the late 1960s, mainly in order to provide information for the planning of the public sector. In connection with this work, attempts have also been made to develop analytical methods. Ribrant (1970) defined the concepts and analytical methods in his examination of the impact of scale distributions and differences in the structure of production costs between different establishments within one particular industry. In his study, the optimal structure of an industry is defined, and light is cast on differences between alternative developments and the optimal development. The analytical method has been applied to eight Swedish industries. No quantitative projections have been presented, but the impact of structural factors on the development of different industries has been estimated in the empirical part of the study.

Methods and structural factors have also been dealt with in outline in the projections by industries published by Industriens Utredningsinstitut[1] (1970) and (1973); in these, the main attention is focussed on the evaluation of the results obtained through an inquiry completed among enterprises. In the medium-term projection issued in 1976 by the same institute, problems concerning structural changes and differences in productivity have been examined by means of Salter-diagrammes. The development estimate published by Statens Industriverk[2] in 1976 introduces a production function examination as an addition to previously used analytical methods. It is used for examining the industry as a whole and its fifteen branches by means of time-series data for the period 1961-1972.

In his study, Du Rietz (1976) has examined structural changes in Sweden in 1954-1970 in the manufacture of plastics, the manufacture of primary metals and engineering. As factors affecting a structural change, Du Rietz examines the firms' entry, exit and growth. In this preliminary report, the analysis remains on a descriptive level, being confined to a presentation of the compilation of data.

Cockerill's study (1974) is confined to international comparisons between the structures and performances of one particular industrial branch - the steel industry. The study begins with a comparison of the structure and recent performance of the steel industry in different countries. Then the evidence on the sources and the extent

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1) The Industrial Institute for Economic and Social Research, Stockholm, Sweden.

2) The National Industrial Board, Sweden.

of economies of scale in industry are reviewed. The findings are employed in an original assessment on the technical efficiency of steel production in each country. The relationship between these efficiency levels and the recent trade performance is examined. The main policy alternatives for increasing the efficiency of steel production are also dealt with. The study is completed by detailed individual studies of each country, based on extensive fieldwork and comprehensive theoretical background information.

In the study by George and Ward (1975), the structures of the British industry by branches and of those of the major EEC countries are compared on the basis of industrial cencus data for 1962-1963. The distribution by concentration and size is examined on both the corporate and the establishment level. The study also analyses the growth and productivity performance of the British industry over the postwar period, with particular reference to the performance of industry in West-Germany.

The report edited by Panić (1976) analyses and compares changes in the structure and performance of the UK and West-German industries using data from industrial and trade statistics and national accounts. Disaggregation to the industry level was needed because the objective "was to try to answer the question of whether the relatively inferior performance of UK industry ... is due to the inferior performance in certain key sectors which account for a large proportion of the total; or whether the relatively poor performance is characteristic of more or less all the major industrial groups"[1]. The problems of comparability between industries in

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1) Panić (1976), p. iv.

different countries in this kind of economic analysis have also been discussed. In measuring the level of performance not only indices of classical labour productivity but also indices of total factor productivity were constructed and compared.

To the same group of studies comparing the development of an industry in different countries also belong two recent reports by Pratten (1976 a and 1976 b). Pratten's main objectives have been the same as Cockerill's, George and Ward's and Panić's but due to the different approach and data base, it completes the set of research reviewed here. Pratten's attempt has been to examine the reasons for differences in performance and competitiveness between the UK and other advanced manufacturing countries. When the studies reviewed above have used mainly data taken from industrial statistics, Pratten has based his study on the data published in company accounts and interviews with managers of companies. The usage of company data is the reason why Pratten cannot derive conclusions at the industry level as the others have done. Another main difference with the studies above is that when the classical framework based on the theory of the firm has been implicitly accepted by others, Pratten emphasizes more behavioral theories and institutional aspects. So the concepts, results and conclusions of Pratten's research seem to be more operational, concrete and intresting for management while the other studies contribute more to the decision-making at the industry level.

In Pratten's (1976 a) first report labour productivity at the UK operations of international companies was compared to labour productivity at the overseas operations of these companies. The main argument for a sample like this is that international companies are expected to know how

labour productivity varies between their operations in different countries, and the reasons for any differences. In this research situation a number of important factors affecting labour productivity are relatively constant, so that it is possible to isolate the effects of other influences on productivity[1]. The small number of observations made it impossible to use an industry breakdown.

The second report by Pratten (1976 b) compares the performance of fifty Swedish companies and a similar number of UK companies which were the nearest matches for the Swedish ones in terms of product mix. A single unifying economic explanation for the differences in performance was not discovered.

The objectives of the study "Industrial review to 1977" by the National Economic Development Office (NEDO) in England 1973 are to identify the problems that eleven major British industries might expect to encounter in raising their output and improving their economic performance and to pinpoint areas of structural change. The study by Bacon and Eltis (1974), "The age of US and UK machinery", published by NEDO, provides material for vintage-effect studies; so far this material has not been used for studies of structural changes based on production functions.

The industrial-economic research team of SITRA[2] published in 1970-1971 reports on the international competitiveness of ten industrial branches in Finland. In these reports, the internal structure of the branches was considered by the distribution of productivity and production costs as well as by the rate of utilization of economies of scale.

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1) Pratten (1976 a), p. xi.

2) The Finnish National Fund for Research and Development, SITRA.

The study by Summa and Sääskilahti (1974) analyzed the structure and growth of the manufacture of machinery in Finland in 1954-1971, and assessed the prospects for expansion in this industry until 1980. The measurement of the efficiency of the use of factors of production in the discussed branch as compared with other industrial branches and the development of techniques for analyzing cyclical fluctuations were ancillary targets.

In the studies by Summa (1975) and Summa and Ylä-Anttila (forthcoming) the average levels of profitability in the Finnish and the Swedish forest industries in the 1970s have been compared by calculating several management ratios from data compiled by enterprise. One incentive to start additional studies was the observation that substantial differences might occur in the average profitability over several years between two enterprises with similar product selection and similar operating environments. Furthermore, the studies point to the fact that investments in Finland and Sweden in the discussed branch have centred on different years and that the ensuing structural differences may be one of the major reasons for large diffrences in profitability between the two groups compared.

One of the targets set by the Industrial Commission 1975 in Finland was to forecast industrial development by industries for 1975-1985. In the Commission's report, attention is paid on differences in the allocation of resources between industries. However, the assessment of changes in the internal structures of industries has been left implicit. In fact, the impact of these internal structural changes on growth estimates for an individual industry and the industry as a whole can be significant, as they affect investments and chances to increase labour productivity.

The reports and projections treated briefly above have mainly been designed to serve practical decision-making purposes; they also describe, however, the same problems and environment on which the present research project hopes to cast more light. The stimuli and ideas which started this project arose from these reports. In most of them, the problems of structural changes in industries form the central basis, but the lack of analytical tools and experience in using them has forced economists to avoid this important field.

4.2. Theoretically oriented studies

In the following, more theoretically orientated studies will be discussed. After examining alternative approaches, the theoretical basis for using production functions in describing the structural changes is considered. Attention will also be paid to studies which attempt to measure the structure of an industry by means of frontier production functions.

At least three different approaches which take into account the impact of structural changes have been used for developing models to describe the behaviour of an industry.
(1) The framework used by SITRA's (1971) industrial-economic research team summarizes the effects of the industries' internal structural factors and those of environmental factors into one indicator (a kind of total efficiency measure) describing the result of activities. Although this approach has proved flexible in practical industrial analyses and projections, the possibilities to develop it further are limited, because it would hardly be possible to carry out a comprehensive quantitative examination by means of the data and theory employed in this approach.

(2) Models at the industry level have been developed, i.a., at the Wharton School. These models share the feature that they have been linked with and they are being used with macroeconomic short-term forecasting models. Adams and Griffin (1969) have constructed a model which recognizes seasonal patterns, cyclical movements and long-term trends in the United States petroleum refining industry. The model is intended for simulation and prediction over the business cycle. The specific aim of the refining model is to forecast demand, the supply responses of the refiners, inventory adjustment, and petroleum product prices. The same kind of framework has been applied by Adams and Blackwell (1973) to the United States forest industries. The study of Higgins (1969) consists of a comprehensive investigation of demand and production relationships for the U.S. steel industry, as an aggregate, in the post World War II period. In his study, the main emphasis is laid on the structure, but a suitable basis for forecasting is also provided. The performance of the steel industry is analyzed in a way that is consistent with aggregative variables taken from the Wharton Model. The Wharton School has also developed other "satellite models to show how microeconometric research can be carried out in contrast to and complementary with our principal activities in macroeconometrics"[1].

(3) As a third approach using models at the industry level we should mention the models by Day (1975b) and his research team which based on recursive linear programming (RLP). The basic premise in these studies of industrial behaviour is that decision-makers with incomplete knowledge constrain themselves by behavioral rules that afford protection from

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1) See Klein (1971), p. 1.

errors of estimation and forecasting, and that these maximizing plans roll: from time to time new plans are made on the basis of new information and old plans for the future are discarded in favour of the current conception of optimal choice. What makes these models realistic is the fact that they are linked with the environment through demand and cost factors. In the use of the models the adaptivity of decision-making is of great importance, because the assumption that decision-makers posses full information is generally not valid when economic theory is used to formulate the development of an industry. In a number of empirical applications, Day´s models have proved promising, but their use is constrained by the demands set on the data needed: detailed engineering data are necessary for constructing a technology matrix, and these can often be obtained only from processing industries. In fact, Day´s approach was considered not to be suitable for the present research project, because the acquisition and compilation of the data would have required too large resources. However, it is intended to incorporate in the study a few central ideas raised by Day´s use of adaptive processes.

Studies in which the structure of an industry and its changes are dealt with on the basis of production theory will be examined next. They have not led to complete "super" models, like the abovementioned, but consist of approaches linked with each other through micro-production theory. Unlike most of the previous studies, Salter (1960) examines the structure of an industry and not only the average production function. Salter takes into account how effectively different production units of the industry utilize their inputs; this can be described, e.g., by means of input coefficients. The so-called Salter-diagrammes are often used for describing the efficiency distributions

of individual production factors. When describing the growth process of an industry, Salter aims at providing a dynamic picture. The empirical part included in Salter's study is based on industrial statistics of the United Kingdom for 1924-1950 and those of the United States for 1923-1950. Although a microeconomic approach to productivity, investment and technological change was proposed and tested by Salter, this field has not been taken up by many economists.

Farrell's article (1957) laid the methodological foundation for the most recent empirical studies of efficiency. Three methods have been used for estimating Farrell's concepts of price, technical and overall efficiency: the isoquant method suggested by Farrell (1957), the profit function approach used by Lau and Yotopoulos (1971), the production function approach proposed by Aigner and Chu (1968) and used by Timmer (1970).

The isoquant method involves the estimation of either a unit isoquant as originally suggested by Farrell (1957), thus implicitly holding scale constant; or as advocated later by Farrell and Fieldhouse (1962), a family of isoquants through the grouping of observations according to output. The main difficulty with this approach is to allow adequate variations in the scale of output. In the original formulation, the problem of scale economies is ignored altogether. In the later version, scale is a discrete, not a continuous, variable. If the firms in a given industry are distributed evenly throughout the whole size spectrum, the selection of isoquants for estimation is essentially arbitrary, and the efficiency measures obtained would therefore also be somewhat arbitrary.

The profit function approach avoids the scale problems associated with the isoquant approach. Defining "profit" as the difference between the value of output and the value of variable inputs (fixed inputs are excluded since they are regarded as given and hence do not influence the level of output at which profits are maximized), and assuming profit maximization, Lau and Yotopoulus (1971) show that profit can be presented as a function of the price of output, the prices of variable inputs, and the quantities of fixed inputs. By normalizing with respect to the price of output, "unit output price profit" is shown to be a function of variable input prices and amounts of fixed factors alone. It is not possible to distinguish empirically between technical and price efficiency by this method. Lau and Yotopoulos have applied this technique to data for Indian agriculture 1955-1957.

The Aigner and Chu (1968) technique involves estimating a frontier production function and measuring the distance from each observation to the frontier. Their approach is a linear or quadratic programming method, where the function is fitted to data by minimizing the sum of deviations subject to the constraint that all deviations are of one sign so that the function is an efficiency frontier. The basic differences between this technique and the profit function method are that no input or output price data are required, and that no firm specific intercept term needs to be estimated in the production function technique. Efficiency comparisons are based on analysis of residuals[1)].

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1) See Schmidt's (1976) note on Aigner and Chu (1968).

In order to reduce the possibility of outlying observations distorting the estimated frontier, Timmer (1971) introduced a "probabilistic" frontier concept. The basic technique is to eliminate a certain percentage of the most efficient firms in the sample as indicated by the observations on or near the frontier estimated for the entire sample, then to re-estimate the function without these extreme observations. Comparisons between these estimates and average production functions obtained by regression analysis of the same data revealed that the adjusted frontier functions came much closer to the average functions than did the unadjusted frontier functions. The adjusted frontiers were found to have essentially the same input coefficients as the average functions, although they had higher intercept terms than the latter, indicating neutral upward transformations of the average functions. Timmer used aggregate farm data for the eight-year period 1960-1967.

Johansen (1972) installs in his study the dynamic theory of production through an integration of micro and macro[1] and of short run and long run aspects. The result is a production theory embracing the development of a whole industry producing a homogeneous output. The fundamental assumption in Johansen's approach is that the essential technological choice has to be made at the stage when investment in new production equipment takes place. Once the investment is made, the factor proportions become fixed. Johansen's aim is to avoid the crudeness of the concept and use of the production function, as it is used in most econometric research with poor results, and

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1) By the "sector" or the "macro" level Johansen means "... a branch of an economy with a reasonably homogeneous output", Johansen (1972), p. 3. It is the same aggregation level we operate with in our study.

to introduce a more realistic framework by using different production situations. Johansen analyses with more detail the properties of his short-run macro function, which forms the basis for studies on the structure of an industry and the changes in it. After introducing elements of the dynamics of production Johansen evaluates critically some empirical econometric studies at the sector level. Johansen classifies and completes theoretically many ideas closely related in Salter (1960). Johansen's framework is adopted as the basis for the studies by Førsund and Jansen (1974), Førsund and Hjalmarsson (1976), Hjalmarsson (1973) and will also be used in the study presented in this paper.

On the basis of the above-mentioned studies by Aigner and Chu (1968) and by Johansen (1972), Førsund and Jansen (1974) completed a study in which they estimated both the average and the best practice production functions with variable scale elasticity for the Norwegian mechanical pulp industry, based on establishment cross-section data. The average cost functions are estimated by OLS, and ML estimators for the parameters of the best practice cost function are obtained by solving LP.

The most recent study in the field of structural changes of an industry is that by Førsund and Hjalmarsson (1976), in which they show the result of a combined time-series cross-section analysis of 28 dairy plants during a period of ten years. A homothetic best-practice or frontier production function is estimated together with estimation of an average production function, and the form of technical progress is studied. Førsund and Hjalmarsson have introduced trends in the scale function parameters. Apart from estimating technical changes in best-practice functions, their study also generalizes the approach by Aigner and Chu (1968) to allow for variable scale elasticity.

In the study by Førsund and Hjalmarsson (1976), Hjalmarsson's earlier studies (1974) have been utilized; in these, various aspects of industrial structure, structural change and productive efficiency are examined. The emphasis in the studies by Hjalmarsson is on the dynamic aspects of structural change and structural efficiency.

Carlsson (1972) presents various definitions of efficiency, integrates the notion of inefficiency into standard microeconomic theory, measures efficiency empirically at the plant level in 26 Swedish manufacturing industries, and analyzes the results in terms of macroeconomic variables. Carlsson has used Aigner and Chu's (1968) technique and cross-section data from the year 1968.

In the recent literature attention has been paid on the estimation of productive efficiency by means of frontier production functions. Afriat (1972) discussed this problem in a manner which recognizes that the production function is a frontier representing the maximum output that may be obtained from given inputs when the inputs are being used in the most efficient manner possible, given the state of knowledge. Richmond (1974) develops further the suggestion made by Afriat when the production function is Cobb-Douglas. He presents also some empirical applications based on the data of Griliches and Ringstad (1971). The next steps in this development process have been taken by Meeusen and van den Broeck (1976) who present an alternative approach to estimate production functions, since the Afriat-Richmond measure yields, as Meeusen and van der Broeck show, systematically underestimated values for productive efficiency. This field of the specification of the production functions, the choice of the distribution for the efficiency variable and the evaluation of the statistical properties of the estimators needs more

research before the results obtained could be accepted as firmly established[1].

Wohlin (1970) has analyzed, in one part of his study, the structure of the Swedish pulp and paper industry. In this study, the term "structure" is understood to refer to the distribution of plants or capacity at different productivity levels. The theoretical approach is based, in great measure, on Salter's work. Wohlin's study deals with quite disaggregated components of costs and evaluates the influence of some external factors on the development of the industry concerned.

The most recent empirical studies at the industry level in Finland include the studies by Lehtonen (1976) and Airaksinen (1975). Lehtonen tests the neoclassical theory by estimating statistical costs functions of Finnish restaurants derivable from the neoclassical theory of the firm. Lehtonen pays special attention to cost functions which are based on technology containing substitutable and non-substitutable factors of production. He also examines how the cost components are affected by the scale of operation. Airaksinen tests a neoclassical framework for explaining interrelated requirements of labour and capital stocks and their utilization rates in the plants of the Finnish brewing industry in 1954-1972. He uses combined timeseries and cross-section data, and he generalizes the model of Rosen and Nadiri (1969) by taking account of operating costs of capital analogously with wage costs.

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1) See Richmond (1974), p. 520.

5. RESEARCH APPROACH AND METHODOLOGY

The study consists of two parts: a theoretical part and an empirical one. We shall present the frame of reference first, then the theoretical and empirical elements of the study and finally the tests which allow us to compare both theoretical and empirical content with one another. The relationships of interest are derived from the micro-dynamic theory of production by using Johansen's (1972) framework. The approach presents an integration of micro and macro levels, which in our study corresponds to plant and industry levels. This framework seems to offer the most flexible background for the empirical part and is well suitable for our need to operate with dynamic analysis The adaptive nature of the structural changes studied is of crucial importance in the analysis of the industrial development. The aim is, therefore, to make more explicit use of the theory of adaptive processes[1] than the previous studies using Johansen's framework have done. We think that this is a step towards more realistic results which will be used in the decision-making in the real world[2]. This is of crucial importance due to the fact that the basic framework used is neoclassical and pay attention to only a few properties in the frame of reference and the environment of the study.

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1) See Murphy (1965).

2) See Day (1975a), pp. 232-235.

In the interpretation of behavioral relationships, especially in structuring the targets of the study and in considering the utilization aspects of the obtained results, the behavioral theories of the firm introduced e.g. by Penrose (1972) and Cyert and March (1963) are discussed. Another aspect connected with this study is Leibenstein's (1966) X-inefficiency, which he defined as the difference between the lowest level of costs potentially achievable and the level of costs actually being achieved. One reason why our concept "structure" does exist may be interpreted by using Leibenstein's approach[1]. It is not, however, necessary to link the behavioral theories and Leibenstein's concepts to our theoretical framework.

In the t h e o r e t i c a l part we specify the target of the study, derive relationships of interest, define the concepts and assumptions used and interpret the measures of the structure and tackle the statistical estimation methods of efficiency frontiers, all at a level which can be applied to all industries. The starting point of this kind of analysis is the information we attempt to derive for decision-making.

After introducing theoretically the key-concept "structure", by which we mean the distribution of the relative performance (efficiency) on the plants or firms within an industry, we are concerned with the measurement of different efficiency indicators. In the simplest case, the measurement method could be condensed by using Salter-diagrammes[2], which illustrate the distribution of productivity of one

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1) Carlsson (1972) has used Leibenstein's X-inefficiency concept in his study.

2) See for definitions and further discussion Salter (1969), pp. 52-53.

factor of production within an industry. It is possible to compare the behaviour of expanding and stagnating industries[1] by this technique. Since the average productivity of an industry is a weighted average of the productivity of its component plants, a rapid rate of increase of output tends to raise the average productivity through the concentration of output in realatively modern plants; conversely, a decline of output tends to lower average productivity because of a high proportion of older plants[2].

The method to be applied generalizes the principle of Salter-diagrammes to cover more than one input and follow the dynamic process of structural changes instead of one cross-section. The effort is to estimate the "total" efficiency of production by using production and cost functions as referred in Chapter 4 above (e.g. the studies of Førsund and Jansen (1974) and Førsund and Hjalmarsson (1976)). After a critical evaluation of the methods used, we apply the Cobb-Douglas and alternative functional forms and a non-linear estimation[3] which to our knowledge has not been interpreted before in this field. By using production and cost functions we also get information on the "normal" properties (returns to scale, the form of the production function etc.) derived usually from these studies[4].

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1) Ibid, figure 12, p. 82.

2) Ibid, p. 82.

3) For futher discussion and non-linear estimation methods of production functions see Meyer and Kadiyla (1974).

4) See e.g. Lehtonen (1976).

An important aspect is to study the behaviour of the indicators of structural change when a) the rate of capacity utilization fluctuates and b) the industry concerned is expanding or stagnating. Capital utilization plays an important part in Johansen´s short-run macro function. The rate of growth of output is a key factor in our scheme when projecting industrial development or explaining variations in efficiency distributions between industries.

The utilization aspects of this kind of analysis is discussed in the theoretical part.

In order to get fully acquainted with the method and to test it, it is important that it is applied, in different situations, to one industry with its sub-branches. The nature of the e m p i r i c a l part of the study is experimental. The framework developed at the general level is applied to the Finnish pulp and paper industry. The data is taken from four sub-branches, and the production of each of them can be considered rather homogeneous. The design of "the experiment" responds also to other research needs: the sample includes both expanding and declining industries, the rate of the capacity utilization varies quite strongly during the period of analysis and the environmental factors can be realistically assumed to be the same for all four sub-branches[1)].

Dynamic approach is emphasized to the extent that cross-section data for only one year cannot be considered sufficient, although this has been the practice in almost all

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1) This is very important in our study because otherwise the external factors studied e.g. by Carlsson (1972) could cause uncontrolled errors in measurement.

previous studies in this field. We utilize primary data at plant level for the period 1960-1975. We have data for both production and cost functions. In this context we also analyze the main characteristics of the industries and the micro units which have generated our data.

Finally the utilization aspects of the results are discussed. The empirical results may raise questions stimulating futher research. We evaluate the usefulness of the framework developed in the decision-making of both industrial policy and strategic corporate planning. If the results obtained seem promising, interesting areas for further research are pointed out e.g. in the field studied by Carlsson (1972), where it would be possible to connect the environmental factors of the industries more closely to our framework. Another field might be in international comparisons. An example is a very interesting possibility to compare the structures and performances of the forest industries in Finland, Norway and Sweden[1].

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1) Compare this with the studies by George and Ward (1975), referred to in this paper p. 12 and by Summa and Ylä-Anttila (forthcoming).

6. CONSTRAINTS AND SIMPLIFICATIONS

Although the aim of the study is to take one step towards a more realistic approach to describe and project industrial development, there are many limitations and constraints still left. This study is delimited to consider only structure and changes in it. With structure we understand the distribution of efficiency of production. The definition used is one among many structural concepts - from locational to market structures.

We do not aim at a quantitative measurement of the factors affecting different efficiency distributions and changes in them at this stage of the study. It is important to connect external factors with the framework when trying to understand and project industrial development, but this cannot be done before the kernel measurement framework is developed and its behaviour studied.

After screening different promising approaches used in this kind of industrial analysis, we arrived at our framework since micro data can only be obtained from the Industrial Statistics[1]. The available data has, however, forced us to make some simplifications and may constrain the application to rather homogeneous industries, which often are process industries. Since this study is based on the production and cost functions, difficulties in measuring the capital variables as well as vintage effects cannot be avoided.

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1) E.g. Day's (1963) approach we could not apply due the lack of engineering data.

7. CONTRIBUTION TO KNOWLEDGE

The relevance of the chosen topic and the need for additional research were already dealt with in Chapter 3. Fields of potential contribution include:

1. Economic formulation of the problem with emphasis on the theory of adaptive processes in Johansen´s (1972) framework.

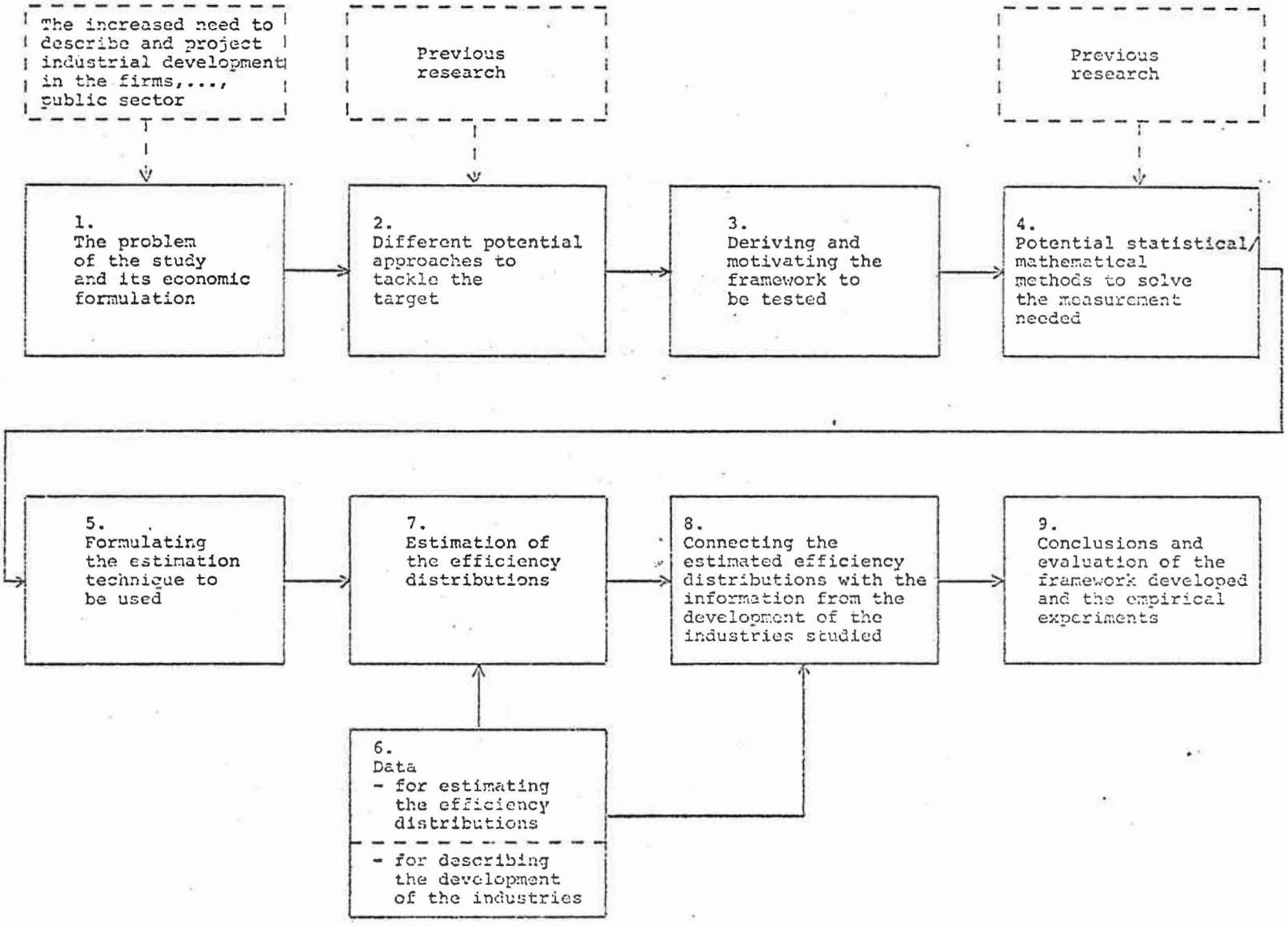
2. Generalization of efficiency estimation methods used in previous studies by employing alternative functional forms (not only Cobb-Douglas) and non-linear models.

3. Arrangment of a test situation of a new kind, which makes it possible to examine expanding/stagnating industries (the rate of output growth varies) and the impact of business cycles (the rate of capacity utilization varies).

4. Emphasis of the dynamic approach and use of time-series data, instead of the approaches assumed in previous studies based on cross-section data for one year.

5. Acquisition and compilation of empirical data and analysis of the results obtained from a industry which is of great importance for the Finnish economy.

THE RESEARCH PROCESS



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